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# ARTIFICIAL INTELLIGENCE IS EVERYWHERE

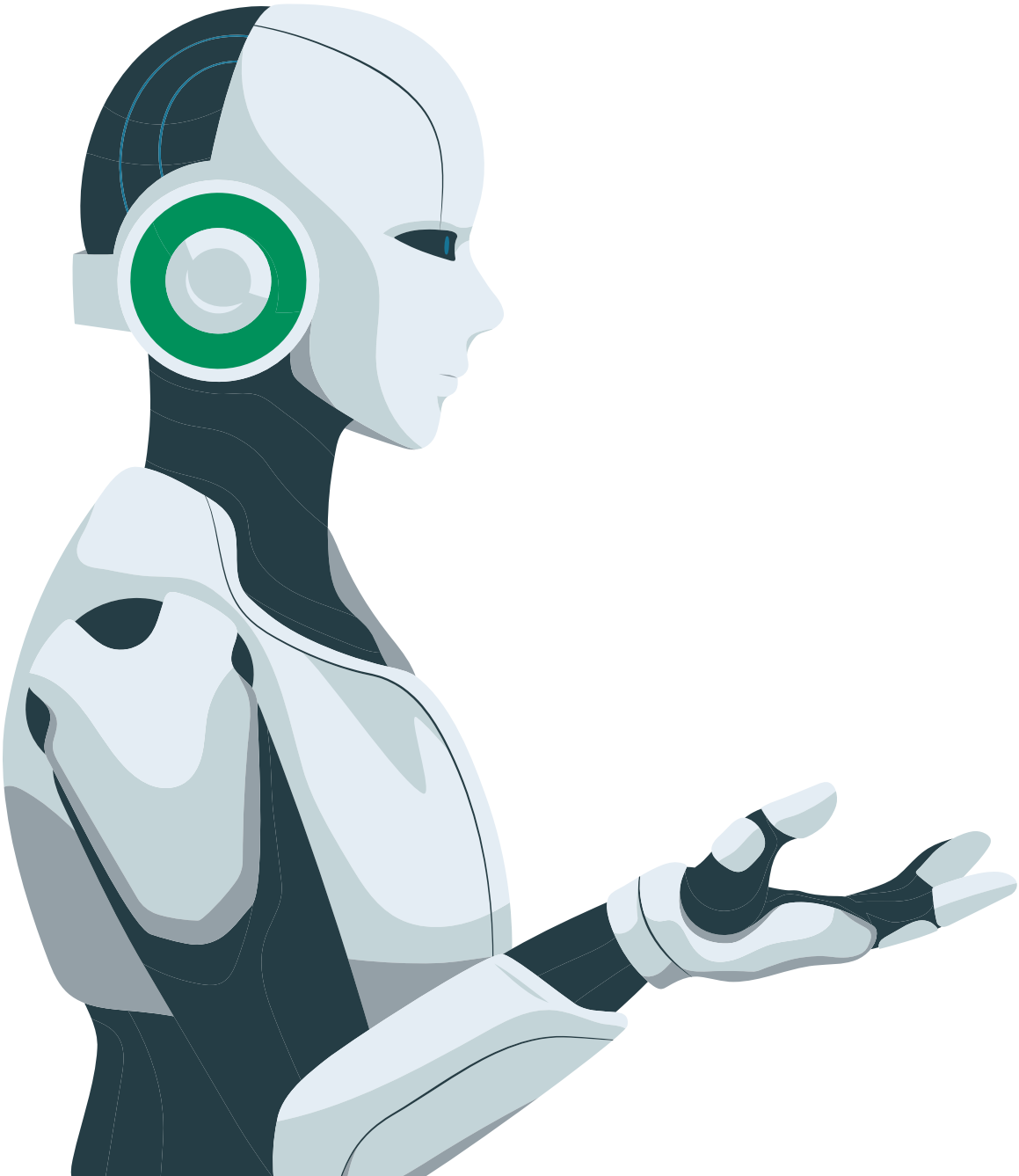
BNP PARIBAS
ASSET MANAGEMENT

The sustainable investor for a changing world

# INTRODUCTION

The single most impactful digital transformation theme is artificial intelligence (AI). AI holds the promise of revolutionising the way we work and the products and services we consume across every sector of the economy. As the capabilities of the technology advance and investments shift from a singular focus on computing power to include additional layers of the technology stack, we continue to find more stocks to invest in that are leaders or beneficiaries of AI.

