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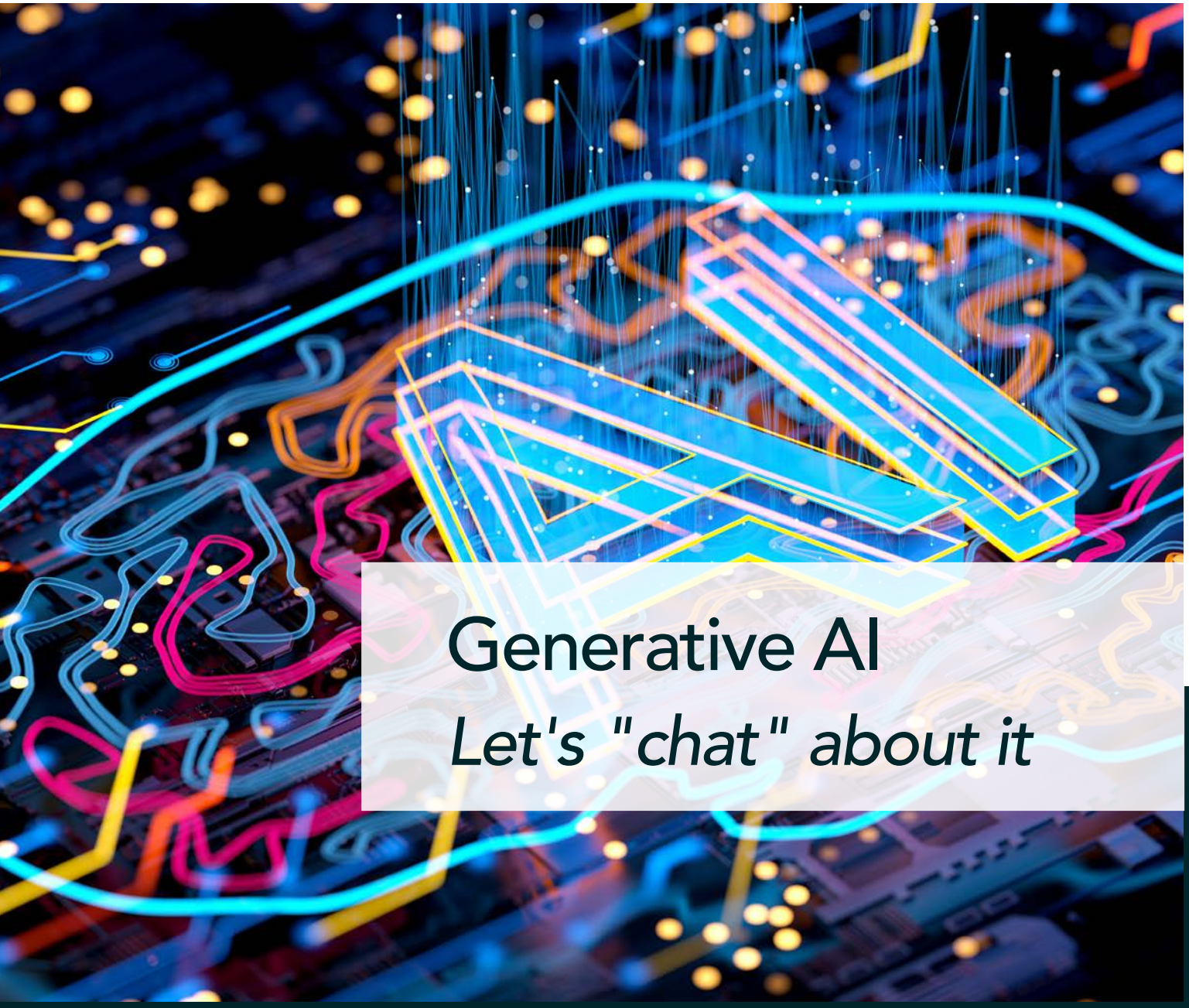
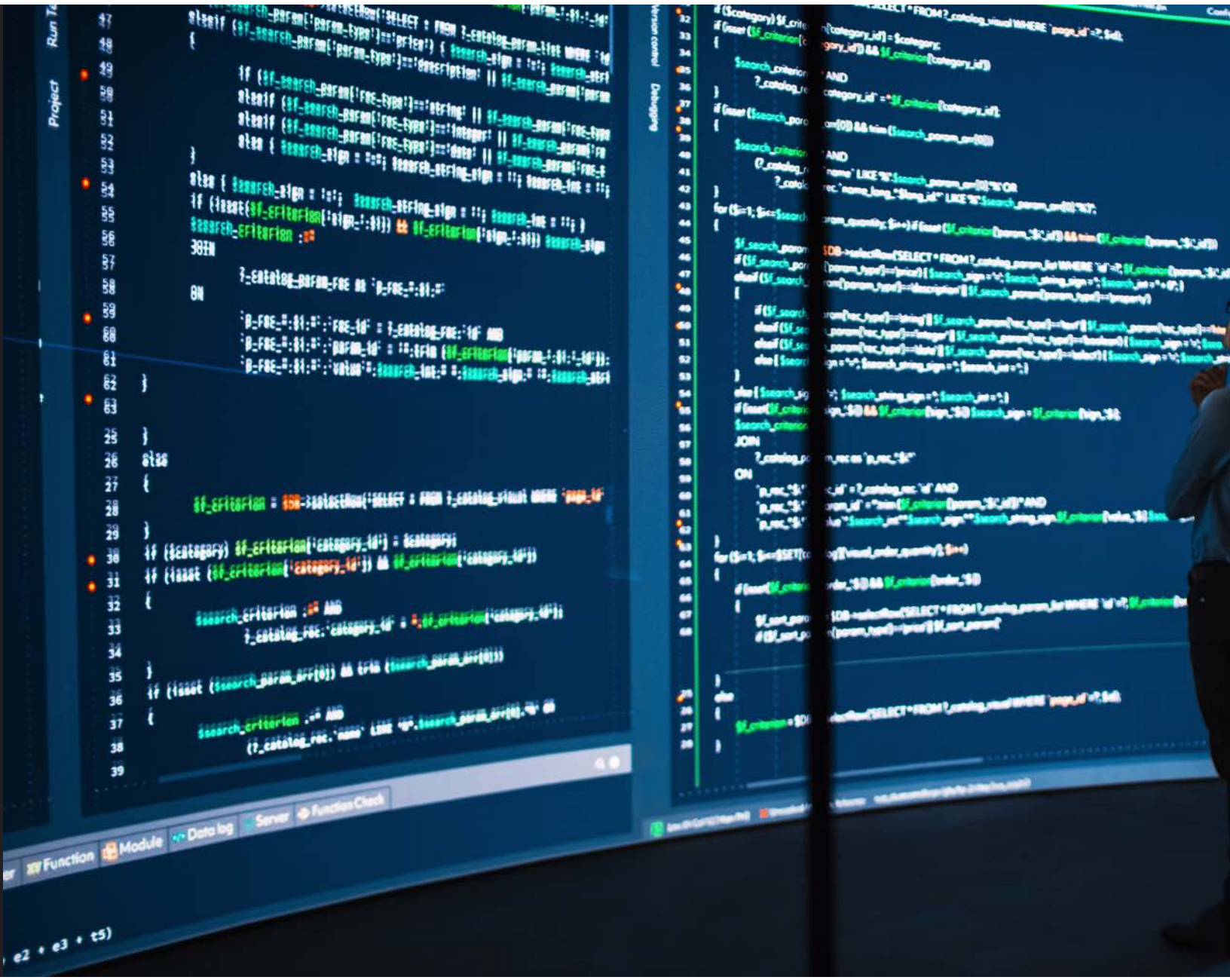


