# Tracking AI Innovation with an AI-Driven Indexing Approach

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## Introduction

In recent years, the world has recognized the immense potential of artificial intelligence (AI), given the compelling and revolutionary advancements made in the field over the past decade. AI is moving from being able to only perform programmed tasks to being able to produce previously increasingly creative content, including text, images and videos. The global AI industry, along with its impact is growing. According to Fortune Business Insights, the global AI market value is expected to expand from USD 515.31 billion in 2023 to USD 2,740.46 billion by 2032, demonstrating a compound annual growth rate (CAGR) of 20.4% during the forecast period.[1] Moving forward, AI's rapid pace of development and potential impact appear to be significant. In 2023, S&P Dow Jones Indices (S&P DJI) launched the S&P Kensho Artificial Intelligence Enablers Index, which seeks to measure the performance of companies that develop and enable AI technology, infrastructure and services. In this paper, we will introduce the AI technology and value chain, and we will elaborate on how we use an indexing approach designed to measure the opportunity they provide.

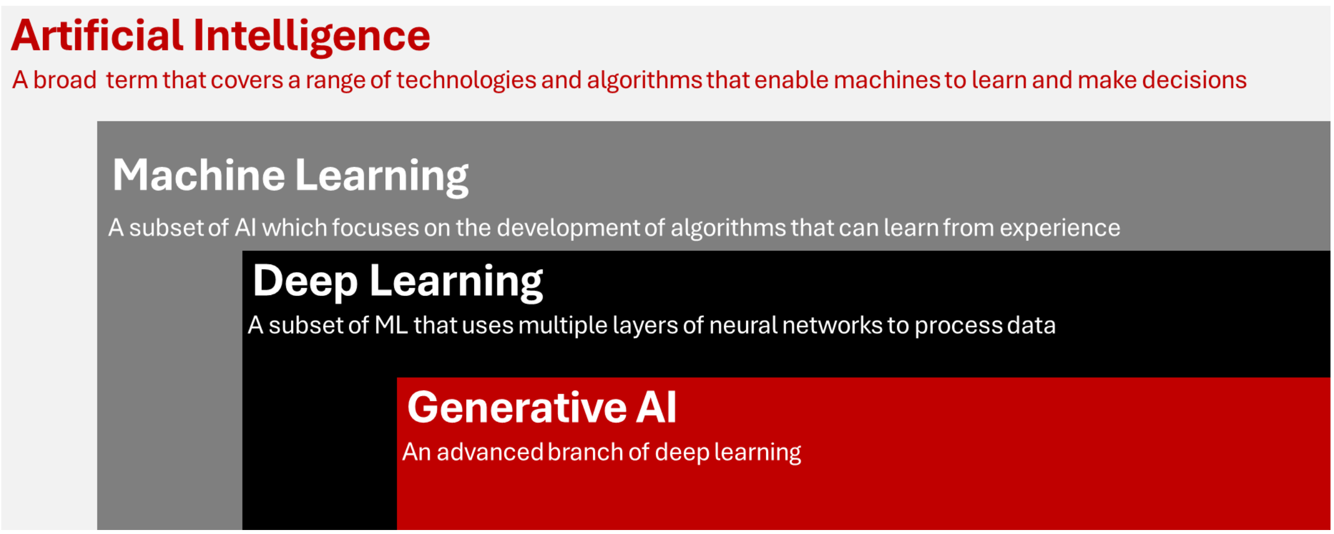
[1] Fortune Business Insights. "Artificial Intelligence Market Size, Share, Growth Report 2032 (fortunebusinessinsights.com)." July 8, 2024.

# What Is Artificial Intelligence?

AI has seamlessly woven itself into our daily lives, from the technology in our smartphones to chatbots powered by generative AI. The first AI system, a robotic mouse that could find its way out of a labyrinth and remember its course, was built by Claude Shannon in 1950.[2] Today, AI systems can perform tasks that closely mimic certain human abilities. So, what exactly is AI, and what technology is behind it?

While definitions may vary, AI generally refers to the ability of machines to exhibit human-like intelligence and a degree of autonomous learning. It is an umbrella term that encompasses a wide variety of technologies, including machine learning, deep learning and generative AI.