In this essay, we provide an overview of the AI theme and how it is enabled by cloud computing and foundational technologies including semiconductors, cybersecurity and renewable energy. We touch on some of the recent advancements as well as the risks and challenges associated with developing and using the technology.



# ARTIFICIAL INTELLIGENCE IS EVERYWHERE

- **Artificial intelligence is fast becoming the pervasive technology at the centre of digital transformation initiatives.** The public release of ChatGPT by OpenAI in November of 2022 catalysed an unprecedented innovation cycle, with cloud service providers and others racing to advance the technology. AI is enabled by cloud computing (training and hosting models), the Internet of Things (collecting data), and foundational technologies including semiconductors, networking equipment, cybersecurity and alternative energy.

- **There are many leaders advancing the AI theme, creating a host of investment opportunities, including developers, foundational technologies and data providers.** The developers are companies creating the innovation in AI and driving the technology forward, including those creating Large Language Models (LLMs) and machine learning algorithms; the cloud service providers that are training and hosting AI models; and the semiconductor companies that provide Graphics Processing Units (GPUs) & Application Specific Integrated Circuits (ASICs). **Foundational technology providers** enable AI and include other semiconductor companies that provide high bandwidth memory and networking chips. This category includes semiconductor capital equipment and materials suppliers, foundries, and providers of networking equipment and data storage systems. It further includes energy efficiency and alternative energy solutions ranging from liquid cooling of datacentres to solar panels. **AI data plays** include companies with proprietary data sets that can be used to train AI models and provide competitive advantages. In addition, we see opportunities to invest in the beneficiaries of AI, which are companies that use AI to improve their products and services. There are companies in the software, biotech and other industries that are leveraging AI.

- **AI use cases** are proliferating. Generative AI is a general-purpose technology with a wide array of applications. Its diverse use cases give us confidence that the technology will impact nearly every sector of the economy. Generative AI models are also progressing rapidly. We expect new use cases to emerge as models attain higher levels of advanced reasoning and accommodate non-text formats like audio, images and video.

**"Many leaders are advancing the AI theme, creating a host of investment opportunities"**

**A few Interesting AI use cases so far include:**

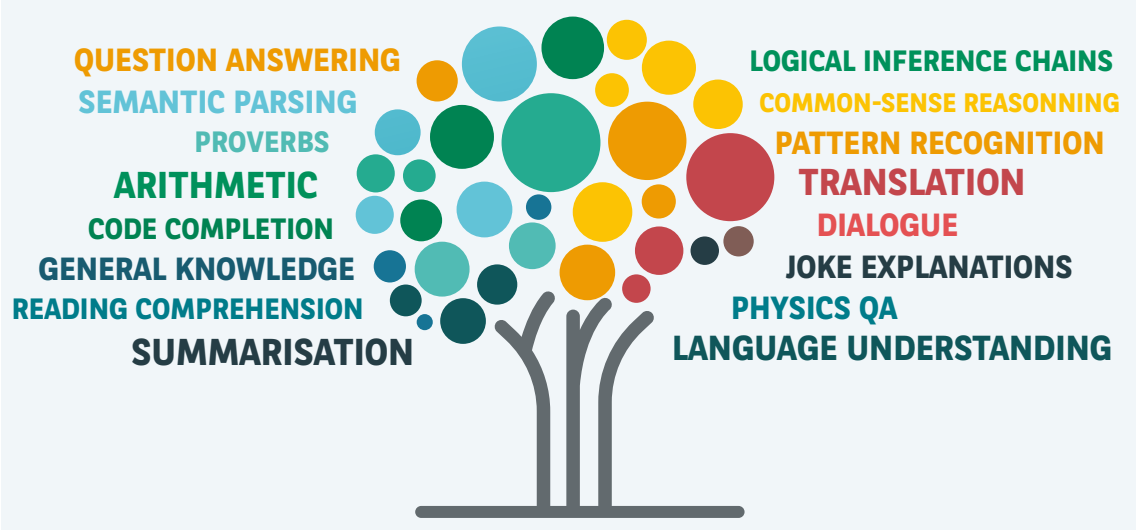
a) **Generating and documenting code**, which can lead to +35-50% productivity improvements for developers[1]

b) **Automating interactions in customer service requests**, which can result in +30-45% productivity improvements[2]

c) **Writing summaries** of medical reports and patient visits; for instance, a medical centre in Taiwan improved doctor and pharmacist productivity after implementing AI copilots. Doctors spend only 15 minutes writing medical reports (compared to an hour previously), while pharmacists have been able to double the number of patients they see per day.[3] **Developing new protein structures**, which has widespread implications across drug discovery and biotechnology, broadly[4]

d) **Simplifying workflows in sales and marketing**: for instance, one multinational company that used generative AI reaped productivity improvements equivalent to four hours per salesperson per week, or USD 50 million annually[3].