Generative AI
Let's "chat" about it

ROCKEFELLER INSIGHTS

Portfolio Opportunities



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GENERATIVE AI

LET'S "CHAT" ABOUT IT

Microsoft's announcement in January of its investment in ChatGPT unleashed a media avalanche into the world of artificial intelligence, or AI. In this report, we examine the trajectory of the technology, highlighting the newest iteration of Generative AI, and its potential to change our lives as both consumers and investors.

Artificial intelligence, or AI, has been defined multiple ways over the decades since its existence. Currently, with some variation, most definitions agree that artificial intelligence refers to the simulation of human intelligence in machines. The process by which these machines are taught how to think is made possible by a single algorithm (set of rules) or a set of algorithms. The data bank to which the machine has access and the complexity of the algorithm need to match the complexity of the task required of the machine.

1. Bernstein Research, June 2021

AI Over the Decades

Artificial intelligence has been evolving since the 1950s. A generation of scientists, mathematicians and philosophers pondered that if humans use available information as well as reason to solve problems and make decisions, why can't machines do the same thing?

In the 1960s, the Defense Advanced Research Projects Agency (DARPA), a government agency, funded research at several academic institutions. Their interest was in creating a machine that could transcribe and translate spoken language as well as process advanced data.

However, the 1970s proved to be a lost decade. Funding slowed because patience dwindled; computers simply could not store enough data and lacked the ability to process tasks quickly enough. In the 1980s, funding for AI took on a global perspective as Japan invested heavily in the technology.

Since then, technological advances in the U.S. have been substantial, due to several factors. Computers have been able to access vast amounts of information and process that information in seconds. Further, the emergence of the cloud and data centers allowed for access to and storage of big data.

Significantly improved semiconductors allowed algorithms to access a massive amount of information and generate meaningful responses. Finally, the cost curve for technology allowed machines to be built at substantially lower costs, allowing for efficiencies in AI research.

UNDERSTANDING THE CAPABILITIES OF AI

There are four basic types of AI and each has a unique space in which it functions most effectively. The degree of complexity in the machine's algorithms and components vary significantly in each type.

REACTIVE

Given identical inputs, the machine will be able to produce the same output. The machine has no ability to learn or adapt to unique situations and has no memory. Examples are IBM's Deep Blue and Google's Alpha Go; chess-playing AI machines.

LIMITED MEMORY

The machine uses memory to learn and improve its responses based on new observations or data. The auto industry utilizes this type of AI in its autonomous vehicles. These "smart" vehicles are conditioned to read the road and react to new circumstances, even learning from past experiences.

THEORY-OF-MIND

The machine is fully adaptive and has extensive ability to learn and retain past experiences. Chatbots are an example and although they are not self-aware, they are advanced and could easily fool people into believing they are interacting with another human.

SELF-AWARE

While this type of AI is only aware of its own existence and present in science fiction, this is the most controversial type. Whether or not AI will ever be able to have awareness of its own existence remains a topic for debate.

2. CreditSights, 10/15/2020
3. Bernstein Research, 8/26/2022

An evolution to Generative AI

AI has been with us every day of our lives, whether at home or on the go. Amazon's Alexa and Apple's SIRI assist us with navigating platforms many of us use daily. Every time someone accesses their phone using facial recognition, AI is involved. So why all the chatter recently about AI?