**Exhibit 1: Artificial Intelligence**




Source: S&P Dow Jones Indices LLC. Chart is provided for illustrative purposes.

## Machine Learning

Machine learning, a subfield of AI, employs algorithms trained on diverse inputs such as historical data, synthesized data or human input. These algorithms identify patterns and learn to make predictions and recommendations by processing data rather than relying on explicit programming instructions.

[2] Max Roser. "The history of AI systems and how they might look in the future | World Economic Forum (weforum.org)." World Economic Forum. Dec. 12, 2022.

Machine learning can be found in various domains. Common examples of machine learning include personalized product recommendations based on past purchases, voice memo translation to text and fraud detection in banking systems.

## Deep Learning

Deep learning is a type of machine learning that uses neural networks to ingest and process data through multiple layers. These networks recognize progressively intricate features, simulating the complex decision-making power of the human brain. Deep learning drives many AI applications that improve the way systems and tools deliver services, such as self-driving cars and facial recognition.

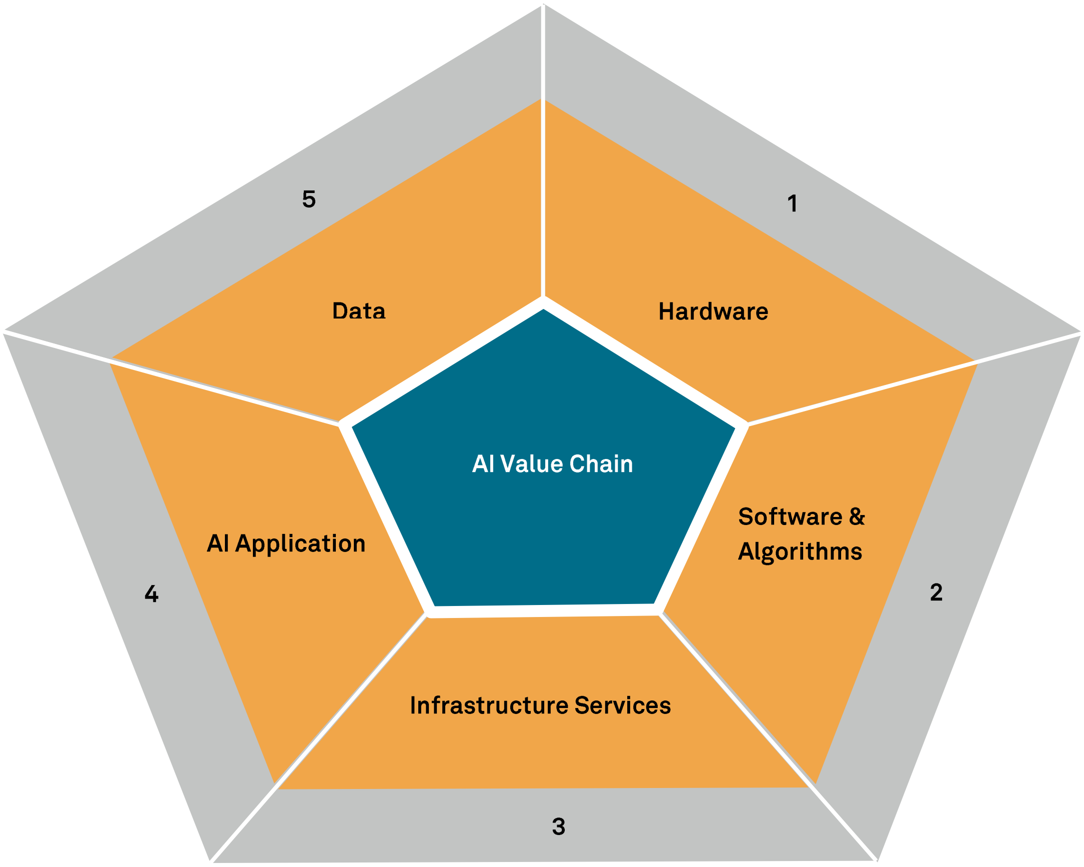
## Generative AI

Generative AI refers to AI systems that can create original content, such as text, images, videos or other data, in response to a user's prompt or request. These systems often utilize large neural networks, such as large language models (LLMs), to learn patterns and generate content that closely aligns with the data they were trained on. Generative AI tools like ChatGPT and DALL-E3 are gaining global popularity, and their impact extends to potentially reshaping how various tasks are performed.