**Examples of use cases of a large language model**




Source: Google (ai.googleblog.com); 4 April 2022.

1. Source: McKinsey Digital, "Unleashing developer productivity with generative AI", 27 June 2023, Unleash developer productivity with generative AI | McKinsey
2. Source: McKinsey & Company, "The economic potential of generative AI: The next productivity frontier", 14 June 2023, Economic potential of generative AI | McKinsey
3. Source: Official Microsoft blog, "Looking Back on FY24: from Copilots empowering human achievement to leading AI transformation", 29 July 2023, Looking back on FY24: from Copilots empowering human achievement to leading AI Transformation - The Official Microsoft Blog
4. Source: MIT News, "Generative AI imagines new protein structures", 12 July 2023, Generative AI imagines new protein structures | MIT News | Massachusetts Institute of Technology

# RECENT ADVANCEMENTS IN AI TECHNOLOGY

- **Advanced levels of reasoning**. A leading generative AI company recently unveiled a large language model that can perform complex reasoning by 'thinking' before it answers a prompt. The model uses a chain-of-thought approach to reason through a problem and plan a step-by-step process to answer the query. The model can also review its strategies and answers to recognise, and subsequently correct, mistakes as needed. This new paradigm series of models may be useful for complex tasks such as designing games, solving puzzles, analysing sentiment, writing code and performing advanced levels of mathematics. The main drawbacks (at this stage) are its higher costs and longer response times compared to previous models.

- **User-experience improvements**. Advancements in how users engage with AI models have resulted in more intuitive experiences and unlocked new use cases. Multi-modal capabilities essentially equip models with 'eyes' and 'ears'; they can ingest and deliver responses in audio and imagery formats. Instead of typing queries or reading responses, users can 'talk' to the model and hear a synthetic voice read the answer. Similarly, users can upload images for the model to analyse or have the model produce images in its responses. Finally, leading model builders have consistently expanded the context window, enabling the models to process more information in each prompt. One frontier model has a two million token context window, which we estimate is equivalent to 16 novels of average length.

**"New models may be useful for complex tasks such as designing games, solving puzzles, analysing sentiment, writing code..."**

- **Semiconductors advancements**. There is rapid innovation in developing next-generation semiconductors to support AI training and inferencing. The two leading providers of GPUs have accelerated their new product introduction cadence to an annual pace, which is challenging given the need for engineering, testing, customer qualifications and production ramp. In addition, in some cases, custom ASICs are being developed and deployed by cloud service providers and other large technology companies for specific AI models. There are also several private start-up companies working on AI accelerator chips. From a semiconductor supply perspective, one of the key constraints has been advanced packaging capacity. This final manufacturing step is critical for GPUs, which are very complex systems. The positive news is that the providers of advanced packaging services are rapidly increasing capacity.

