

Taking the Robot out of the Human, Putting the Robot into an Index

Nasdaq CTA Artificial Intelligence & Robotics Index™

Melissa Marks, Nasdaq Global Indexes

Mark Marex, Nasdaq Global Indexes

Introduction: The History of AI and Robotics

AI & Robotics have become contagious, spreading solutions across numerous industries beyond Technology. Artificial Intelligence (AI) is a branch of computer science where human intelligence is relayed into and demonstrated by a machine, while robotics is the intersection of computer science and engineering that creates physical bots to mimic human behavior. Though these two disciplines don't necessarily need one another to exist, their combination leads to limitless opportunities and advancements across the modern economy.

AI may seem like a newer field that only emerged as a result of a technological boom in the late 2000s, but it dates back almost 80 years to 1946 when the ENIAC (Electronic Numerical Integrator and Computer) was created. This computer did not resemble what we think of as a computer today, but instead took up an entire room filled with wires and machines. The ENIAC was designed during World War II to calculate artillery firing tables, performing calculations 2400x faster than humans and reaching an unprecedented level of efficiency. It was one of the first of its kind that led computer scientists to question how far this field could go. In 1950, Alan Turing – now recognized as the founding father of AI – posed the question, “Can machines think?” in his seminal paper, “Computing Machinery and Intelligence,” and AI, as we know it, was born.

For the next two decades, AI was in its golden years, surrounded by excitement, enthusiasm, promises of the future, and most importantly, funding. These promises were often slow to be realized, leading to AI's “winter” during which funding for AI-related research dried up and support for the field dwindled to an all-time low. Computer scientists stayed somewhat optimistic, and in the late 1980s – when AI emerged as a success once again – its adoption skyrocketed, expanding rapidly with no sign of slowing down.

Like AI, the field of robotics emerged decades ago, but it was ultimately the intersection of these two disciplines that drove a more widespread adoption of robotics by society, businesses, and governments alike. Though the components that define the industry continue to grow and push boundaries as discoveries and ideas emerge every day, the goals of AI and robotics have remained the same – improve efficiency, ensure quality, and provide innovative solutions.

Terms to know:

- **Structured Data** is a highly specific data type that can fit within fixed fields and columns in databases (i.e., names, addresses, dates, credit card numbers)

- **Machine Learning** is a discipline within AI that recognizes outcomes of software and computer processes to gain knowledge and become more accurate without the intervention of a human or explicit instruction after inception. This type of algorithmic learning is used on structured data.
- **Automation** refers to the capability of computerizing processes to reduce human intervention.
- **Robotic Process Automation (RPA)** is a software technology that makes it easy to build, deploy, and manage software robots that emulate human actions.
- **Business Process Management (BPM)** uses various methods to discover, model, analyze, measure, improve and optimize business processes.
- **Application Performance Management (APM)** is the monitoring and management of the performance and availability of software applications.
- **Digital Transformation (DX)** is a strategy for enabling the incorporation of digital technologies into operational processes, products, solutions, and customer interactions.

What is Robotic Process Automation?

With the knowledge of machine learning algorithms paired with robotics, a new form of automation has risen and rapidly expanded: Robotic Process Automation (RPA). RPA bots are software robots that can be imagined in one of three ways: attended, unattended, or a hybrid of the two. Attended RPA is triggered by a user and can be embedded on an employee's device or auto-run based on certain conditions. Unattended RPA is autonomous – self-controlling and not governed by outside forces – and can be set on specified intervals or bot-initiated. The hybrid RPA space lies somewhere between autonomy and user interaction, utilizing characteristics of both unattended and attended bots.

It is important to note that RPA bots are not humanoid robots and do not physically exist, cannot entirely replace humans, and do not possess logical thinking or decision-making skills. RPA bots are usually programmed to perform tedious and repetitive tasks like data entry and extraction, web scraping, employee and customer onboarding, and scheduling. According to Deloitte's Global RPA Survey, the benefits of RPA adoption are significant, leading companies to exceed expectations in quality, accuracy, productivity, and cost reduction.¹

During the Covid-19 pandemic, we saw the Healthcare industry take a hard hit with employee wellbeing and quality of care diminishing due to high patient volume and poor working conditions, creating an ideal use case for RPA technology. When implemented in the healthcare space, RPA has the ability to automate processes like document digitization, patient scheduling and management, infection control and triage, and billing services. By automating mundane and time-consuming processes, healthcare workers could gain more time to spend on their patients and themselves. In a hospital setting, the implementation of RPA can help to reduce healthcare administration costs, increase the speed of processes, and improve accuracy, productivity, and patient experience.²

Aside from efficiency and quality improvements, businesses that have embraced and adopted RPA have benefitted from the technology's high-level encryption capabilities and use of scriptless automation. Though robust encryption is a standard across most industries, scriptless automation is a unique factor that makes the software more accessible and user-friendly, especially for businesses employing workers with lower-level

¹ <https://www2.deloitte.com/ro/en/pages/technology-media-and-telecommunications/articles/deloitte-global-rpa-survey.html>

² <https://www.ibm.com/cloud/blog/amazing-ways-that-rpa-can-be-used-in-healthcare#:~:text=Benefits%20of%20RPA%20in%20healthcare&text=Healthcare%20leaders%20can%20implement%20RPA,the%20automation%20of%20mundane%20tasks.>

programming skills. According to McKinsey Tech Trends studies, up to “50% of today’s work activities could be automated by 2025”³

