What's Next for AI and Robotics?

David Tsoi, CFA, CAIA, FRM, CESGA, CAMS, Senior Index Research Strategist, *Nasdaq Index Research*

While artificial intelligence (AI) has a history of almost 80 years, the public release of ChatGPT in November 2022 has significantly aroused our interest and raised awareness about generative AI. The launch of ChatGPT has been described as the "iPhone moment" for AI, driving robust user adoption. The general public is now increasingly utilizing AI and organizations are in a race to integrate AI tools into their business models. At the same time, robots are becoming smarter and more agile due to AI enhancements.

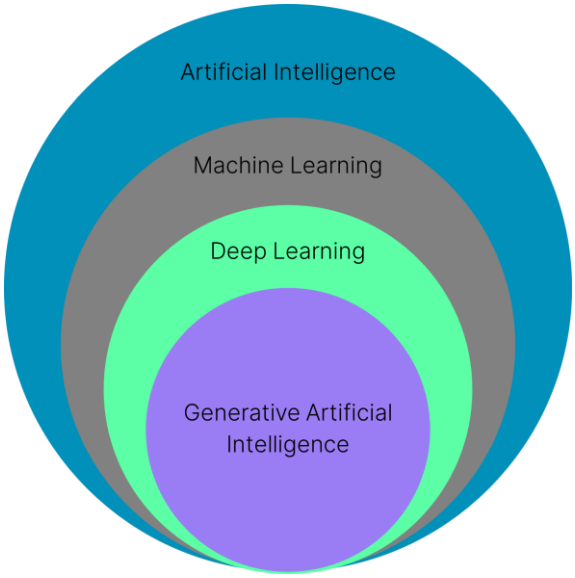
An overview of AI, Machine Learning, Deep Learning and Generative AI

Artificial intelligence is used to classify machines that emulate human intelligence and cognitive functions like problem-solving and learning.

Machine learning is a subset of AI that uses algorithms to detect patterns in data sets, allowing machines to learn without explicit programming by a human.

Deep learning is a subset of machine learning that uses multi-layered neural networks to simulate the complex decision-making power of the human brain.[1] Deep learning can make non-linear, complex correlations within datasets, but it demands more training data and computational resources compared to classic machine learning.

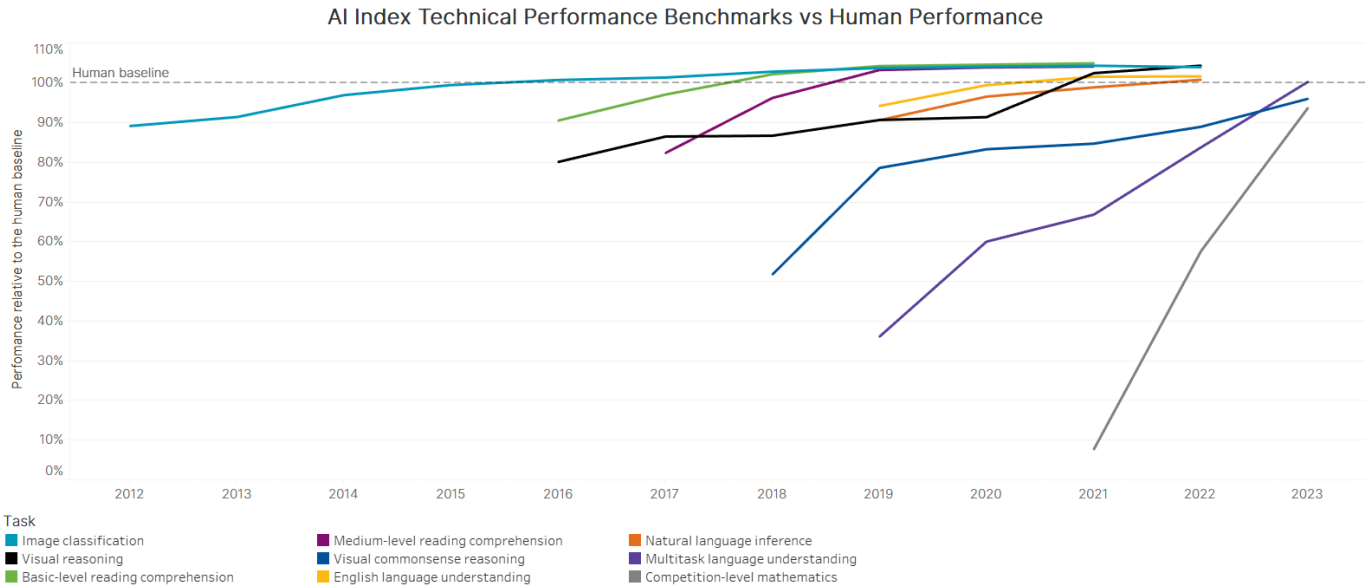
Generative AI relies on deep learning models to generate original content, such as text, images, audio, video, or software code, in response to a user's prompt or request.



Has AI Surpassed Human Intelligence?

AI has outperformed human baselines across several benchmarks, including image classification in 2015, basic reading comprehension in 2017, and natural language inference in 2021. AI has not exceeded human performance in certain tasks, such as competition-level mathematics and visual commonsense reasoning. Yet, AI showed huge progress in these complex cognitive tasks. Introduced by UC Berkeley researchers in 2021, MATH is a dataset of 12,500 challenging competition-level mathematics problems, and the baseline for human accuracy is 90%.[2] While AI systems could only solve 6.9% of the MATH questions in 2021, a GPT-4-based model achieved an accuracy of 84.3% in 2023.[3] AI systems' capabilities in visual reasoning, which assess their ability to reason across visual and textual data, are also improving steadily. On the visual commonsense reasoning dataset, GPT4RoI achieved an impressive accuracy of 81.6% in 2023, substantially improving from the 44.0% accuracy attained by another AI model in 2018. It came close to the human-level performance of 85%.[4]