# AI Value Chain

Rapid advancements in AI algorithms, hardware improvements and infrastructure cost have made AI strategy a priority for investors and organizations. Despite discussions of AI often centering around generative AI tools like ChatGPT, AI includes much more than just these applications. The AI value chain encompasses the entire process of developing and deploying AI technologies, including hardware, software & algorithms, infrastructure service, AI application and big data providers (see Exhibit 2).

**Exhibit 2: AI Value Chain**




Source: S&P Dow Jones Indices LLC. Chart is provided for illustrative purposes.

# Hardware

Hardware provides a foundation for the development of AI. Specialized hardware accelerators, such as graphics processing units (GPUs), tensor processing units (TPUs) and field-programmable gate arrays (FPGAs), are designed to deliver high performance and efficiency while supporting machine learning workloads. By enabling faster training times, improved inference speeds and enhanced scalability, these hardware accelerators contribute significantly to AI applications.

Creating an AI model through training is computationally intensive, involving substantial data movement and communication. For instance, OpenAI's GPT-3, a generative AI model with approximately 175 billion parameters, has been trained on about 45 terabytes of text data.[3] To handle such workloads effectively, large clusters of GPUs or TPUs equipped with specialized accelerator chips are necessary for parallel processing across billions of parameters.

[3] Kindra Cooper. "OpenAI GPT-3: Everything You Need to Know [Updated] (springboard.com)." Springboard. Sept. 27, 2023.

Recent years have witnessed rapid advancements in AI hardware, ushering in an era of enhanced efficiency and performance. These developments empower businesses to harness AI technologies for innovation and efficiency. Nvidia, a prominent chip manufacturer, has launched numerous GPUs in the past decade.[4] Nvidia's CEO, Jensen Huang, recently unveiled a new AI chip architecture called "Rubin," accelerating the company's already rapid pace of AI chip development.[5] Intel and AMD, two other major manufacturers, are also actively involved in ongoing developments. Intel has announced the launch of its next-generation CPU, Lunar Lake, while AMD's Ryzen AI 300 processors are expected to arrive in the near term.[6]

## Software and Algorithms Solution

AI software and algorithms, which serve as the driving force behind AI, enable data and information to be processed in ways that aim to align with human intuition. An AI algorithm processes training data to learn and improve, and then it performs its tasks based on the knowledge gained from the training data. Some AI algorithms can autonomously learn and adapt to new data, refining their processes. Others may require programmer intervention to optimize their performance.

There are four types of machine learning algorithms: supervised, unsupervised, semi-supervised and reinforcement learning.[7]

- **Supervised** learning algorithms need human intervention to train them with clearly labeled and categorized data. Once sufficiently trained, these algorithms can autonomously label similar images.
- **Unsupervised** learning algorithms are trained with uncategorized and unlabeled data. Instead of following predefined instructions, they identify patterns and determine the appropriate categories and labels for the data.
- **Semi-supervised** learning involves using datasets that contain both labeled and unlabeled data. The labeled data provided by the operator helps guide the algorithm in labeling the remaining data.
- **Reinforcement** learning allows the algorithm to independently determine the best way to complete a task by learning through a complex set of rules that provide rewards or punishments.

4 Zian (Andy) Wang. "NVIDIA, RTXs, H100, and more: The Evolution of GPU | Deepgram." Deepgram. May 21, 2024.

5 Rebecca Picciotto. "Nvidia announces new AI chips as market competition heats up (cnbc.com)." CNBC. June 2, 2024

6 Jon Martindale, Jacob Roach, and Matthew Connatser. "AMD vs. Intel: a turning point in this fierce rivalry | Digital Trends." Digitaltrends. June 18, 2024.

7 https://www.sas.com/en_gb/insights/articles/analytics/machine-learning-algorithms.html

These algorithm types collectively contribute to different domains within AI, including machine learning and deep learning. The software and algorithms form the foundational models upon which AI applications can be developed. Training the algorithm solutions/models is extremely costly and time consuming due to the repetitive adjustments needed to achieve accuracy, often requiring millions of dollars and several months. Taking OpenAI's GPT-3 for example, the training process spanned thousands of hours on hundreds of GPUs, with costs estimated between USD 4 million and USD 12 million.[8] Consequently, giant tech firms have a competitive edge in the current AI model market (see Exhibit 3).