Primary Markets

Based on recent studies done by McKinsey Global Institute, by 2030 nearly “70 percent of companies may have adopted at least one type of AI technology.”⁴ A number of studies done on this topic show promising statistics, but one major challenge is combating the misconception that robots and machines will take over human jobs. As more knowledge about the inclusion of AI and Robotics technology is spread, companies have come to understand that robots and AI are incorporated into businesses to complement human work, not replace it. With this in mind, AI and Robotics technologies are becoming more widely adopted across the board, and the companies leading this innovation are finding more end markets to target, including:⁵

- Autonomous Systems
- Software
- Automotive
- Electronic Equipment
- Biotechnology
- Financial Services
- Healthcare
- Military & Defense
- Manufacturing
- Energy

Given the wide array of companies that are developing, commercializing, and utilizing AI & Robotics technologies, an index-based solution from Nasdaq and CTA may offer investors a compelling, differentiated approach to tracking the most important players in this theme.

Methodology Summary

The Nasdaq CTA Artificial Intelligence & Robotics Index (NQROBO™) is designed to measure the performance of Artificial Intelligence (AI) and Robotics companies – as classified by the Consumer Technology Association (CTA) – that are engaged in the technology, industrial, medical, and other economic sectors.

NQROBO utilizes modified equal weighting, rebalances quarterly, and reconstitutes semi-annually in March and September. Each index constituent is given a CTA AI Intensity Rating that captures the perceived degree of a company’s AI and Robotics sector involvement within one of three categories: Enabler, Engager, and Enhancer.

³ https://www.mckinsey.com/~/_/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/The%20top%20trends%20in%20tech%20final/Tech-Trends-Exec-Summary

⁴ <https://www.mckinsey.com/featured-insights/artificial-intelligence/notes-from-the-ai-frontier-modeling-the-impact-of-ai-on-the-world-economy>

⁵ <https://www.forbes.com/sites/forbestechcouncil/2022/05/31/why-robotics-and-artificial-intelligence-are-the-future-of-mankind/?sh=6aacabd01689>

- **Enablers** are companies that develop the building block components for robotics or artificial intelligence, such as advanced machinery, autonomous systems/self-driving vehicles, semiconductors, and databases used for machine learning.
- **Engagers** are companies that design, create, integrate, or deliver robotics and/or artificial intelligence in the form of products, software, or systems.
- **Enhancers** are companies that provide their own value-added services within the Artificial Intelligence and Robotics ecosystem, but which are not core to their product or service offering.

(For more information on the index methodology, [click here](#))

Eligibility criteria

- Minimum market cap of \$250M;
- Minimum three-month average daily dollar traded volume of \$3M;
- Minimum free float of 20%;
- CTA classified AI or Robotics company;
- Intensity Rating Category Weights:
 - Enabler 25%
 - Engager 60%
 - Enhancer 15%

Recent additions: Old and New

Since the last report on NQROBO was released in Spring 2020, we have seen the index change as holdings were deleted and added during its semi-annual reconstitutions. Of the 37 total securities added since April 30, 2020, seven have since been removed, while another three have been deleted and readded to the index. Among these are companies that very recently IPO'd, as well as some other companies that have been publicly traded for decades. What did it take for those more seasoned companies to qualify for inclusion in the index?

Two major players to point out are Deere & Co. (DE) and Advanced Micro Devices (AMD), which became publicly traded companies in the 1940s and 1970s, respectively. Deere, a long-time provider of agricultural machinery and lawn care equipment, recently announced at the 2022 CTA Consumer Electronics Show (CES) that a fully autonomous tractor is ready for large-scale production. This tractor was created for a specific purpose: to feed the world as the “global population is expected to grow by... [nearly 2 billion] ...by 2050.”⁶ DE’s application of AI and robotics in the agriculture industry is a crucial step forward as the UN predicts a 60% increase in food production is needed to support the growing global population.⁷ In addition to providing food for the expanding population, DE’s groundbreaking solution improves the quality of life and safety of the agriculture community as “farmers only need to transport the machine to a field and configure it for autonomous operation... [farmers] can leave the field to focus on other tasks while monitoring the machine’s status from their mobile device.”

In a similar fashion, AMD revealed at CES 2021 the release of the AMD Ryzen™ 5000 Series Mobile Processor. AMD provides FPGAs (field-programmable gate array), SoCs (system on chip), and various other types of semiconductor designs, and is widely known for its highly efficient and extremely powerful processors. With eight cores – the physical “brain” of the machine – and 16 threads – virtual components that divide each core into multiple cores – AMD claims that the Ryzen™ 5000 Series Mobile Processor is one of “the world’s most powerful processors ever.”⁸

While DE and AMD have been around for decades, the NQROBO Index also includes relatively newer companies, such as C3.ai (AI), UiPath (PATH), TuSimple (TSP), and AutoStore (AUTO). C3.ai and UiPath are software providers that support sectors such as Finance, Customer Services, Telecommunications, Healthcare, and Government, among others. Both quickly made it into the top 10 holdings in the index by weight year-to-date, contributing 2.10% and 2.44%, respectively. C3.ai is a leading enterprise AI application platform provider and UiPath provides RPA for large-scale end-to-end automation. TuSimple and AutoStore are equipment providers