[1] https://www.ibm.com/think/topics/ai-vs-machine-learning-vs-deep-learning-vs-neural-networks
[2] https://arxiv.org/pdf/2103.03874
[3] https://aiindex.stanford.edu/wp-content/uploads/2024/05/HAI_AI-Index-Report-2024.pdf
[4] https://visualcommonsense.com/leaderboard/



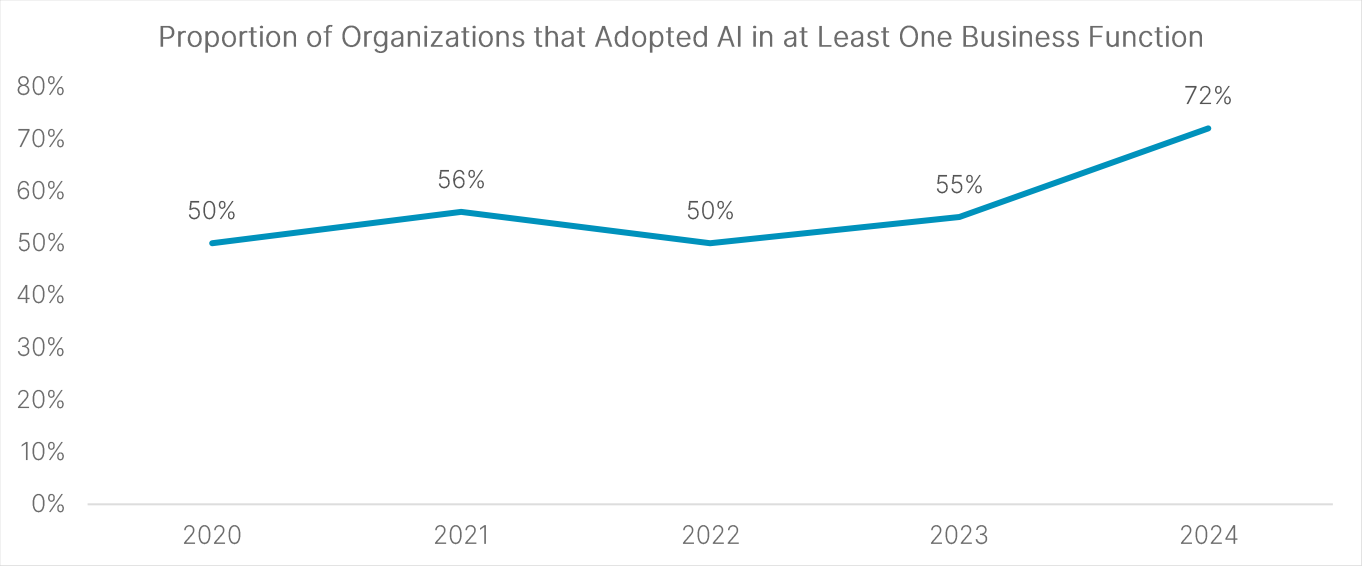
Source: Artificial Intelligence Index Report 2024. Values are standardized to create a uniform metric for comparing benchmarks. The scaling function is adjusted so that the best model's performance for each year is measured as a percentage of the human baseline for a specific task.

AI Adoption Continues to Accelerate

Initial winners of the first phase of the AI boom are companies that provide the infrastructure for AI technology, such as chip designers/manufacturers and cloud providers. This mirrors previous technology market cycles, where infrastructure providers reaped rewards ahead of other components in the tech stack. Big tech firms emerge as a dominant force in the first phase, capitalizing on their substantial first-mover advantages and deep pockets. NVIDIA has undeniably led the initial phase of the AI boom. With its adjusted stock price nearly tripled over the last 12 months[5], the chip designer surpassed Microsoft to become the world's most valuable company with a market capitalization of US$3.34 trillion on June 18, 2024. Major cloud computing companies, such as Amazon, Microsoft, and Alphabet, have swiftly implemented multi-year investment strategies to bolster their cloud capacity for the AI era. For instance, Amazon has committed to allocating US$148 billion to construct and manage data centers worldwide in the next 15 years.[6]

We are now in the phase in which organizations have begun utilizing and deriving business value from this technology — the application phase. The desire to enhance efficiency and lower costs has driven companies across industries to integrate AI into their operations. According to a global survey by McKinsey, 72% of organizations have adopted AI in at least one business function early this year, up from 55% in 2023. Generative AI adoption is most prevalent in marketing and sales, product and service development, and IT functions.[7] AI was mentioned in nearly 80% of earnings calls across all Fortune 500 companies in 2023, a significant increase from 53% in 2022.[8] Focusing only on chipmakers and cloud computing providers that facilitate AI model creation is no longer the ideal approach. It is crucial for investors to ensure their portfolios include companies across the AI value chain. Companies that design, create, integrate or deliver AI products, software or systems are increasingly benefiting from the growing AI spending across various industries.

[5] Source: Bloomberg. As of September 30, 2024.
[6] https://www.bloomberg.com/news/articles/2024-03-28/amazon-bets-150-billion-on-data-centers-required-for-ai-boom
[7] https://www.mckinsey.com/capabilities/quantumblack/our-insights/the-state-of-ai
[8] https://aiindex.stanford.edu/wp-content/uploads/2024/05/HAI_AI-Index-Report-2024.pdf



Source: McKinsey Global Survey on AI. As of March 5, 2024.