**Exhibit 3: Example of AI Models**

| Company | Text | Image | Audio or Music | 3D | Video |
|---|---|---|---|---|---|
| Microsoft | - | - | VALL-E | RODIN Diffusion | GODIVA |
| OpenAI | GPT-4 | DALL-E3 | Jukebox | Point-E | - |
| Google/ DeepMind | LaMDA Gemini | Imagen | MusicLM | DreamFusion | Imagen Video |
| Stability AI | StableLM | Stable Diffusion 2 | Dance Diffusion | - | - |
| NVIDIA | MT-NLG | Edify | - | Edify | Edify |

Source: S&P Dow Jones Indices LLC. Table is provided for illustrative purposes.

## Infrastructure Services

As AI has become increasingly integrated into our daily lives, many AI projects require immense power to run their workloads. However, hardware like GPUs and TPUs are both expensive and scarce, making it challenging and costly for most businesses to acquire and maintain this critical hardware on-premises. Consequently, it is essential to have a structure that supports effective and efficient workflows, and this is where AI infrastructure is seen as relevant. The AI infrastructure market is expanding and is projected to reach USD 309.4 billion by 2031.[9]

AI infrastructure comprises technologies, frameworks and tools designed to develop and deploy AI-powered applications and solutions. Cloud infrastructure is a typical part of AI infrastructure that enables companies to easily access computational power and manage their expenses as needed. "Flexible cloud infrastructure is highly adaptable and can be scaled up or down more easily than traditional IT infrastructure as an enterprise's requirements

[8] "What Is GPT-3 And How is it Revolutionizing Artificial intelligence - Big Data Analytics News." Bigdata. April 25, 2022.

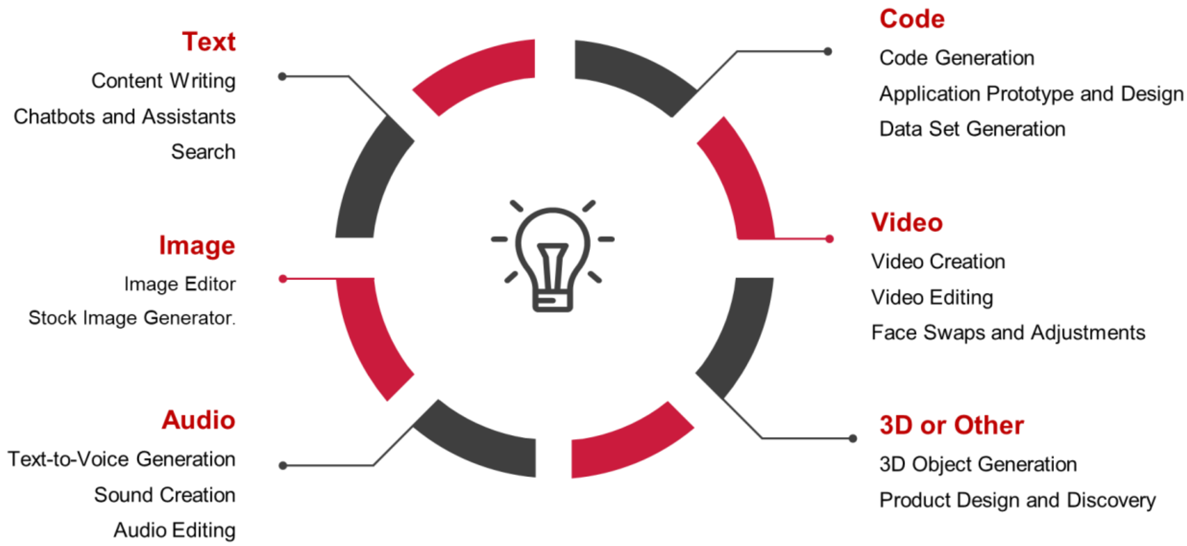
[9] "The State of AI Infrastructure at Scale 2024 (ai-infrastructure.org)." ClearML. 2024.

change."[10] There are many cloud service providers, with Google Cloud, Microsoft Azure and IBM Cloud being among the popular infrastructures.