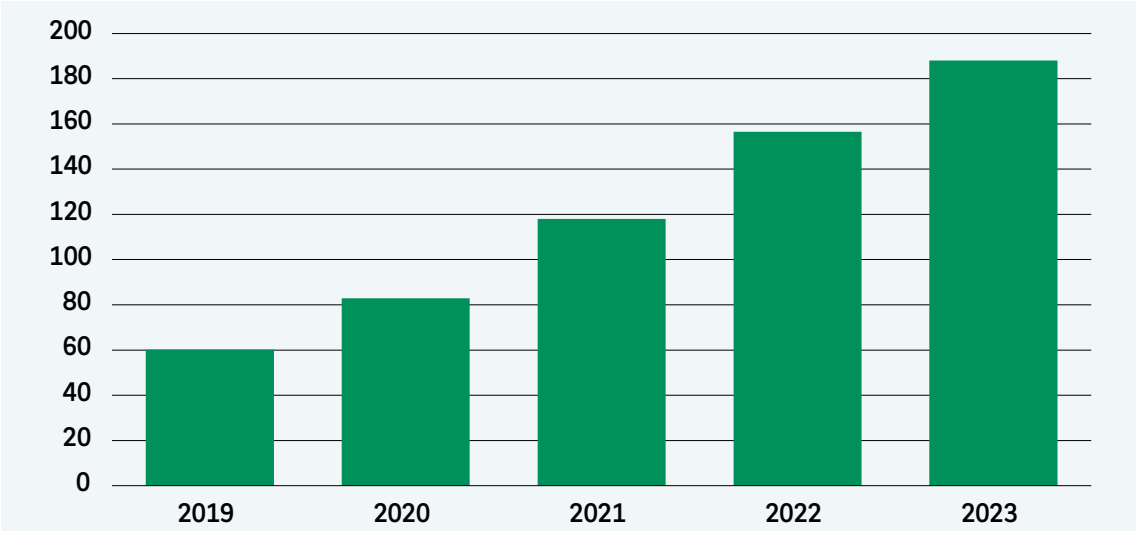
# HARNESSING THE CLOUD

- **The transition to the cloud is a key priority for enterprises**. The cloud provides several advantages over on-premise architectures, including (a) lower costs for storage and compute; (b) elasticity, or the ability to seamlessly scale or shrink capacity as needed; (c) enhanced security; (d) access to advanced technologies like AI, and (e) greater ability to rapidly innovate.

- **The benefits afforded by the cloud create a strong value proposition** that incentivises companies to migrate their IT workloads. We believe the trends are durable and maintain a favourable view on the growth opportunity for cloud computing, overall.

- **We estimate the three major US cloud service providers grew cloud revenue at more than a 30% compound annual growth rate** over the last four years, surpassing USD 180 billion in combined revenue in calendar 2023. Despite this notable scale, there is still a long growth runway as only ~20% of total compute has migrated to the cloud[5].

**Exhibit 1: US major cloud service provider revenue (in USD bn)**




Sources: Company reports, BNP Paribas Asset Management USA.

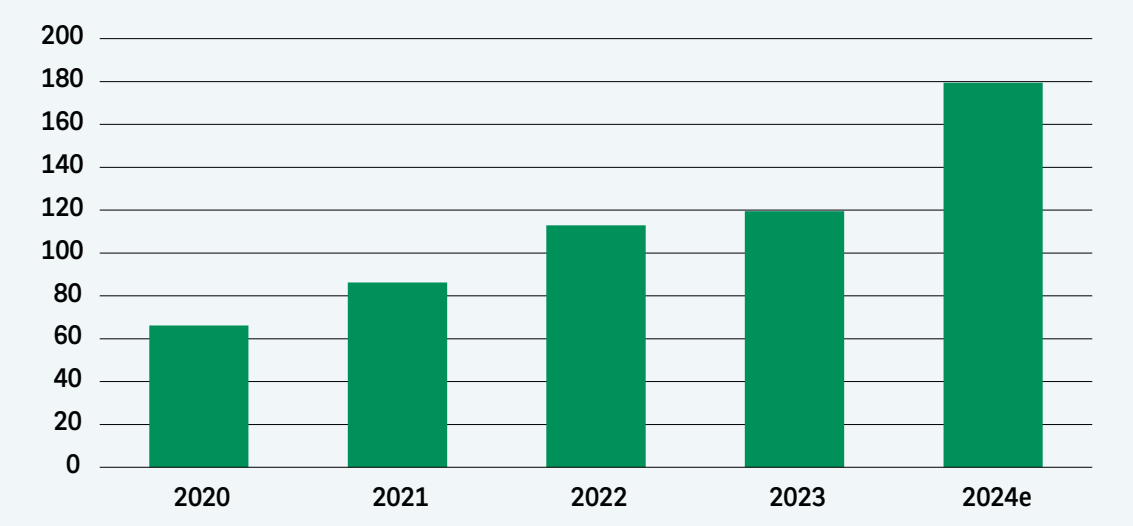
- **The cloud is a gateway to AI**. The cloud providers have vast footprints of datacentres, close relationships with the leading semiconductor companies, access to foundational LLMs, and the most widely available supply of GPUs. As a result, they are ideally situated to offer access to generative AI technology. We expect AI to be an additional propellant for growth in the years ahead.

5. Analysis based on the installed server base. Source: BofA Global Research, "2023 Year Ahead: A Tale of Two Halves", 4 January 2023.