Experts are expecting significant advancements in AI tools to accelerate scientific discoveries. These tools are specifically directed toward tackling critical global challenges, such as diseases, climate change, and energy crises. Discovering novel medications plays a crucial role in improving human health. The conventional approach to identifying and validating drug targets is a time-consuming and frequently trial-and-error process. Only 14% of all drugs in clinical trials obtain approval from the Food and Drug Administration (FDA) eventually.[9] From the initiation of a discovery program to securing marketing approval, the process typically spans 12 to 15 years.[10] In 2020, Google Deepmind's AlphaFold 2 AI system achieved a fundamental breakthrough in molecular biology by accurately predicting the 3D structure of proteins from their amino acid sequences.[11] By comprehending a protein's structure, which is closely connected to its functions, scientists can gain valuable insights into its role and mechanisms of action. AlphaFold 3 was introduced in May 2024, which can predict the structure and interactions of all life's molecules, including proteins, DNA and RNA, and small molecules that could function as drugs. DeepMind also unveiled the "AlphaFold Server", a free online tool for non-commercial research, enabling scientists to validate their hypotheses before conducting real-world experiments.[12] According to Dr. Nicole Wheeler, a microbiology expert at the University of Birmingham, AlphaFold 3 has the potential to substantially accelerate the drug discovery pipeline, as the current bottleneck in biotechnology lies in physically producing and testing biological designs.[13]

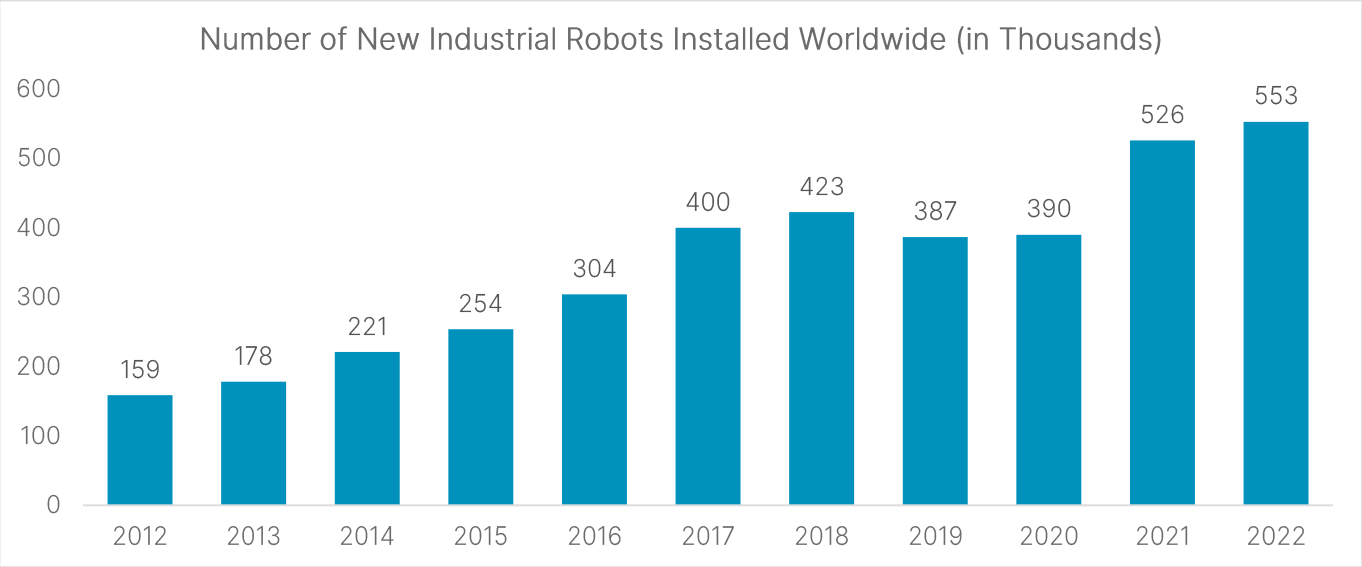
AI also contributes to solving environmental issues. Only 9% of the world's plastic waste is recycled, and nearly half ends up in landfills.[14] Waste ending up in landfills and incinerators releases greenhouse gases into the atmosphere. Better waste management is crucial to ending plastic pollution. With over 50% share in the global recycling plant market, Bollegraaf partners with AI start-up Greyparrot to retrofit thousands of recycling facilities globally with AI tools that increase recycling rates and provide detailed insights into waste streams.[15] Greyparrot's device monitors trash on conveyor belts and labels it under 70 categories, such as aluminum cans (recyclable), books (sometimes recyclable), and bottle caps (non-recyclable).[16] In addition, recent years have witnessed the advent of various AI-powered agricultural tools. Deere & Company's AI-driven "See & Spray" technology reduced herbicide use by an average of 59% on corn, soybean, and cotton fields across the US during the 2024 growing

[9] https://mitsloan.mit.edu/press/measuring-risks-and-rewards-drug-development-new-research-mit-shows-success-rates-clinical-trials-are-higher-previously-thought
[10] https://www.researchgate.net/publication/341097009_The_Stages_of_Drug_Discovery_and_Development_Process
[11] https://deepmind.google/discover/blog/alphafold-a-solution-to-a-50-year-old-grand-challenge-in-biology
[12] https://blog.google/technology/ai/google-deepmind-isomorphic-alphafold-3-ai-model/#life-molecules
[13] https://www.sciencemediacentre.org/expert-reaction-to-the-latest-version-of-deepminds-alphafold
[14] https://ourworldindata.org/plastic-pollution?insight=only-a-small-share-of-plastic-gets-recycled#key-insights
[15] https://www.bollegraaf.com/news/bollegraaf-and-greyparrot-forge-strategic-ai-partnership-to-transform-global-waste-management-industry
[16] https://www.washingtonpost.com/climate-solutions/2024/02/07/ai-recycling-sorting

season.[17] Besides saving farmers on herbicide costs, using less herbicide means reduced runoff and less collateral damage to plant and animal life outside farms.

AI is Enhancing the Capabilities of Robots

While robots have been around for decades, recent technological advancements in areas such as AI, 5G connectivity and cloud computing are accelerating their adoption and capabilities. 553,052 industrial robots were installed worldwide in 2022, more than tripling the number a decade ago. Asia led the way with 73% of newly deployed industrial robots, followed by Europe at 15%, and the Americas at 10%.[18]



Source: International Federation of Robotics. As of September 26, 2023.