# AI Application

With the rapid advancement of AI infrastructure, the range of its applications is expanding, leading to numerous real-world uses for AI systems today, from drafting an email to autonomous driving. The latest generative AI applications, such as ChatGPT, Copilot and Stable Diffusion, can perform a wide range of tasks (see Exhibit 4). Their ability to synthesize human language and other data types, including images, videos, software codes and drug discoveries is notable.

**Exhibit 4: Applications of Generative AI across Modalities**




Source: S&P Dow Jones Indices LLC. Chart is provided for illustrative purposes.

AI is prevalent across many industries. By automating tasks that do not require human intervention, AI may save money and time, while reducing the risk of human error. Here are some examples of how AI can be employed in different industries:

- Financial services: Fraud detection is a significant application of AI in the finance industry. AI's ability to analyze vast amounts of data allows it to identify anomalies or patterns indicative of fraudulent behavior. Additionally, AI applications can communicate with clients and investors. According to McKinsey, generative AI could add anywhere from USD 200 billion to USD 340 billion in value to the banking industry annually.[11]

[10] Mesh Flinders, Ian Smalley. "What is ai infrastructure? | IBM." IBM. June 3, 2024.

[11] "Economic potential of generative AI | McKinsey." McKinsey. June 2023.

- Healthcare and pharmaceuticals: There are AI applications across the healthcare industry, from discovering new drugs to surgery support. Researchers can leverage generative AI to explore and develop new drugs. Gartner believes that “more than 30% of new drugs and materials will be systematically discovered using generative AI techniques by 2025”.[12] AI-powered robotics can assist in surgeries near highly delicate organs or tissues, helping reduce blood loss and minimize the risk of infection.
- Media and entertainment: The media and entertainment industry can leverage AI technology in various ways, as both focus on creating unique content. For example, generative AI can assist in creating and editing visual content, producing short highlight videos of sporting events and managing media libraries.

The applications of AI extend beyond the mentioned industries, encompassing fields such as manufacturing, travel & transportation, and retail. Gartner projects that by 2026, over 100 million people will use generative AI to assist with their work.[13] Thus, AI applications are exhibiting notable potential to enter the mainstream.

## Data Provider

In the realm of AI, data training is crucial. This process ensures that machine learning models are accurate, efficient and fully functional. “Garbage in, garbage out” is frequently used in the tech world but it is especially true in relation to AI training data. Without high-quality training data, even the most advanced machine learning algorithms will likely fail to perform effectively.

AI models are trained on massive datasets. Due to its versatility, AI training data comes from numerous sources, largely depending on the specific use case. These sources can include publicly available data from Wikipedia, government sites, social media and academic institutions, as well as private data from large databases. OpenAI, for example, partnered with Shutterstock to train its model using Shutterstock’s vast library of images, videos, music and metadata.[14]

As AI applications gain increasing attention across various industries, the growing demand for AI training data is also creating new opportunities. According to Cognitive Market Research, the global AI training data market was valued at USD 1.87 billion in 2023 and is projected to grow at a compound annual growth rate (CAGR) of 23.50% from 2023 to 2030.[15]

[12] “Generative AI: What Is It, Tools, Models, Applications and Use Cases (gartner.com).” Gartner. 2023

[13] “Generative AI: What Is It, Tools, Models, Applications and Use Cases (gartner.com).” Gartner. 2023

[14] Emma Roth. “OpenAI’s DALL-E will train on Shutterstock’s library for six more years - The Verge.” The Verge. July 12, 2023.

[15] “AI Training Data Market will grow at a CAGR of 23.50% from 2024 to 2031. (cognitivemarketresearch.com).” Cognitive Market Research. March 2024.