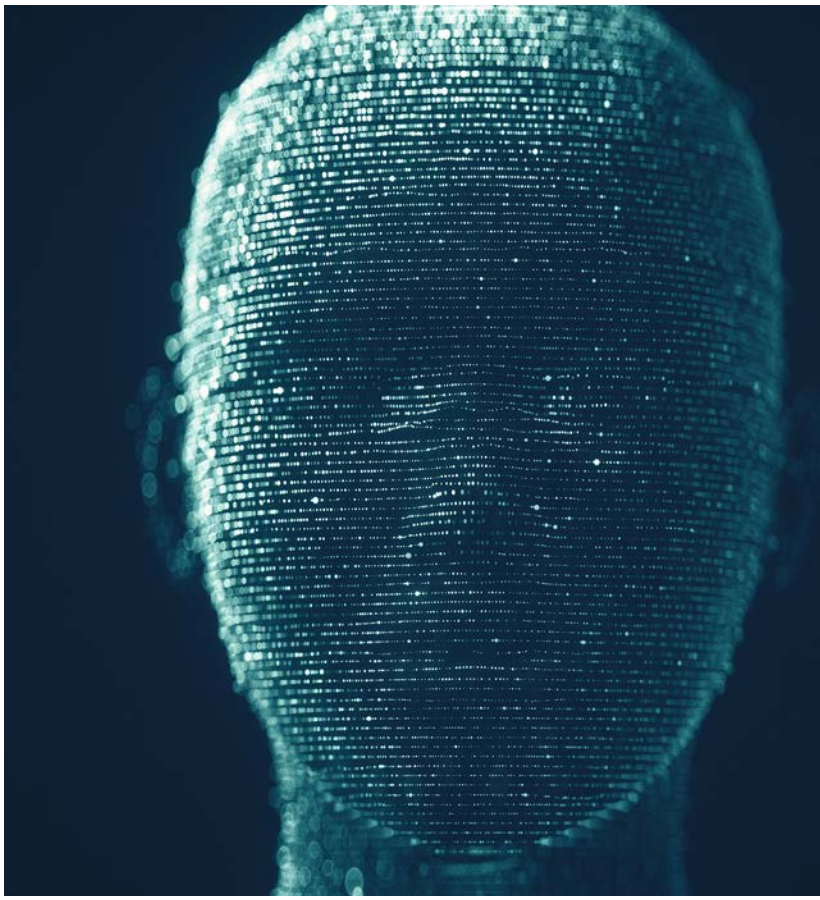
While traditional AI systems can produce original data, they are best known for their ability to recognize patterns and make predictions, classify data and detect fraud.

A more robust type of artificial intelligence, called generative AI, was first introduced in the 1960s with ELIZA, a chatbot created by Joseph Weizenbaum.[1] But widespread development of new and improved generative AI models did not occur until 2017, when Google introduced its Transformer model.[2]

Generative AI refers to artificial intelligence systems that use deep learning algorithms to create new and original content based on the data and parameters upon which the system is trained. These systems create new data by using probabilistic models to produce outputs based on learned patterns. This content can include text, images, music and even 3D models. Generative AI technology uses a learning process called generative adversarial networks (GAN).

Within these networks there are two processes that work together: the generator (data creator) and the discriminator (data evaluator). The two combine to generate real, unique content. The complex process of generative AI gives it a significant benefit over traditional AI systems. Because it can create original and unique content, there are entirely new use cases for generative AI. We explore some of these later in the report.

1. csail.mit.edu, 3/24/2022
2. Global X, 3/3/2023



Microsoft makes a big splash

ChatGPT (GPT = Generative Pre-trained Transformer) is an AI chatbot auto-generative system that was officially introduced by its creator, AI research laboratory OpenAI, in November 2022. ChatGPT uses machine-learning algorithms and an advanced version of generative AI to generate human-like responses through its language model.

ChatGPT utilizes the information it has learned through training, in which its dataset spans across multiple sources including articles, textbooks and websites. ChatGPT does not have the ability to scour the internet – only the database in which it has learned through training. This leads to some limitations because the last dataset update for the chatbot was in 2021.

Further, as ChatGPT learns from its experiences, the potential for conflict arises between what it has learned from training vs. what those experiences have "taught" the tool.

Nonetheless, the chatbot is impressive with its ability to process a response in fractions of a second. It understands (to some degree) typographical errors and can correct inputs that it has been given.