A key step in integrating AI with robots is the development of multimodal models that can take multiple types of data as input. For instance, while language models learn from extensive text data, vision-language models are trained using combinations of images (static or moving) and their corresponding textual descriptions. Taking one step further, the new "vision-language-action models" (VLAMs) employed in robotics integrate text and images, along with data relating to the robot's physical presence, such as internal sensor readings and actuator positions. With a small amount of robot training data, the model can transfer concepts embedded in its language and vision training data to direct robot actions, even for tasks it has never been explicitly trained for. The multimodal nature of VLAMs enables robots to learn more like humans do – transferring learned concepts to novel situations.[19] The new models also allow robots to articulate the rationale behind their actions, which is particularly useful when their behavior is unexpected or undesirable. Another advantage is that a robot's behavior can be modified with text prompts instead of complex reprogramming.

With recent AI advancements and declining production costs, mass production and widespread adoption of humanoid robots could soon become a reality. Humanoid robots can potentially free up human workers from hazardous, dull and dirty tasks. A total of 5,486 fatal work injuries occurred across the US in 2022. With 23.5 fatalities per 100,000 full-time equivalent workers, farming, fishing and forestry occupations had the highest fatality rate among all occupational groups.[20] Other possible applications of humanoid robots include coal mining, chemicals manufacturing, disaster rescue, and nuclear reactor maintenance. Goldman Sachs projects the total addressable market for humanoid robots to reach US$38 billion by 2035. Figure, a company developing general-

[17] https://www.deere.com/en/news/all-news/see-spray-herbicide-savings
[18] https://ifr.org/ifr-press-releases/news/world-robotics-2023-report-asia-ahead-of-europe-and-the-americas
[19] https://blog.google/technology/ai/google-deepmind-rt2-robotics-vla-model/
[20] https://www.bls.gov/news.release/pdf/cfoi.pdf

purpose humanoid robots, has raised US$675 million in Series B funding from investors including Microsoft, NVIDIA, OpenAI, and Amazon's founder Jeff Bezos.[21] Its humanoid robot, Figure 01, learned to make coffee with a Keurig machine after only 10 hours of training footage.[22] The firm is partnering with BMW to deploy its humanoid robots in the automaker's manufacturing facility in the US.[23] In June 2024, Tesla claimed that it had deployed two Optimus humanoid robots working in a factory autonomously.[24] The company could start selling Optimus by the end of 2025.[25]

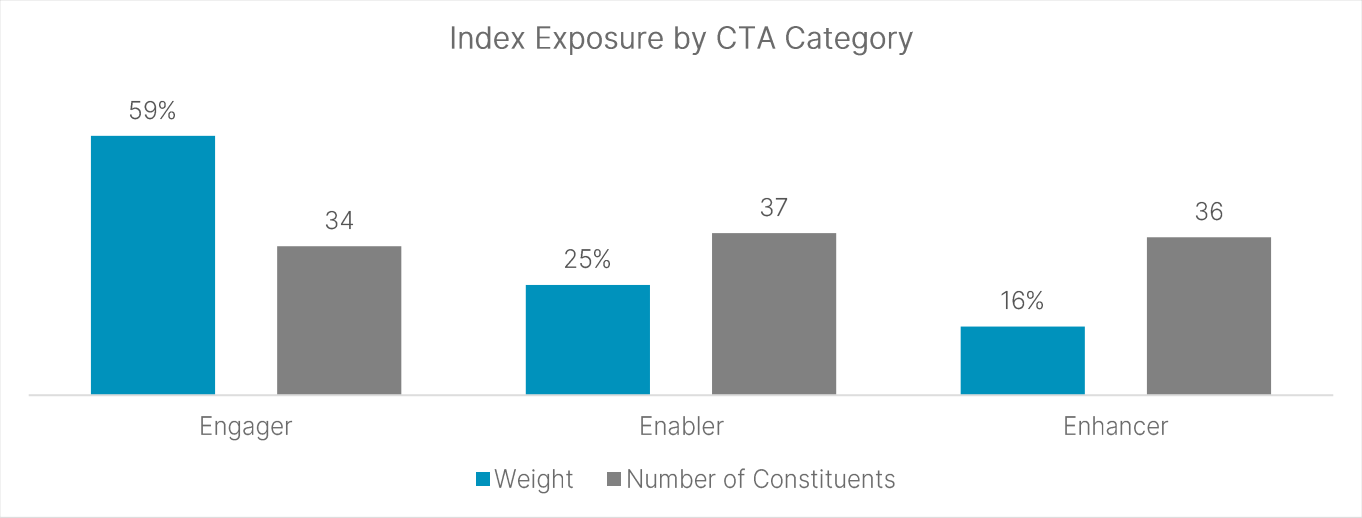
Nasdaq CTA Artificial Intelligence & Robotics™ Index (NQROBO™)

NQROBO tracks the performance of AI and robotics companies, as classified by the Consumer Technology Association (CTA), that are engaged in the technology, industrial, health care and other sectors. NQROBO is a modified equal-weighted index that rebalances quarterly and reconstitutes semi-annually in March and September. Each index constituent is assigned a CTA AI Intensity Rating, which captures the perceived degree of a company's AI and robotics involvement within one of the following three categories:

- Enablers (weight: 25%) are companies that develop the building block components for AI or robotics, such as advanced machinery, autonomous systems/self-driving vehicles, semiconductors, and databases used for machine learning.
- Engagers (weight: 60%) are companies that design, create, integrate, or deliver AI or robotics in the form of products, software, or systems.
- Enhancers (weight: 15%) are companies that provide their own value-added services within the AI and robotics ecosystem, which are not core to their product or service offering.