# DIGITAL INFRASTRUCTURE: FOUNDATIONAL TECHNOLOGIES ENABLING AI

The cloud service providers, large enterprises and government entities are investing heavily to build and equip the datacentres required to support artificial intelligence initiatives. We have a positive outlook for investments in digital infrastructure over the next several years, although we expect the spending trajectory to be uneven. Today, most of the capital investments are focused on computing power, which is driving demand for semiconductors including GPUs and high-bandwidth memory (HBM) chips. Providers of server computers and other datacentre equipment are also experiencing robust growth. Moving forward, some of the focus is likely to shift in favour of investment in networking and storage equipment to support training and inferencing of large language and other AI models.

**Exhibit 2: Estimated capital expenditures of leading generative AI builders* (in USD bn)**




*Estimated combined capital expenditures of major US cloud service providers and a leading US social media company
Sources: Company reports, BNP Paribas Asset Management USA.

- There is increasing demand for cooling systems, energy efficiency and renewable energy sources. GPUs are power-hungry chips, and the recent announcement of a model capable of more advanced mathematical reasoning results in higher energy requirements to run models in production. AI datacentres are so energy-intensive that access to power is a concern in many regions, including Loudoun County, Virginia, and a lot of effort is going into finding new sites. Datacentre companies and cloud service providers are considering converting crypto-mining data centres to AI; asset management firms are launching infrastructure funds to finance new datacentre and energy projects; and the US government is encouraging companies to consider building datacentres in locations where coal plants have been shuttered.

- We believe that software development tools, database software and cybersecurity systems are critical components of the digital infrastructure required to support AI

initiatives. AI algorithms are software and can be developed and managed with the same tools used for traditional applications. Enterprises have an incentive to upgrade their legacy database software with modern systems that can handle both structured and unstructured data. Cybersecurity is key to protecting algorithms and data from attacks. In an interesting twist, AI is also being applied to improve these software tools. For example, one database company developed an AI-powered tool to help customers migrate from legacy systems to their modern platform. Furthermore, cybersecurity systems are incorporating machine-learning techniques to better identify and thwart threats.

**"Enterprises have an incentive to upgrade their legacy database software with modern systems that can handle both structured and unstructured data"**

## WHAT IS THE RETURN ON INVESTMENT FOR AI?

- Developing generative AI technology and providing access to leading LLMs is an expensive endeavour. Leading technology companies are racing to build out datacentres, acquire GPUs and develop foundational models. A key topic of debate is whether these companies can earn a good return on this spend. Some company management teams believe there is more risk to not investing in generative AI and 'missing' the next technology wave than in overinvesting and potentially earning lower ROIs.

- We believe the returns will be attractive in the long run, but the level of ROI will vary, perhaps dramatically, by company. The companies best positioned will be those that expand beyond the infrastructure layer and create new applications or services that can be separately monetised.

- For context, we estimate the major US cloud service providers and a leading social media company investing in generative AI will increase their combined capital expenditures by more than 50% year-over-year to more than USD 175 billion in 2024. Most of this spend will be targeted at their AI initiatives. Historically, this group has generated over 20% returns on invested capital (ROIC), on average. In these early stages, there may be short-term pressures on ROIC given the lagged effect between AI investments today and when meaningful revenue is ultimately generated from those initiatives. In the long run, however, we expect returns to improve as these investments mature and as AI adoption marches higher.

- One key variable is the high cost of GPUs and whether that will decline over time, as competitors catch up to the current market leader. The vast majority of capital spending for AI datacentres is currently spent on GPUs.