Microsoft has been investing in OpenAI since 2019. However, in January 2023, the company's announcement of a new multiyear, multibillion-dollar investment with OpenAI commanded the attention of investors and launched a media avalanche of AI-related commentary.

Microsoft's follow-up comments that it would be adding ChatGPT's capabilities to its Bing search engine tool got the attention of competitors, and the race for consumer-focused generative AI tools was officially on. The artificial intelligence that once resided in science fiction books and movies is now more of a reality than ever.

Lots of buzz in the early innings...

The potential for a machine to think like a human, incorporating logic, reason, and creativity is quite overwhelming. Some have called generative AI the most transformational technological change since the mobile phone. Others say it will be the most compelling investment of the decade.

It certainly began with sufficient excitement. From its launch in November 2022, it took ChatGPT just five days to reach one million active users; it took Netflix 3.5 years to achieve the same penetration.[3] This adoption rate is 3x that of social media platform TikTok and 10x that of photo/video sharing service Instagram.

Within 48 hours of announcing that ChatGPT would be incorporated in its search engine Bing, Microsoft received "test drive" requests from more than one million users.[4] Apple recently approved the use of BlueMail, an e-mail application with AI-powered language tools, for its customers after the developer ensured that it features content moderation. Analysts at multinational bank Barclays predict that every consumer application will have some form of generative AI written for it over the next three years.[5]

In 2022, investors spent $2.6 billion on 110 unique generative AI-focused start-ups in the U.S., many of which are likely to be lower quality businesses.[6] Is this enthusiasm indicative of a bubble already forming around the space or a sign of legitimate growth potential?

It is estimated that the global AI market could reach $900 billion by 2026, a 19% compound annual growth rate from current levels, and that AI could boost the global economy by $15 trillion over the next seven years.[7]

3. Bank of America, 2/28/2023
4. Bloomberg, 2/28/2023
5. Barclays, 3/3/2023
6. Bloomberg, 2/18/2023
7. International Data Corporation, February 2023

...but AI is not free of glitches and concerns

For all the enthusiasm surrounding generative AI, there are plenty of nay-sayers, mostly centered around the potential for misuse and security breaches – and the obvious lack of regulation. Even Elon Musk and Sam Altman, co-founders of OpenAI, have attempted to temper the enthusiasm surrounding the broader public use of AI, and have expressed concern about the challenges with regulating its content.

Much of the media criticism of chatbots has focused on the potential for plagiarism, as students increasingly turn to these tools for assistance in writing papers and completing homework assignments. As a result, many schools and universities have banned usage. But there may be greater risks than these.

With generative AI, cyber-criminal actors have access to another wide-reaching stage, as chatbots can craft e-mails that appear legitimate but could be phishing or identity-based attacks. Chatbots also raise legal questions about intellectual property, data/information ownership and privacy. Some artists have already accused AI image generators of plagiarizing their work and some software engineers say that AI code generators use chunks of their computer code.[8]

Early adopters have complained that the chatbots have exhibited strange behaviors and produce inaccurate, incomplete, or biased output. Developers emphasize that a chatbot's output is dependent upon, and limited by, the parameters and dataset accessible by the bot. Responses can therefore be nonsensical, or if the query is too long or uses jargon, the bot may become confused. For these reasons, some industry executives suggest that, at least for now, AI uses should be reserved for simple, repeatable tasks, or for the generation of boilerplate items. It is important to emphasize that chatbots cannot make decisions – that task will still require human input.

Will the chatbot take my job?

While chatbots cannot make decisions, are they smart enough to replace some employees? There is growing concern, among workers and legislators alike, that AI tools will displace certain jobs, and that employers will find cost incentives in doing so.

It is possible that tasks focused on data analytics, spreadsheet population and analysis, research or composition/editing may be more efficiently performed by AI-powered tools. But labor economists point out that there is little evidence that transformational technologies sacrifice human capital. For example, the invention of ATMs did not displace bank tellers; rather, the footprint of banks expanded, and tellers' roles became more sophisticated and complex.