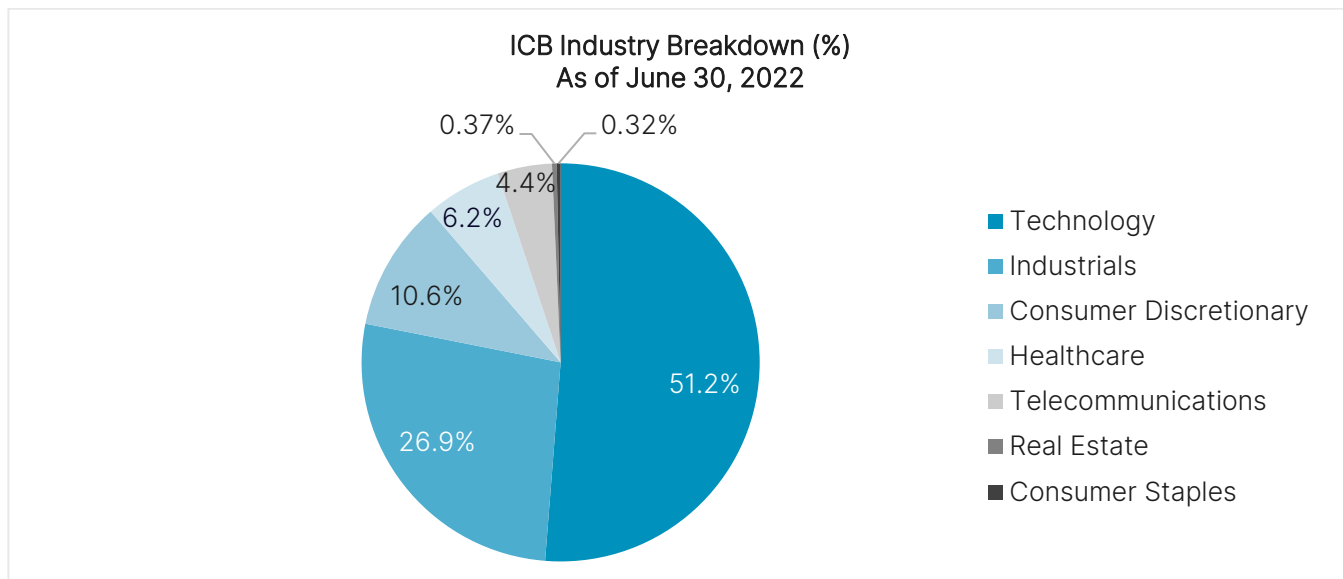
⁶ <https://www.deere.com/en/news/all-news/autonomous-tractor-reveal/>

⁷ <https://www.un.org/en/chronicle/article/feeding-world-sustainably#:~:text=According%20to%20estimates%20compiled%20by,toll%20on%20our%20natural%20resources.>

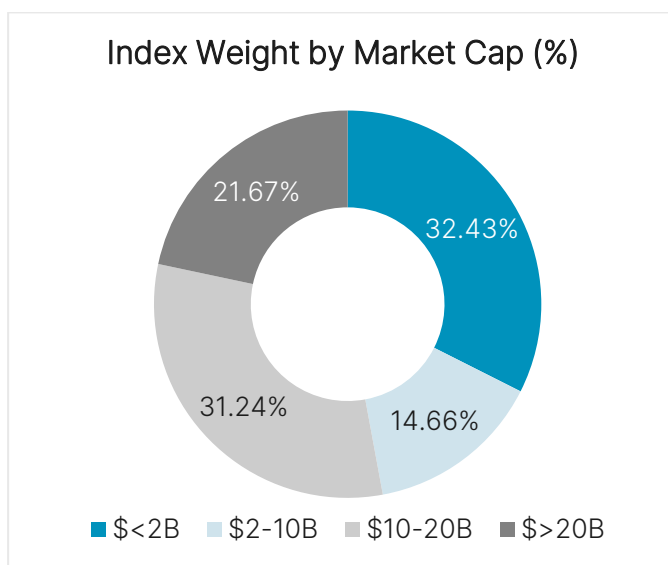
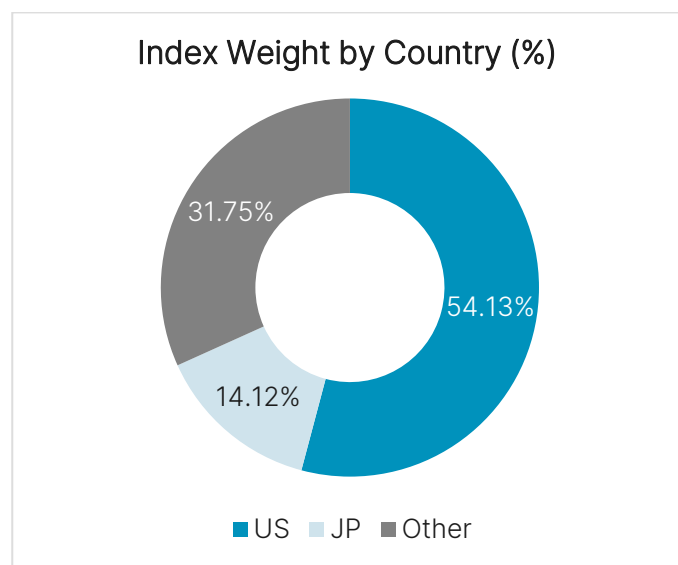
⁸ <https://www.amd.com/en/partner/amd-powers-the-future-ces-2021>

that primarily serve the Industrial, Retail, and Healthcare industries. TuSimple is introducing the first Autonomous Freight Network (AFN) through the use of autonomous trucks, and AutoStore is most well known for their Grid™ system, “a railway for robots,” primarily used in factory settings. Though these four companies serve different purposes within the technology space, one common thread is that they offer high efficiency, increased productivity, and cost-reductive benefits to companies using their solutions.