Eligible securities ranked in the top 30 by their CTA AI Intensity Ratings within each category, including ties, are selected for the index. Each constituent is assigned an equal weight within its category during quarterly rebalancing.

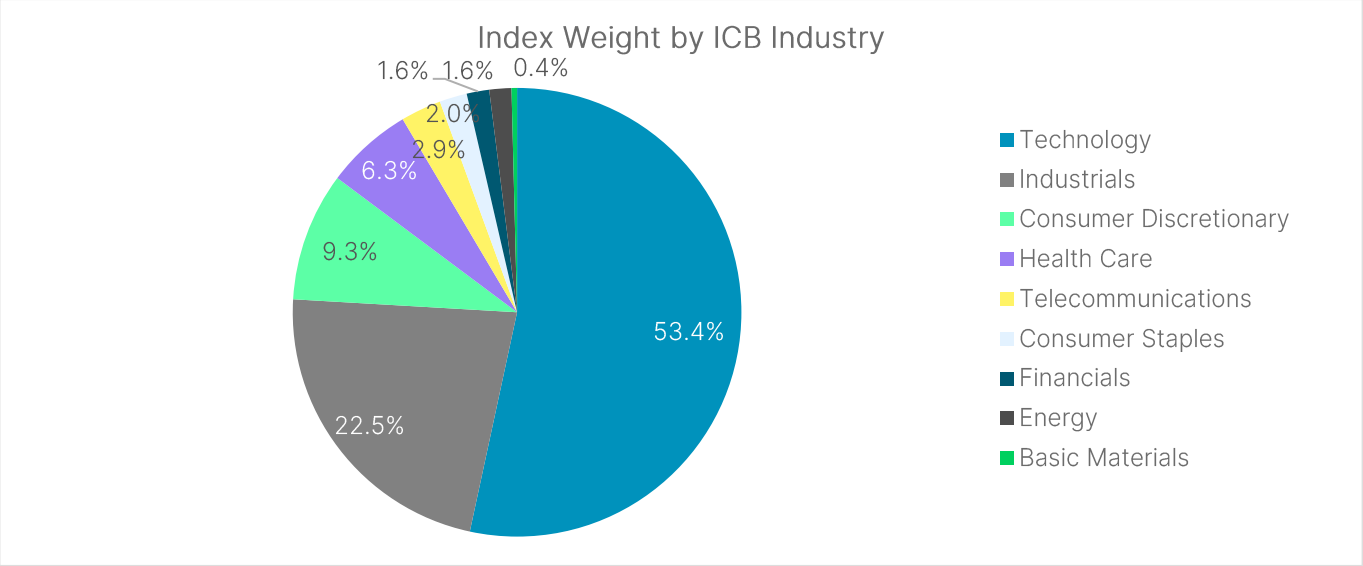
Composition of NQROBO



Source: Nasdaq Global Indexes, CTA. As of September 30, 2024.

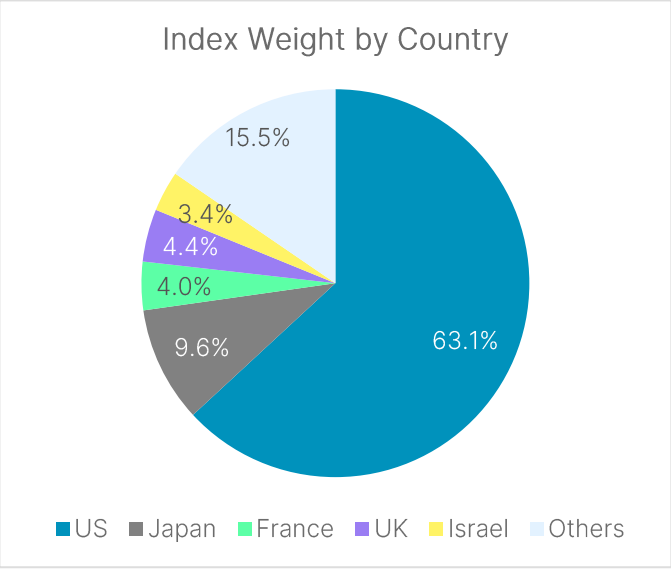
[21] https://www.prnewswire.com/news-releases/figure-raises-675m-at-2-6b-valuation-and-signs-collaboration-agreement-with-openai-302074897.html
[22] https://www.youtube.com/watch?v=Q5MKo7Idsok
[23] https://www.prnewswire.com/news-releases/figure-announces-commercial-agreement-with-bmw-manufacturing-to-bring-general-purpose-robots-into-automotive-production-302036263.html
[24] https://x.com/Tesla/status/1800612353932722458
[25] https://www.reuters.com/technology/tesla-could-start-selling-optimus-robots-by-end-next-year-musk-says-2024-04-24/

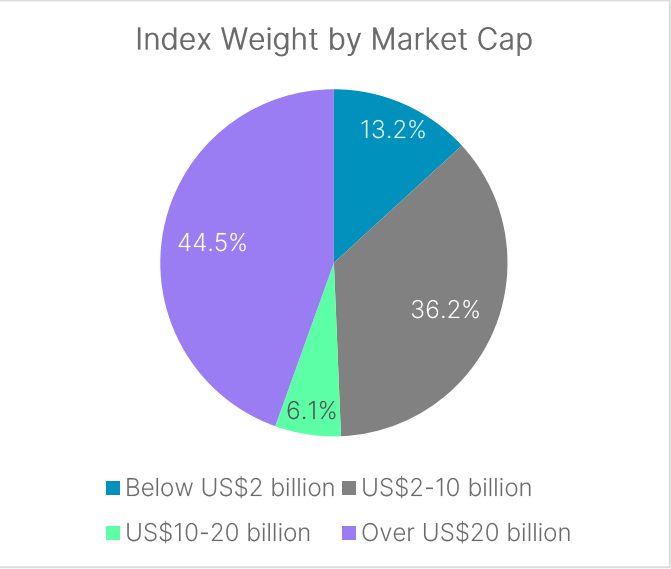
As of the end of September 2024, each company in the Engager category had a weight ranging from 1.4% to 2.2%. 56% of Engagers were software companies by weight, including ServiceNow, Palo Alto Networks, Synopsys, and Cadence Design Systems. Individual weights of Enablers fell between 0.6% and 0.9%. Examples of Enablers include semiconductor companies (e.g., NVIDIA, TSMC, AMD and Qualcomm), hyperscalers (e.g., Amazon, Microsoft and Alphabet), electrification and automation solution providers (e.g., Schneider Electric and ABB), and medical equipment firms (e.g., Intuitive Surgical and Tecan). With the smallest weight allocation in NQROBO, each security in the Enhancer category contributed between 0.3% and 0.7% to the index. Technology giants operating in multiple business areas, such as Apple, Tencent, and Samsung Electronics, are some of the Enhancers in the index, as is the previously mentioned industrial conglomerate Deere.