Microsoft co-founder Bill Gates, in an interview with German business news outlet Handelsblatt, said that AI will enhance jobs by improving worker efficiency and productivity. He highlighted certain tasks like invoice preparation, filing e-forms, and crafting company correspondence as perfectly suited for positive impacts from AI.[9] As generative AI becomes more widespread, there are likely to be new jobs created, specifically in the training of AI technology.

8. Wall Street Journal, 2/8/2023
9. Bloomberg, 2/10/2023

FUTURE IN FOCUS

GENERATIVE AI IMPACT ON MARKET SECTORS

If AI has the potential to enhance productivity and re-shape the future of industries, where is it likely to have a significant impact?

TECHNOLOGY

Clearly, the technology sector, where AI is already embedded, is likely to experience additional enhancements. AI can assist software developers write and debug computer code and will certainly upgrade current search engines, as it partners with chatbot applications. Greater computing requirements suggest the need for faster, more sophisticated semiconductors, and data centers will surely have more data to be stored. Cybersecurity firms are likely to have more on their plates, as the need for e-mail and identity security grows along with advanced threat detection.

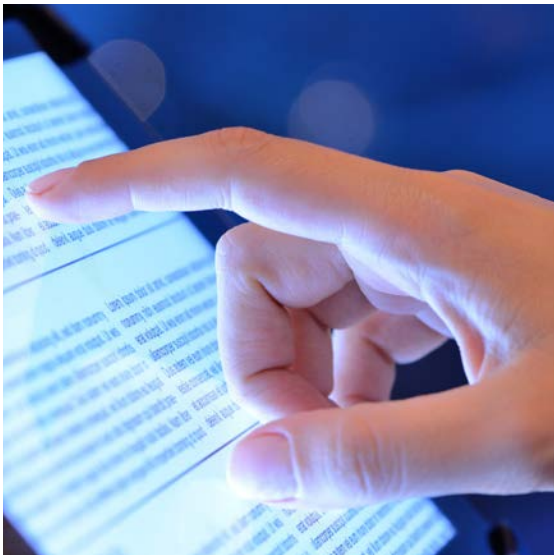
HEALTH CARE & FINANCIALS

Both sectors have been identified by analysts as prime beneficiaries of advanced AI tools, since both utilize large volumes of electronic data and information. Applications within health care could include patient care summaries, diagnosis management, remote patient monitoring, genomic data and population health management. Financial firms could use AI to improve bank & insurance data analysis and credit risk assessments, mortgage processing, and to help detect fraud.

16. Bernstein Research, 8/26/2022
17. Bernstein Research, June 2021
18. Bernstein Research, 1/9/2023
19. Bernstein Research, June 2021
20. Bernstein Research, June 2021

FUTURE IN FOCUS

GENERATIVE AI IMPACT ON MARKET SECTORS

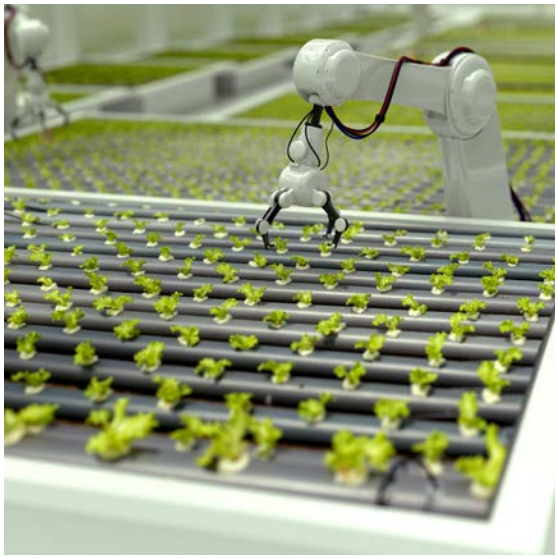


CONSUMER

Consumer-related industries offer several opportunities to benefit from AI, from online learning, writing/editing textbooks, and preparation of presentation materials to composing newspaper/journal articles, creative storytelling, and advertising. There could also be uses for language translation, creating travel itineraries, and even composing music lyrics and melodies. Media companies BuzzFeed and the publisher of Sports Illustrated have both announced plans to generate articles and quizzes with ChatGPT.[10] Video game designers report using generative AI to develop character profiles, trailers, and news releases, leveraging AI's creative capabilities.