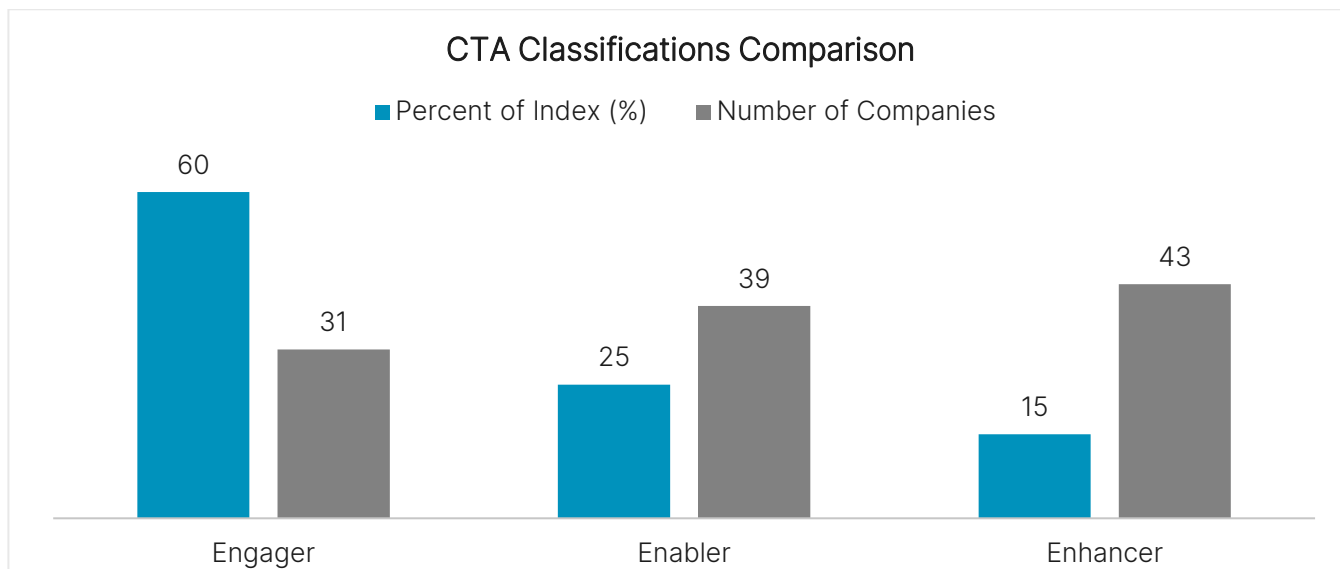
Index Composition



From an index composition standpoint, NQROBO provides reasonable levels of diversification across sector, geography, and size exposures. The Industry Classification Benchmark (ICB) systematically classifies companies into 11 Industries, 20 Supersectors, 25 Sectors, and 173 Subsectors. The largest portion, 51.2% of the index, is made up of companies within the Technology industry as of June 30, 2022. Following Technology, Industrials make up 26.9%, Consumer Discretionary accounts for 10.6%, Healthcare comprises 6.2%, and Telecommunications accounts for 4.4%. Smaller sector allocations are seen in Real Estate and Consumer Staples.



US-based companies make up the majority of the index at just above 54%, followed by Japan, the largest international allocation, with 14%. The rest of the index, just under 32%, is comprised of 16 other countries. Nearly 53% of the index is populated by large-cap companies with market caps in excess of \$10 billion, and of those, 41% exceeded \$20 billion. Mid-cap companies with market caps between \$2-10 billion make up 14.7% of the index weight, while small-cap companies under \$2 billion comprise 32.4%.