Source: Nasdaq Global Indexes, FactSet. As of September 30, 2024.

NQROBO provides diversification across industry, geography, and size exposures. As of the end of September 2024, the predominant industry within the index was Technology at 53.4%, followed by Industrials at 22.5%, Consumer Discretionary at 9.3%, and Health Care at 6.3%. Two-thirds of the Technology constituents were software companies (per ICB Subsector). Tech's relatively low weighting in the index, at least compared to several other leading AI thematic benchmarks, speaks to NQROBO's unique methodological approach that seeks to provide exposure across multiple stages of the AI value chain, beyond the initial infrastructure winners.

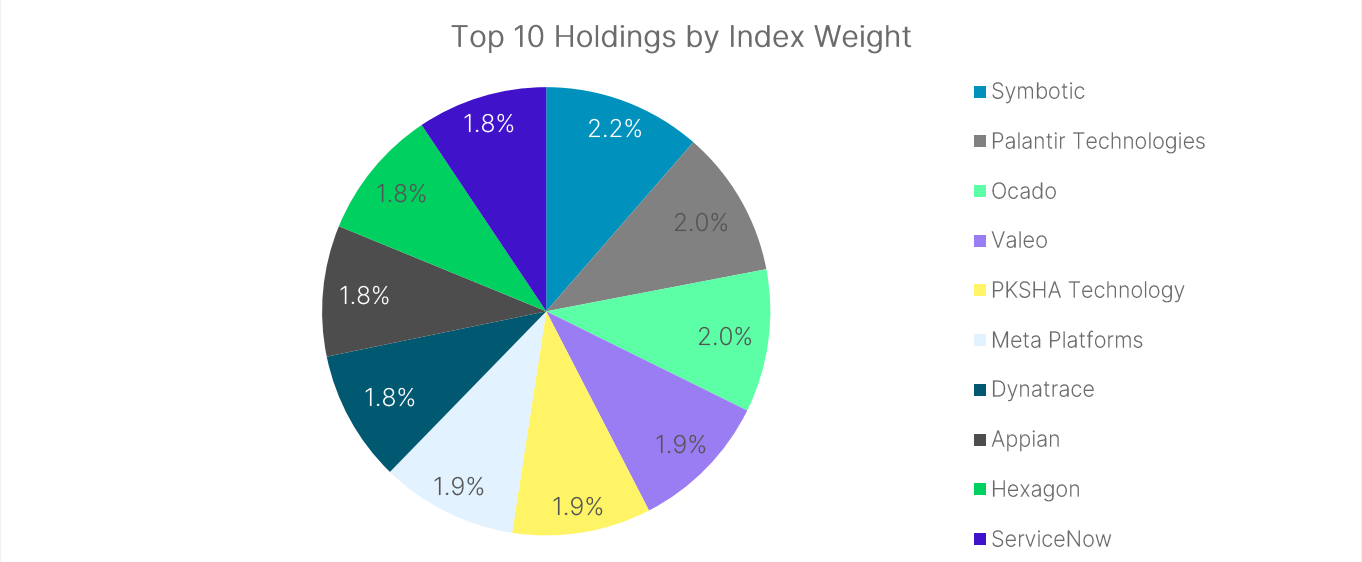




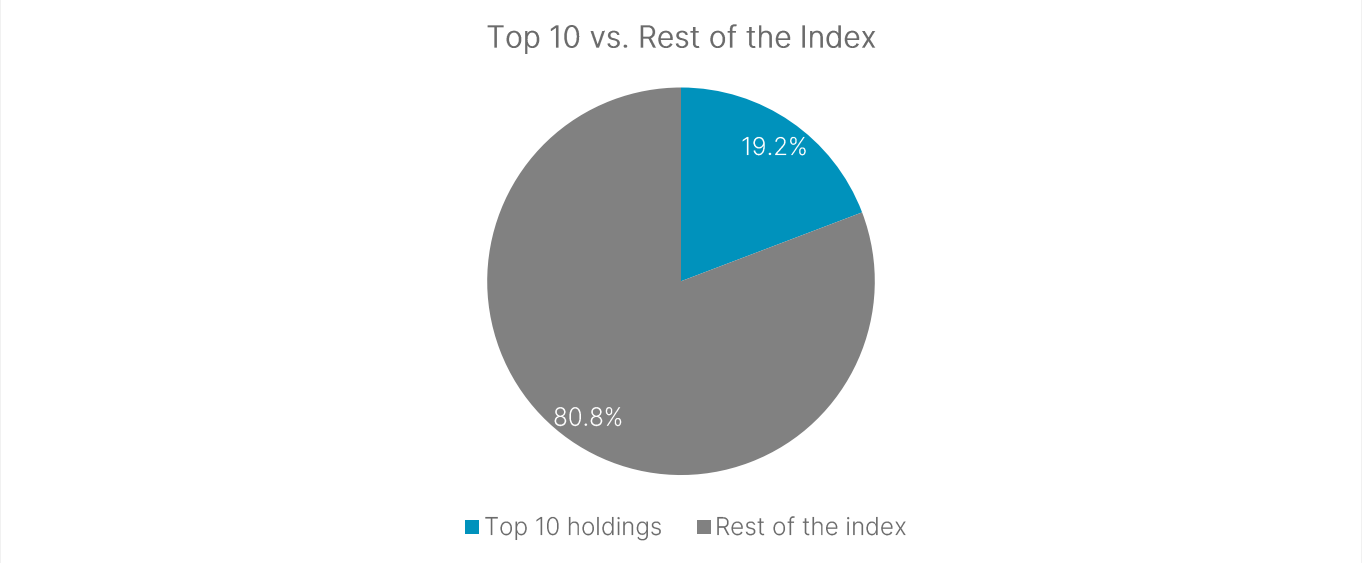
Source: Nasdaq Global Indexes, FactSet. As of September 30, 2024.