**"In the long run, we expect returns to improve as investments mature and AI adoption marches higher"**

## UNDERSTANDING AI CHALLENGES AND RISKS

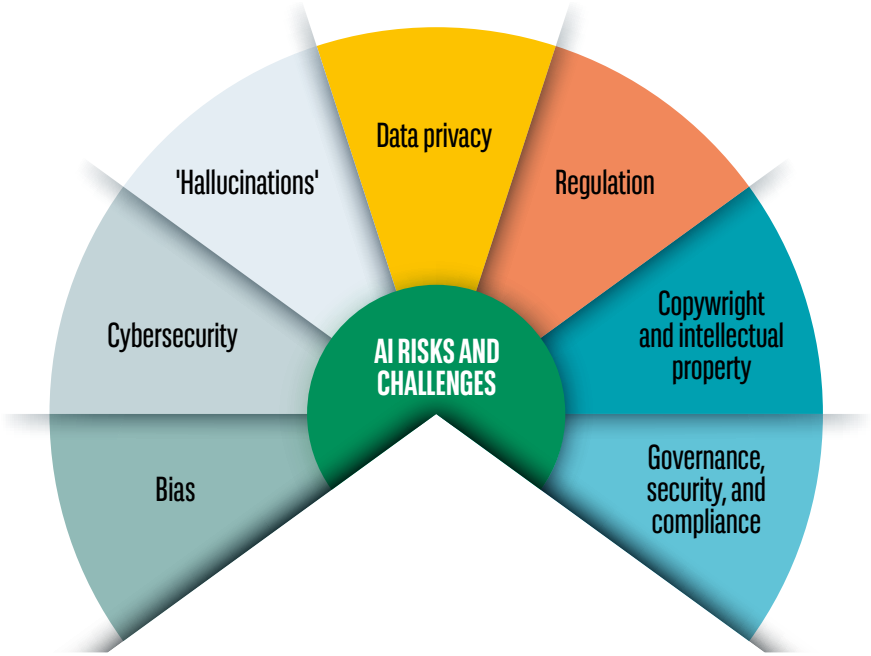
- Part-and-parcel with emerging technologies like generative AI are potential risks, uncertainties and disruption. Stricter regulations could stymie the pace of innovation, slow demand for AI infrastructure, and negatively impact technology investors.

- LLMs have made significant strides but there are still several areas that require further improvement and refinement. Models are susceptible to producing 'hallucinations', or outputs which have incorrect or misleading information. AI developers need to mitigate bias through diverse and representative training data so that outputs are fair and unbiased. Governance, security and compliance protocols need to align with enterprises' standards. Data privacy and cybersecurity are critical areas of focus. Generative AI is a new threat vector that needs to be protected against bad actors.

- Given the ease and accessibility of AI content generation, it would not surprise us if the amount of synthetic content one day dwarfs that of all human-generated content throughout history. It will be imperative for users to be able to discern what is real from what is fake. Various tagging innovations like unique identifiers or watermarking can help users understand the source of content in the future.

- Copyright and intellectual property rights of model inputs and outputs are key subjects of debate. Fundamental questions around fair use, data rights and attribution may not have answers for several years as high-profile cases work their way through the US legal system.

"It will be imperative AI for users to be able to discern what is real from what is fake"




Source: BNP Paribas Asset Management, USA

# CONCLUSION

Artificial intelligence is the most important technology theme since the dawn of the Internet age three decades ago. As the technology advances and becomes more pervasive, the investment opportunities within publicly traded equities are broadening from a small number of leading companies to a larger universe of enablers and beneficiaries. There are several risk factors and uncertainties associated with AI, so an active approach to investment management is required to capitalise on the positive trend while avoiding the pitfalls.

# AUTHORS

**Pamela Hegarty**

**Senior Portfolio Manager, ESG Champion**

Pamela is the lead portfolio manager for the disruptive technology strategy and is responsible for helping guide the team's investments in the technology, Communication services and utilities sectors. She joined the company in 2016.

Before joining BNP Paribas Asset Management, Pamela has worked as a portfolio manager and equity analyst at Boston Common Asset Management, State Street Global Advisors and Baring Asset Management.

Pamela began her career at Janus Capital Group in 1995 as a Senior Analyst for seven years, where she conducted analysis of stocks with a specialisation in the technology sector.

She graduated Cum Laude from Harvard University with a degree in Applied Mathematics and received her MBA With Distinction from the Johnson School of Management at Cornell University.

Pamela is a CFA charterholder and a member of the CFA Institute.

She is based in Boston.

**Derek Glynn**

**Associate Portfolio Manager**

Derek is an Associate Portfolio Manager responsible for the Information Technology and Communication Services sectors on the US equities team. He joined the team in 2021.

Prior to this position, Derek was a Senior Research Analyst and Vice President at Consumer Edge Research covering the Consumer Mobility and Automotive industries. Prior to that, he spent four years at Quad Capital where he assisted in all aspects of the portfolio management process.

He graduated Summa Cum Laude from the Villanova School of Business at Villanova University. He is a CFA charterholder and a member of the CFA Institute. Derek in based in Boston.

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