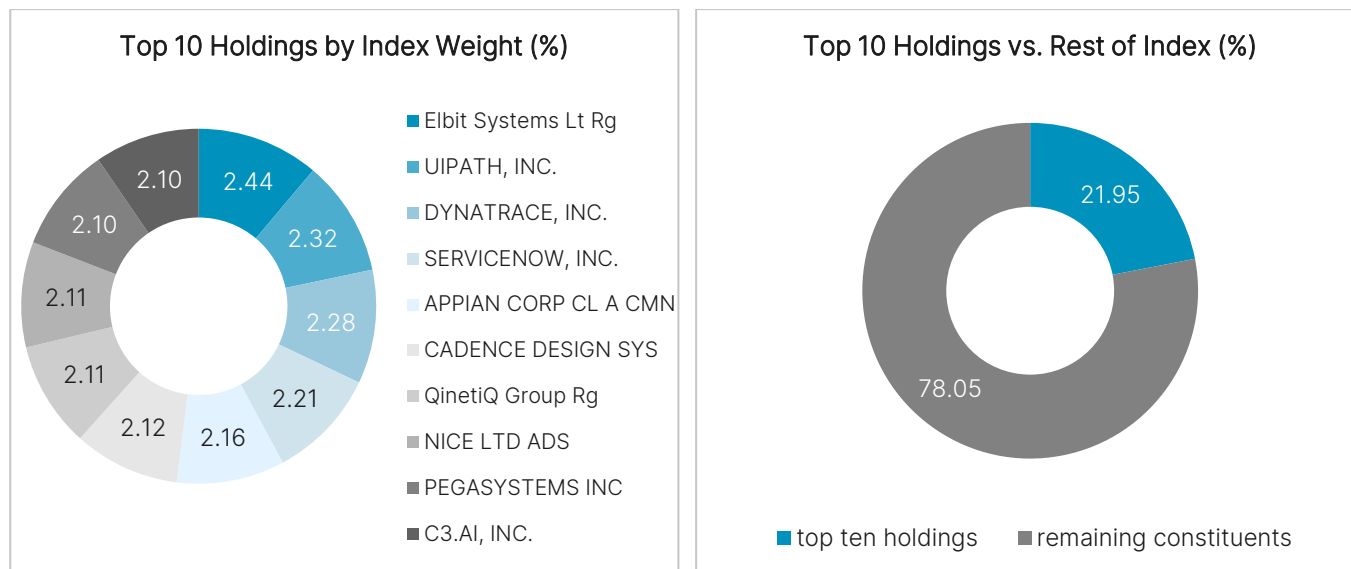


The other major way of breaking down the composition of the index weight is by the previously described categorization into engagers, enablers, and enhancers.

Examples of engagers include UiPath, Dynatrace, NICE Ltd., Pegasystems, and Appian. Though these may not be household names, engagers in this index primarily provide software services at a large scale. Some of the better-known enablers listed in the index include NVIDIA, Micron Technology, and Taiwan Semiconductor Manufacturing, all of which are major semiconductor companies. Among the enhancers, some of the most familiar names are Amazon, Tesla, Alphabet (Google), Johnson & Johnson, and Microsoft Corp. These companies provide their own value-added services within the AI and robotics ecosystem.

As per the methodology, when looking at the classification composition by index weight, the majority is held by the engagers, followed by enablers, then enhancers, but we observe the opposite trend when looking at the number of companies in each category. With allocations between 0.26-0.49% per company, a large number of enhancers is needed to maintain 15% of the index. Though engagers make up the smallest portion of the index by number of companies, they hold the largest individual weights falling between 1.11-2.44% each. Enablers lie in the middle range both in the number of companies and required index weight, with each security in this category contributing between 0.49-0.72% to the index (as of June 30, 2022).

Top Ten Holdings: Impact and Performance



The top 10 holdings account for nearly 22% of the index weight and are all classified as engagers, making up over one-third of their category's weight. Of these 10 securities, four are major providers of RPA software, namely UiPath, NICE Ltd., Appian, and Pegasystems.

As noted above, the newest addition of the four is UiPath, starting its run in the public market at the end of April 2021 and joining NQROBO only five months later in September 2021. After its swift rise to the top of the RPA industry, UiPath announced new research that showed "the economic benefit expected by the use of RPA software by UiPath customers will grow... to \$55 Billion in 2025... cumulatively, the economic impact will reach \$129 billion."⁹ In addition to providing RPA software that automates common business processes, UiPath's unique platform of upskilling services, where RPA improves skill level and overall job satisfaction of employees, sets them apart from industry competitors.

After its addition in March 2019, NICE Ltd. quickly made its way into the top 10 holdings by index weight and has remained within the top 30 ever since. Their most notable RPA product is NEVA, standing for (NICE) Employee Virtual Attendant, that when paired with human service agents helps to "deliver hyper-personalized and meaningful service to every customer."¹⁰ This is a perfect example of how AI & Robotics can work in tandem with human employees to improve quality of service.