INDUSTRIALS

AI-generated software is already employed in areas like precision agriculture, factory automation, and supply chain optimization. Other applications where the tools may leverage productivity are engineering/construction project management, drilling optimization using energy well geology, and analysis of water/gas/electricity usage patterns.



NOTE:

The table on the next page identifies several publicly traded participants in the generative AI ecosystem. Please note that this is a sampling and not a complete list.

Any references to a company or publicly traded entity are strictly for illustrative purposes only and are not intended to be construed as investment advice or as a recommendation to purchase, sell or hold any security.

Perhaps expectations for generative AI are ahead of the earnings power of the technology right now. There are certainly limitations and security-related issues that are significant. Nonetheless, technology is evolving rapidly and new generations of AI are around the corner. The longer- term potential applications of AI, as we have suggested in this report, are wide-reaching. We expect to write more on this topic in the future, especially if it appears that Bill Gates was correct when he said in February that "AI will change the world."[11]

Selective Artificial Intelligence Participants

Stock	Symbol	
Nvidia	NVDA	Produces graphic semiconductors that train AI models and can handle calculations for Large Language Models. Produces memory, storage and optical chips that will be needed with additional AI-generated data.
Microsoft	MSFT	Investment in ChatGPT, that will be incorporated into Bing search engine and office apps (Word, PowerPoint, Outlook). Has ability to build, manage and monetize AI across the business.
Alphabet Class A	GOOGL	Several years of experience with AI-assisted search; search volumes should grow with generative AI Invested in chatbot systems Bard and DeepMind Sparrow.
Meta Platforms	META	Should be additional content creation needs with generative AI Has generative AI initiatives in the works for social and advertising sites, likely also a chatbot service for messaging apps.; building AI supercomputer to help distribute creator content.
Snap Inc.	SNAP	Announced "my AI" service to tier its subscription offering and monetize its content.
Arista Networks	ANET	Provides data center switching for AI workloads, that generate higher switching content. Expansion of hyperscale AI networks and workloads will require greater switching needs.
GitLab Inc.	GTLB	Participates in the writing, testing, and securing of AI-generated code. Owns AI-powered tool (Copilot) that improves productivity.
Adobe Systems	ADBE	Generative AI should allow for greater creation of video/image/presentation content. Adobe's AI engine Sensei could be leveraged with the company's inventory of images and data to enhance the breadth and speed of creative output.
Wix.com	WIX	Provides development platform for professional-quality websites. Generative AI likely to enhance the speed of building websites and accelerate the development of code and content creation.
Palo Alto Networks	PANW	Offers new identity threat detection response (ITDR). Through user identity and behavioral data, IDTR employs AI-powered technology to detect identity-driven cyber-attacks.
Exchange Traded Funds		
Global X Artificial Intelligence and Technology ETF	AIQ	The fund seeks to track the performance of the Indxx Artificial Intelligence and Big Data Index.
First Trust Nasdaq Artificial Intelligence and Robotics ETF	ROBT	The fund seeks investment results that correspond generally to the price and yield of the Nasdaq CTA Artificial Intelligence and Robotics Index.
WisdomTree Artificial Intelligence and Innovation ETF	WTAI	The fund seeks to track the price and yield performance of the WisdomTree Artificial Intelligence and Innovation Index.

10. Wall Street Journal, 2/8/2023
11. Bloomberg, 2/10/2023