# Potential AI Opportunities

In order to track AI opportunities, S&P DJI launched the S&P Kensho Artificial Intelligence Enablers Index in 2023. The index seeks to measure the performance of U.S.-listed companies that develop and enable the technology, infrastructure and services enabling AI, specifically:

- Hardware—including graphics processing units (GPUs), central processing units (CPUs), application-specific integrated circuits (ASICs), field-programmable gate arrays (FPGAs), accelerators and other specialized chips and computing equipment that support high-performance AI-related technologies.
- Software and solution developers of AI algorithms and products—including LLMs, generative AI, deep learning, robotic process automation, human-to-machine communication and other AI methods.
- Infrastructure services (cloud, edge and hybrid computing) and big data technology—integral to enabling data-intensive AI capabilities.
- Products and services that provide a framework specifically for AI applications—including AI-as-a-service platforms, cloud-based machine learning development platforms, automated machine learning (AutoML tools), AI-based analytics and data visualization platforms and computer vision and audio technology.
- Data curation and data management providers of big data extract, transform and load (ETL) solutions that support the effective training and functioning of AI models.

S&P DJI also offers the following related indices.

- S&P Kensho Global Artificial Intelligence Enablers Index, which seeks to measure the performance of global companies developing and enabling AI technology, infrastructure and services.
- S&P Kensho Global Artificial Intelligence Enablers Screened Index, which seeks to measure the performance of global companies developing and enabling AI technology, infrastructure and services, while seeking to meet certain sustainability criteria.

# Kensho Approach

Kensho, the AI and Innovation Hub for S&P Global, utilizes advanced machine learning and natural language processing (NLP) techniques, along with S&P Global's extensive data resources, designed to provide customers with comprehensive and actionable insights. It specializes in processing natural language data, including complex documents and speech, to transform unstructured data into business insights.

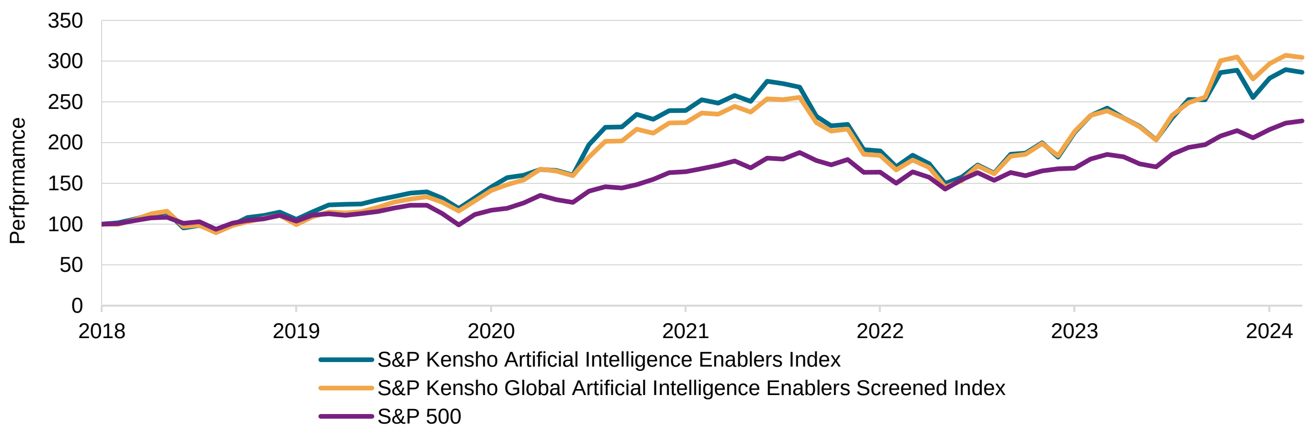
The integration of NLP in index creation has introduced efficiencies into the analysis of unstructured text data. Instead of manually sifting through extensive filings and reports, NLP technology assists our analysts by linking companies to specific themes, streamlining their analysis process. S&P DJI Global Kensho Indexing Solutions, combined with analyst oversight, are used to develop innovative solutions. The series of S&P Kensho Indices also aim to demonstrate the value of NLP in identifying companies' involvement in emerging areas that may not be easily identified through traditional revenue-based screening.

The S&P Kensho Artificial Intelligence Enablers Index and the S&P Kensho Global Artificial Intelligence Enablers Screened Index are indices that utilize the Kensho technology. Industry descriptions are condensed into key search terms, which are then used by Kensho's NLP system to search through the annual filings of each company. If any of the search terms are found in the context of a product or service offered by the company, the filing is flagged as relevant. These filings are then reviewed by a human index analyst, and they are included in the index composition. S&P DJI Global Kensho Indexing Solutions enable us to harness these technologies effectively by introducing greater transparency and reducing subjectivity in the creation of thematic indices.