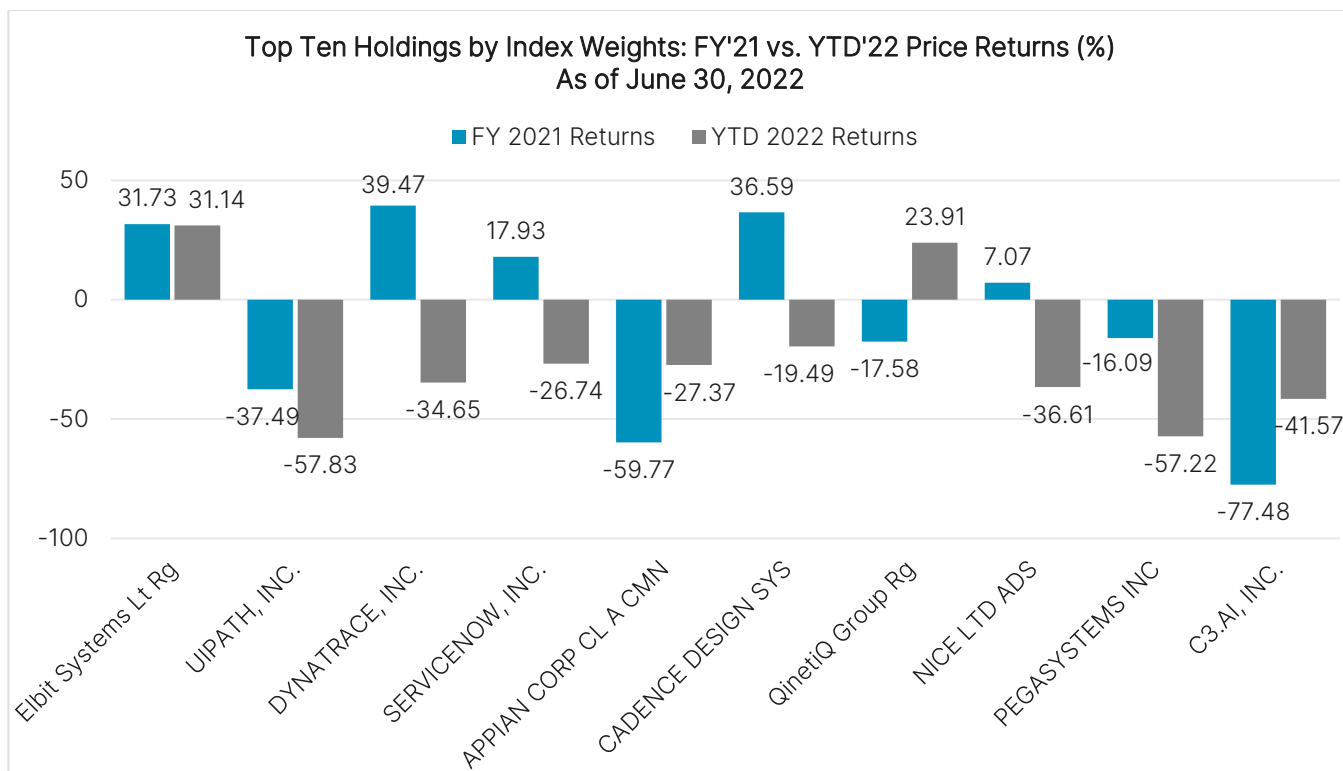
Appian, which has held a spot on NQROBO since the index launch in December 2017, has been a key player in the software space since its founding in 1999, all the way through its initial public offering in May 2017. It provides software to companies like Bayer, Deloitte, Enterprise, and KPMG, among other big names across multiple industries. Appian's RPA software is unique in that it automates end-to-end processes without the user having to write any code.¹¹ Pegasystems, added to the index in March 2019, has been publicly traded since 1996 and has evolved into a top provider of BPM and RPA software. As a result of interviewing five customers with several years of experience using its hybrid RPA approach that delivers AI-powered decision making and workflow automation,

⁹ <https://www.uipath.com/hubfs/idceconomicimpact.pdf>

¹⁰ https://www.nice.com/websites/rpa/ultimate-cx-team/?sitelink=3&utm_source=google_search&utm_medium=cpc&utm_campaign=neva_automation_leader&utm_content=587961429065&utm_term=nice%20systems%20rpa&gclid=EAlaIqobChMI19zp39-C-QIYIbCh19XgbFEAAYASACEgIIPD_BwE

¹¹ <https://appian.com/platform/complete-automation/robotic-process-automation-rpa.html>

Forrester reported that Pegasystems' clients have gained \$34.9M in business value.¹² Low code platforms such as Appian and Pega are accessible beyond computer scientists and programmers, allowing users across disciplines to utilize the software.



As of the end of 2021, Dynatrace, Cadence Design System, and Elbit Systems outperformed the other top holdings in the index with full-year price returns of 39.47%, 36.59%, and 31.73%, respectively. ServiceNow and NICE Ltd also finished out the year with positive returns. On the other hand, C3.ai, Appian, and UiPath did not show the same luck finishing 2021 deep in the red.

After the worst first half the global markets have seen in over 50 years, the majority of these constituents experienced negative returns YTD as of June 30, 2022, with the exceptions of Elbit Systems and QinetiQ. Both of these companies are major providers of multinational defense software and electronics, with heightened demand since the Russian invasion of Ukraine in February 2022. Elbit Systems' CEO, Bezhael Machlis, told Reuters that the current conflict in Ukraine is causing growing demands in several domains as well as growing budgets all over the world in defense spending.¹³ Similarly, QinetiQ's CEO, Steve Wadey, stated in their most recent quarterly earnings call that the events in Ukraine have "reinforced the vital importance of a technologically advanced defense industry to society." The company has seen a modest increase in demand for its capabilities and a fundamental reinforcement of the strategic long-term needs of its customers.¹⁴

Dynatrace and Cadence Design Systems, both top performers in 2021, suffered massive drops YTD as of June 30, 2022, of over 74% and 55%, respectively. Dynatrace provides Application Performance Management (APM) platforms that monitor RPA bots and cloud software services. Cadence Design Systems offers AI-driven