US-based firms constituted more than three-fifths of the index weight, with Japanese companies holding the second-largest share at 9.6%. The rest of the index was comprised of firms from 13 other countries with an aggregate weight of 27.2%. Half of the constituents were large-cap companies with a market cap exceeding US$10 billion. The weight of securities with a market cap over US$20 billion reached 44.5%, doubling the figure two years ago. Mid-cap firms with a market cap between US$2 billion and US$10 billion accounted for 36.2% of the index weight, more than doubling the proportion in June 2022. Small-cap companies under US$2 billion in valuation comprised nearly one-sixth of the index.

Top 10 Holdings and Recent Additions

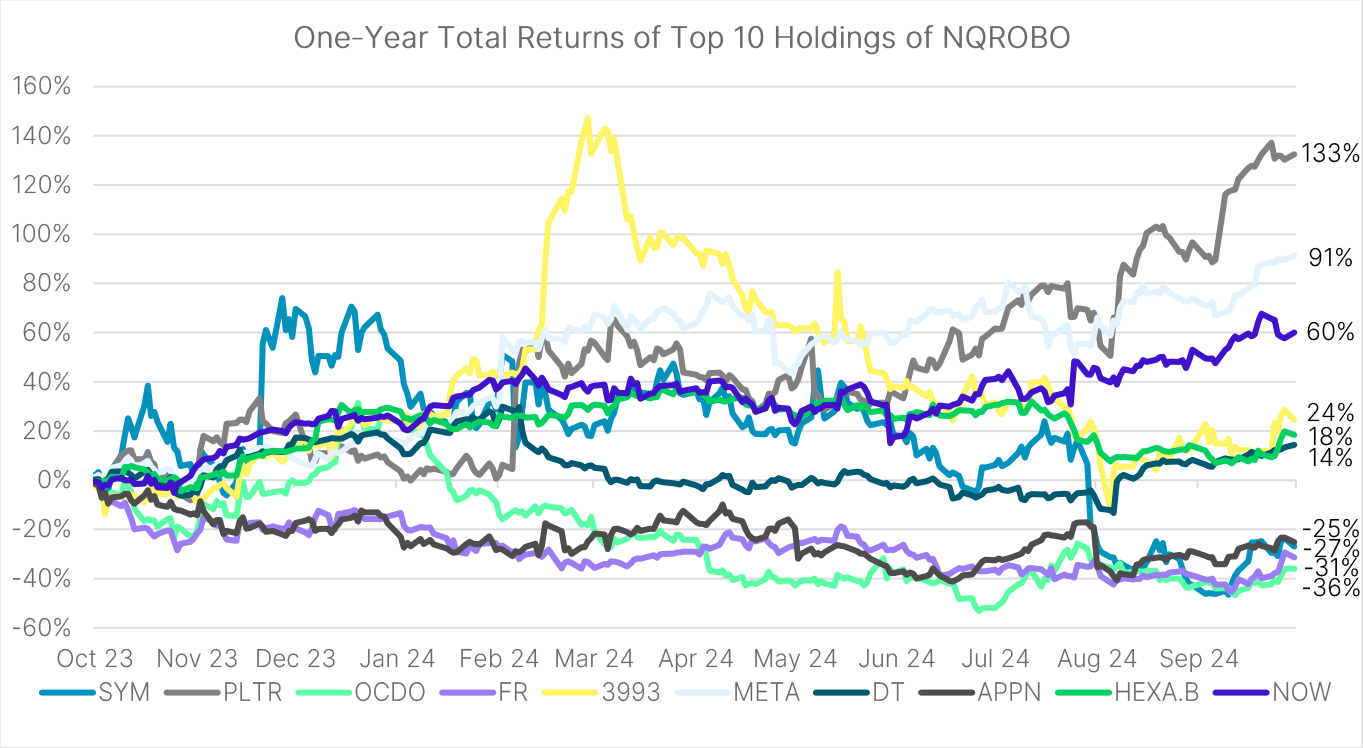


Source: Nasdaq Global Indexes. As of September 30, 2024.



Source: Nasdaq Global Indexes. As of September 30, 2024.

As of the end of September 2024, the largest 10 constituents accounted for nearly one-fifth of the index weight and were all classified as Engagers, making up almost one-third of their category's weight. The top 10 holdings delivered a 12-month total return of 22.1% on average. Palantir Technologies, Meta Platforms and ServiceNow each delivered a total return of at least 60%.



Source: Nasdaq Global Indexes, FactSet. As of September 30, 2024.

29 securities have been added to the index since September 2022. Seven of them have been removed as they either no longer fulfill the index eligibility requirements or were delisted after being acquired.