# Performance

Both the S&P Kensho Artificial Intelligence Enablers Index and the S&P Kensho Global Artificial Intelligence Enablers Screened Index outperformed the S&P 500® over the back-tested five-year period ending July 31, 2024 (see Exhibit 5). Since 2018, the S&P Kensho Artificial Intelligence Enablers Index has outperformed the S&P 500 by 4.41% per year (see Exhibit 5).

**Exhibit 5: Historical Back-Tested Performance**




Source: S&P Dow Jones Indices LLC. Data as of July 31, 2024. Index performance based on monthly total return in USD. The S&P Kensho Artificial Intelligence Enablers Index was launched Aug. 21, 2023. The S&P Kensho Global Artificial Intelligence Enablers Screened Index was launched July 29, 2024. All data prior to such date is back-tested data. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of the document for the inherent limitations associated with back-tested performance.

**Exhibit 6: Back-Tested Risk/Return Profiles**

| Period | S&P Kensho AI Enablers Index | S&P Kensho Global AI Enablers Screened Index | S&P 500 |
|---|---|---|---|
| **Annualized Return (%)** | | | |
| 1-Year | 18.15 | 27.36 | 22.15 |
| 3-Year | 4.82 | 9.03 | 9.60 |
| 5-Year | 18.30 | 21.50 | 15.00 |
| Since May 31, 2018 | 18.59 | 19.79 | 14.19 |
| **Annualized Volatility (%)** | | | |
| 1-Year | 101.48 | 102.04 | 98.75 |
| 3-Year | 29.59 | 28.84 | 17.84 |
| 5-Year | 27.22 | 25.46 | 18.08 |
| Since May 31, 2018 | 26.91 | 25.58 | 17.85 |
| **Risk-Adjusted Return** | | | |
| 1-Year | 0.18 | 0.27 | 0.22 |
| 3-Year | 0.16 | 0.31 | 0.54 |
| 5-Year | 0.67 | 0.84 | 0.83 |
| Since May 31, 2018 | 0.69 | 0.77 | 0.79 |
| **Maximum Drawdown (%)** | | | |
| Since May 31, 2018 | 45.56 | 43.02 | 23.87 |

Source: S&P Dow Jones Indices LLC. Data as of July 31, 2024. Index performance based on monthly total return in USD. The S&P Kensho Artificial Intelligence Enablers Index was launched Aug. 21, 2023. The S&P Kensho Global Artificial Intelligence Enablers Screened Index was launched July 29, 2024. All data prior to index launch date is back-tested data. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of the document for the inherent limitations associated with back-tested performance.

## Screen Overlay

The S&P Kensho Global Artificial Intelligence Enablers Screened Index was launched in July 2024 and incorporates sustainability screens.

- All eligible companies are screened based on involvement in controversial weapons, small arms, military contracting, coal, thermal coal, oil sands and tobacco product-related business activities.
- Companies that are not compliant with the United Nations Global Compact (UNGC) are also excluded. The UNGC principles are a measure of controversial behavior and include matters involving human rights, labor rights, the environment and anti-corruption.
- After the business activities screen, the index excludes the companies without S&P Global ESG scores and the bottom 10% of stocks by count of S&P Global ESG Scores in the S&P Global BMI. The S&P Global ESG Scores result from S&P Global's annual Corporate Sustainability Assessment (CSA), a bottom-up research process that aggregates underlying company data to score levels.

- In addition, the index committee monitors the risk incidents and controversial activities related to companies within the indices through the S&P Global Media & Stakeholder Analysis (MSA). The MSA includes a range of issues, such as economic crime and corruption, fraud, illegal commercial practices, human rights issues, labor disputes, workplace safety, catastrophic accidents and environmental disasters. A company may be excluded if it has been flagged by the MSA.

For more information on the screens, please refer to the index methodology.

# Conclusion

Though significant advancements have been made in AI, this technology continues to evolve. At S&P DJI, we leverage NLP to develop a series of AI-related innovative thematic indices under the Kensho umbrella. The S&P Kensho Artificial Intelligence Enablers Index seeks to measure companies involved in the evolving AI space, especially the companies that utilize AI capabilities through technology, infrastructure and services.

# Appendix

## Exhibit 6: Top 10 Constituents by Market Cap in the S&P Kensho Artificial Intelligence Enablers Index

| Company | Exchange Ticker | Country of Domicile |
|---|---|---|
| Microsoft Corp | MSFT | U.S. |
| Nvidia Corp | NVDA | U.S. |
| Alphabet Inc C | GOOG | U.S. |
| Broadcom Inc | AVGO | U.S. |
| Oracle Corp | ORCL | U.S. |
| SAP SE ADR | SAP | Germany |
| Adobe Inc. | ADBE | U.S. |
| Advanced Micro Devices | AMD | U.S. |
| Alibaba Group Holding Ltd ADR | BABA | China |
| Intl Business Machines Corp | IBM | U.S. |

Source: S&P Dow Jones Indices LLC. Data as of July 31, 2024. Table is provided for illustrative purposes.

# Performance Disclosure/Back-Tested Data

The S&P Kensho Artificial Intelligence Enablers Index was launched Aug. 21, 2023. The S&P Kensho Global Artificial Intelligence Enablers Screened Index was launched July 29, 2024. All information presented prior to an index's Launch Date is hypothetical (back-tested), not actual performance. The back-test calculations are based on the same methodology that was in effect on the index Launch Date. However, when creating back-tested history for periods of market anomalies or other periods that do not reflect the general current market environment, index methodology rules may be relaxed to capture a large enough universe of securities to simulate the target market the index is designed to measure or strategy the index is designed to capture. For example, market capitalization and liquidity thresholds may be reduced. Complete index methodology details are available at www.spglobal.com/spdji. Past performance of the Index is not an indication of future results. Back-tested performance reflects application of an index methodology and selection of index constituents with the benefit of hindsight and knowledge of factors that may have positively affected its performance, cannot account for all financial risk that may affect results and may be considered to reflect survivor/look ahead bias. Actual returns may differ significantly from, and be lower than, back-tested returns. Past performance is not an indication or guarantee of future results. Please refer to the methodology for the Index for more details about the index, including the manner in which it is rebalanced, the timing of such rebalancing, criteria for additions and deletions, as well as all index calculations. Back-tested performance is for use with institutions only; not for use with retail investors.

S&P Dow Jones Indices defines various dates to assist our clients in providing transparency. The First Value Date is the first day for which there is a calculated value (either live or back-tested) for a given index. The Base Date is the date at which the index is set to a fixed value for calculation purposes. The Launch Date designates the date when the values of an index are first considered live: index values provided for any date or time period prior to the index's Launch Date are considered back-tested. S&P Dow Jones Indices defines the Launch Date as the date by which the values of an index are known to have been released to the public, for example via the company's public website or its data feed to external parties. For Dow Jones-branded indices introduced prior to May 31, 2013, the Launch Date (which prior to May 31, 2013, was termed "Date of introduction") is set at a date upon which no further changes were permitted to be made to the index methodology, but that may have been prior to the Index's public release date.

Typically, when S&P DJI creates back-tested index data, S&P DJI uses actual historical constituent-level data (e.g., historical price, market capitalization, and corporate action data) in its calculations. As ESG investing is still in early stages of development, certain datapoints used to calculate S&P DJI's ESG indices may not be available for the entire desired period of back-tested history. The same data availability issue could be true for other indices as well. In cases when actual data is not available for all relevant historical periods, S&P DJI may employ a process of using "Backward Data Assumption" (or pulling back) of ESG data for the calculation of back-tested historical performance. "Backward Data Assumption" is a process that applies the earliest actual live data point available for an index constituent company to all prior historical instances in the index performance. For example, Backward Data Assumption inherently assumes that companies currently not involved in a specific business activity (also known as "product involvement") were never involved historically and similarly also assumes that companies currently involved in a specific business activity were involved historically too. The Backward Data Assumption allows the hypothetical back-test to be extended over more historical years than would be feasible using only actual data. For more information on "Backward Data Assumption" please refer to the FAQ. The methodology and factsheets of any index that employs backward assumption in the back-tested history will explicitly state so. The methodology will include an Appendix with a table setting forth the specific data points and relevant time period for which backward projected data was used.

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