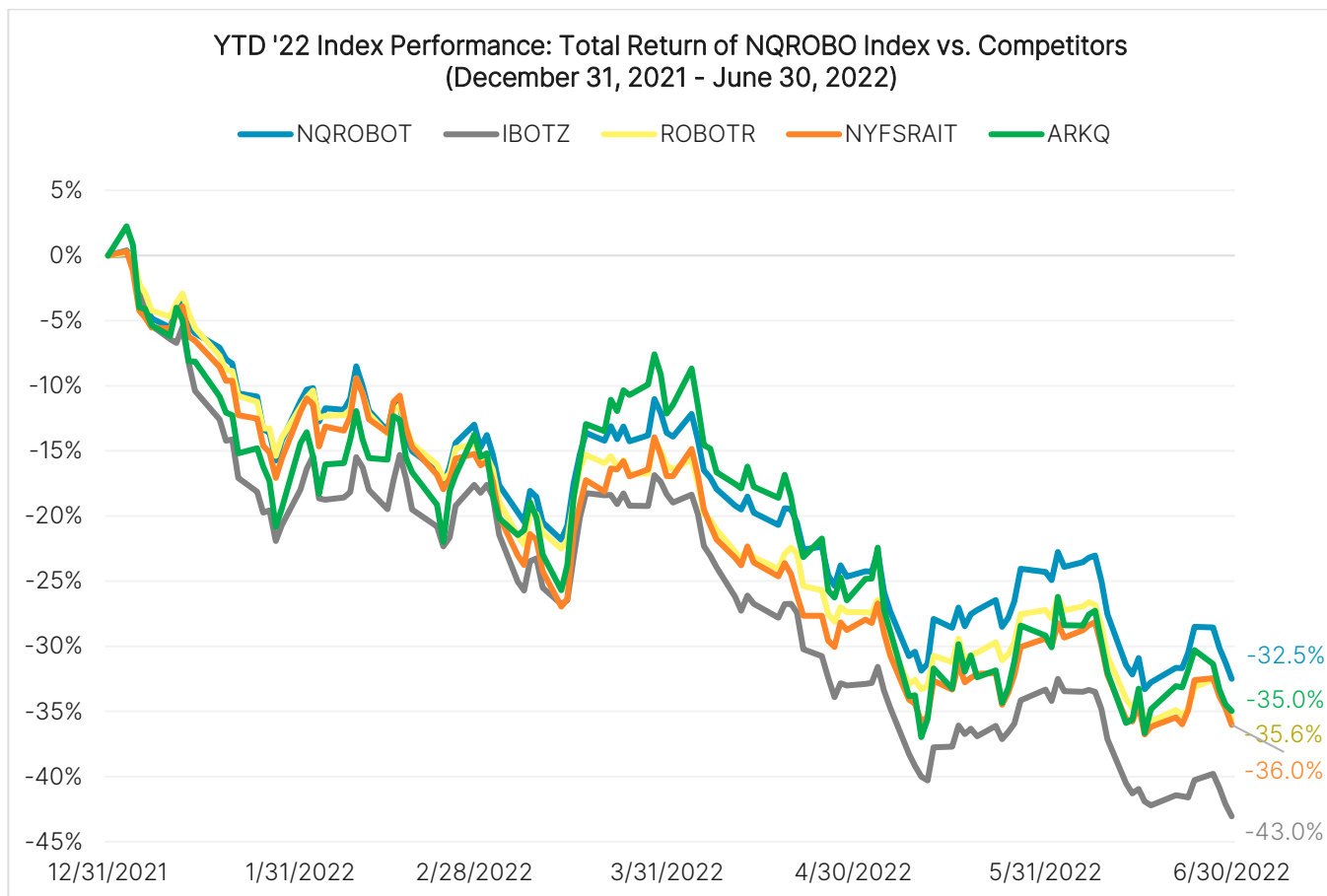
¹² <https://www.pega.com/products/platform/robotic-process-automation>

¹³ <https://www.reuters.com/business/israels-elbit-systems-q4-profit-dips-revenue-up-2022-03-29/>

¹⁴ <https://seekingalpha.com/article/4513289-qinetiq-group-plc-qntqf-ceo-steve-wadey-on-q4-2022-results-earnings-call-transcript>

optimization software that accelerates time to market and lowers design risk. These companies saw significant pullbacks in price along with the broader US equity market, particularly within the growth-heavy tech sector.

Recent Performance Against Competitors

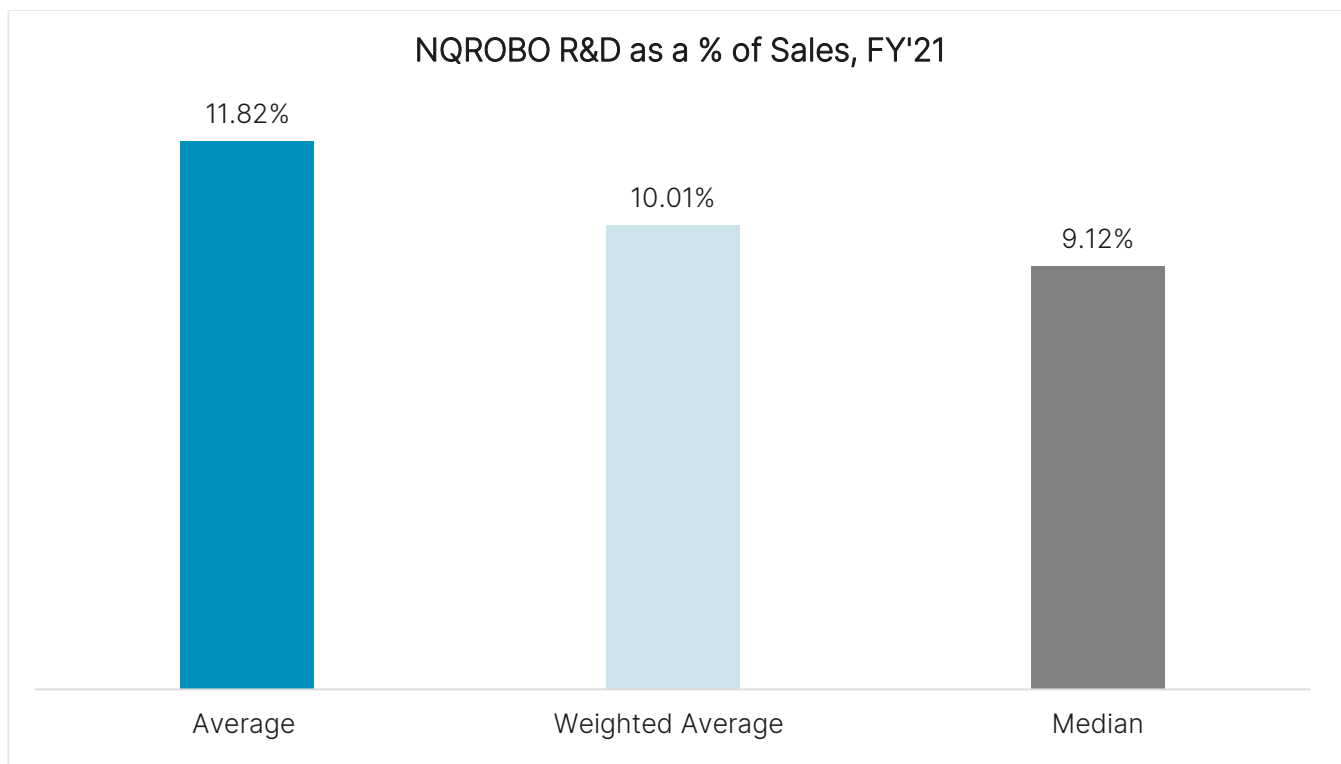


With global markets tumbling in and out of bear market territory over the past few months, it is no surprise that NQROBO and its competitors have also generated negative returns year-to-date. NQROBO was down 32.5% YTD as of June 30, 2022 (total return basis), vs. a decline of 20% for the S&P 500 Total Return Index (SPXT). Yet when measured against competitor products, NQROBO outperformed the ARK Autonomous Technology & Robotics ETF (ARKQ) by 2.5%, the ROBO Global Robotics & Automation Total Return Index (ROBOTR) by 3.1%, the NYSE FactSet Global Robotics & AI Total Return Index (NYFSRAIT) by 3.5%, and the Indxx Global Robotics & AI Thematic Index (IBOTZ) by 10.6%. Since its launch on December 18, 2017, NQROBO has produced a cumulative total return of 32.5% (as of June 30, 2022).

An Objective Champion in R&D

In terms of quantifying the intensity of technological innovation taking place across the index's constituent base, reported expenditures on R&D provide a useful barometer. In 2021, NQROBO recorded an aggregate R&D expense of \$273 Bn, vs. total revenues of nearly \$2.9 trillion. The aggregate ratio of R&D as a percentage of sales was thus 10.5%, in-line with the Nasdaq-100 Index® (NDX®), a perennial leader in R&D that consistently outperforms broader market benchmarks like the S&P 500 Index (SPX). In terms of the average ratio per company, the weighted average, or the median, NQROBO scored anywhere from just over 9% to slightly below 12% - a

substantial rate of R&D investment that suggests continued innovation.¹⁵ With annual revenues growing by 17.5% YoY in 2021, the index may exceed \$3 trillion in revenue in 2022 and \$300 Bn in R&D even with a modest slowdown in growth.



Conclusion

AI & Robotics have evolved over the course of many decades, from the obscure pursuits of academic and government researchers to increasingly indispensable roles within the modern economy. Providing high quality of service, achieving unmatched efficiency, and offering innovative solutions are universal objectives that companies are constantly looking to improve upon. As customers adopt new technology into everyday life, there is a fast-growing demand for companies to do the same. Without the adoption of AI & Robotics, companies may not be able to keep up with the technology-led and consumer-driven market we're experiencing today.

The Nasdaq CTA Artificial Intelligence & Robotics Index (NQROBO) delivers insight into the rapidly changing AI & Robotics market by tracking leading companies that play key roles within the space. ETFs that track this index are: the First Trust Nasdaq Artificial Intelligence and Robotics ETF in the U.S. (XNAS: ROBT), the Cathay Nasdaq CTA Artificial Intelligence and Robotics ETF in Taiwan (TWSE: 00737) and the Ping An Nasdaq AI & Robotics ETF in Hong Kong (HKEX: 3023).

Sources: Nasdaq Global Indexes, Bloomberg, FactSet

¹⁵ The chart excludes the impact of TuSimple Holdings, BrainChip Holdings, and Luminar Technologies which had R&D expense ratios of 4587%, 522%, and 311%, respectively. These outliers would have skewed the average R&D/Sales ratio to a whopping 59.5%.

Disclaimer:

Nasdaq® is a registered trademark of Nasdaq, Inc. The information contained above is provided for informational and educational purposes only, and nothing contained herein should be construed as investment advice, either on behalf of a particular security or an overall investment strategy. Neither Nasdaq, Inc. nor any of its affiliates makes any recommendation to buy or sell any security or any representation about the financial condition of any company. Statements regarding Nasdaq-listed companies or Nasdaq proprietary indexes are not guarantees of future performance. Actual results may differ materially from those expressed or implied. Past performance is not indicative of future results. Investors should undertake their own due diligence and carefully evaluate companies before investing. **ADVICE FROM A SECURITIES PROFESSIONAL IS STRONGLY ADVISED.**

© 2022. Nasdaq, Inc. All Rights Reserved.