Palantir Technologies (PLTR)

As a new member of NQROBO since March 2024, Palantir Technologies was the third-largest constituent and delivered a total return of 132.5% in the last 12 months. The software firm unveiled its Artificial Intelligence Platform (AIP) last year, enabling large language models to function within enterprise boundaries and on privately held data. Palantir has evolved from serving the US intelligence community to collaborating with numerous government agencies in the US and allied nations. In May 2024, the AI platform leader secured a US$480 million contract from the US Department of Defense for a prototype known as the Maven Smart System[26], which integrates data from multiple sources to identify military points of interest and accelerate the work of intelligence analysts. In September 2024, Palantir won a US$100 million contract to extend Maven Smart System access across the US military services, including the Army, Air Force, Space Force, Navy, and Marine Corps.[27] As demand for AI tools has surged, Palantir has broadened its commercial business. Sales from the US commercial segment surged 55% year-over-year to US$159 million in Q2 2024 as the company boosted its US commercial customer base by 83% year-over-year to 295.[28] Over 18% of its net sales from the past year were reinvested back into research and development (R&D).[29]

Palo Alto Networks (PANW)

As a leader in various cybersecurity end markets, Palo Alto Networks has been included in NQROBO since September 2022 and its stock price has climbed 45.8% over the past 12 months.[30] The company supports its customers through a comprehensive platform that includes network security, endpoint security and cloud security. In recent years, enterprises have aimed to reduce the number of cybersecurity products and vendors they depend on to reduce costs. As a platform-based cybersecurity vendor, Palo Alto Networks is well-positioned to capitalize on this trend. In May 2024, the California-based firm unveiled three advanced copilots utilizing generative AI, fully integrated into its flagship security platforms. These tools will help

[26] https://www.defense.gov/News/Contracts/Contract/Article/3790490/
[27] https://www.defense.gov/News/Contracts/Contract/Article/3910169/
[28] https://investors.palantir.com/files/Palantir%20Q2%202024%20Business%20Update.pdf
[29] Source: Bloomberg. As of September 30, 2024.
[30] Source: Bloomberg. As of September 30, 2024.

security analysts identify, understand, and mitigate threats more efficiently.[31] The company spent more than 23% of its net sales on R&D in the last 12 months.[32]

Intuitive Surgical (ISRG)

Robotic surgery, an advanced field within medical technology, has revolutionized surgical procedures. Founded in 1995, Intuitive Surgical is the pioneer of robotic-assisted surgery and has continued to thrive from the growing global adoption of robotic surgery. Its da Vinci surgical systems performed over 2.2 million procedures in 2023, marking a 22% increase from the previous year.[33] The company introduced its fifth-generation multiport robotic system, the da Vinci 5, featuring improved precision, enhanced ergonomics and over 10,000 times the computing power of its predecessor.[34] The firm has also developed the Intuitive Hub, a visual media platform enabling surgeons to live stream surgeries and utilize telepresence for real-time case observation and mentoring. Intuitive Surgical achieved a total return of 68.0% and dedicated over 14% of its net sales to R&D over the past year.[35]

Schneider Electric (SU)

As the undisputed leader in the electrification market, Schneider Electric generated a 12-month total return of 52.7%.[36] The industrial company is well positioned to capitalize on the electrification, energy transition and digitization trends with its comprehensive portfolio of energy management, automation and software solutions. In September 2024, Schneider introduced its high-speed industrial robot, the ultra-compact Lexium Scara (Selective Compliance Assembly Robot Arm). With a 40% smaller size and a 40% longer z-arm stroke compared to other robots in its category, the Lexium Scara is a cost-effective solution for manufacturing and assembly processes.[37]

Apple (AAPL)

Apple was added to the index in September 2023 and delivered a total return of 36.8% in the last 12 months.[38] Although Apple's pace of hardware innovation has slowed in recent years, it has a growing opportunity to attract customers with software and AI. Introduced in June 2024, Apple Intelligence will be limited to devices using A17 Pro and M-series processors. ChatGPT will be integrated across Apple platforms, allowing users to access its functions without switching between tools.[39] The company is set to launch its comprehensive suite of Apple Intelligence features through a series of updates to iOS 18, spanning from late 2024 to mid-2025.[40]

Conclusion

AI adoption by enterprises across various sectors worldwide has surged significantly in the past year. Remarkable progress in AI tools is expected to expedite scientific breakthroughs and address pressing global issues like health care and environmental changes. The field of robotics has also advanced notably with researchers applying AI to machines. Robots are becoming more capable, easier to program, and able to explain their actions.

The Nasdaq CTA Artificial Intelligence & Robotics Index (NQROBO) tracks the performance of leading companies that play key roles within the AI or robotics space. ETFs tracking the index include the First Trust Nasdaq Artificial Intelligence and Robotics ETF (Nasdaq: ROBT) and the Cathay Nasdaq CTA Artificial Intelligence and Robotics ETF (TWSE: 00737).

[31] https://www.paloaltonetworks.com/company/press/2024/palo-alto-networks-delivers-more-autonomous-cybersecurity-through-copilots-for-strata--prisma-and-cortex-platforms
[32] Source: Bloomberg. As of September 30, 2024.
[33] https://www.sec.gov/Archives/edgar/data/1035267/000103526724000118/a2023formarsv3.pdf
[34] https://www.intuitive.com/en-us/products-and-services/da-vinci/5
[35] Source: Bloomberg. As of September 30, 2024.
[36] Source: Bloomberg. As of September 30, 2024.
[37] https://www.se.com/ww/en/about-us/newsroom/news/press-releases/schneider-electric-increases-productivity-of-manufacturing-processes-with-new-ultra-compact-lexium-scara-high-speed-robot-66e80d23871c20f77f08bba3
[38] Source: Bloomberg. As of September 30, 2024.
[39] https://www.apple.com/newsroom/2024/06/introducing-apple-intelligence-for-iphone-ipad-and-mac/
[40] https://www.bloomberg.com/news/articles/2024-07-28/apple-intelligence-to-miss-initial-release-of-upcoming-ios-18-ipados-overhauls

Disclaimer: