EQUITY

# Reintroducing the The MVIS® US Listed Semiconductor 25 Index

## Powering "Everything Everywhere All at Once"

Joy Yang
Head of Product Management and Marketing
Josh Kaplan
Head of Research and Investment Strategy


MarketVector™

# Contents

Investing in the Semiconductor Industry ..... 2

Making Sense of a Complex Ecosystem ..... 3

Classifying Semiconductor by Product Type ..... 3

Drivers of Growth ..... 6

Government Initiatives, Investment, and Incentives ..... 6

Disruptive Technology Themes ..... 8

Index Design and Architecture ..... 10

Incorporating Semiconductors into an Investment Solution ..... 11

IMPORTANT DEFINITIONS AND DISCLOSURES ..... 13

# Investing in the Semiconductor Industry

Semiconductors are the unsung heroes of the electronics world, permeating every aspect of our lives. They are seemingly in **Everything**, they are **Everywhere,** and as a core component of the quantum computing revolution, we might just see them **All at Once**. Just as the movie **"Everything, Everywhere, All at Once"**[1] captivated audiences with its mind-bending exploration of parallel universes, the semiconductor industry holds the promise of unlocking unimaginable computational power, allowing us to explore multiple possibilities simultaneously, powering many of today's future growth themes. But unlike emerging technology trends, the value of semiconductors has been firmly established and is considered foundational. The journey began in 1874[2] with the introduction of the semiconductor point-contact AC-DC converter. Since then, the industry has experienced remarkable growth. Yet, it is still one of the fastest-growing industries, constantly evolving through continued innovation around the materials, design, and manufacturing in the semiconductor value chain.

Significant progress over the last few decades in semiconductor innovation has been centered around the continued miniaturization of transistors, leading to the creation of more powerful and energy-efficient microchips. This trend, following Moore's Law[3], has allowed for the exponential growth of computing power and the proliferation of devices such as smartphones, tablets, and wearable devices. Moreover, semiconductors play a crucial role in the rapid growth of emerging technologies; Artificial intelligence (AI), 5G, the Internet of Things (IoT), autonomous driving, streaming, and quantum computing have all been propelled forward by advancements in semiconductor technology. Looking to the future, semiconductors are poised to bring even more transformative changes to various sectors.

This industry however is highly specialized and relies on global cooperation across the value chain with no single company or country owning the full process across design, fabrication, testing, and packaging. This highlights the importance of applying appropriate classifications to the space, allowing investors to identify semiconductor pure-plays (defined by associated revenue) and map them to other major themes effectively.

In this paper, we update the investment case for the MarketVector Indexes™ ("MarketVector") flagship MVIS® US Listed Semiconductor 25 Index (MVSMH), tracked by more than USD 9 billion assets under management[4]. We start by exploring how to distinguish between different semiconductor technologies and use cases. Semiconductors are not a "one size fits all" solution and understanding their diverse applications is crucial in identifying how to gain exposure to specific tech themes as they evolve. We will then delve into the driving forces behind the growth of the semiconductor industry, the prevalence of semiconductors in other notable growth themes. Finally, we will showcase the index's methodology, built and maintained based on best practices of benchmark design, ensuring the investability and capacity required to underlie some of the largest semiconductor funds in the world.

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[1] "Everything, Everywhere, All at Once", 2022 film, https://www.imdb.com/title/tt6710474/.
[2] Karl Ferdinand Braun developed the crystal detector, the first semiconductor device, in 1874, Wikipedia, https://en.wikipedia.org/wiki/Semiconductor.
[3] "Moore's law" is the observation, by Gordon Moore, that the number of transistors in an integrated circuit doubles about every two years, Wikipedia, https://en.wikipedia.org/wiki/Moore%27s_law.
[4] marketvector.com. Data as of May 2022.

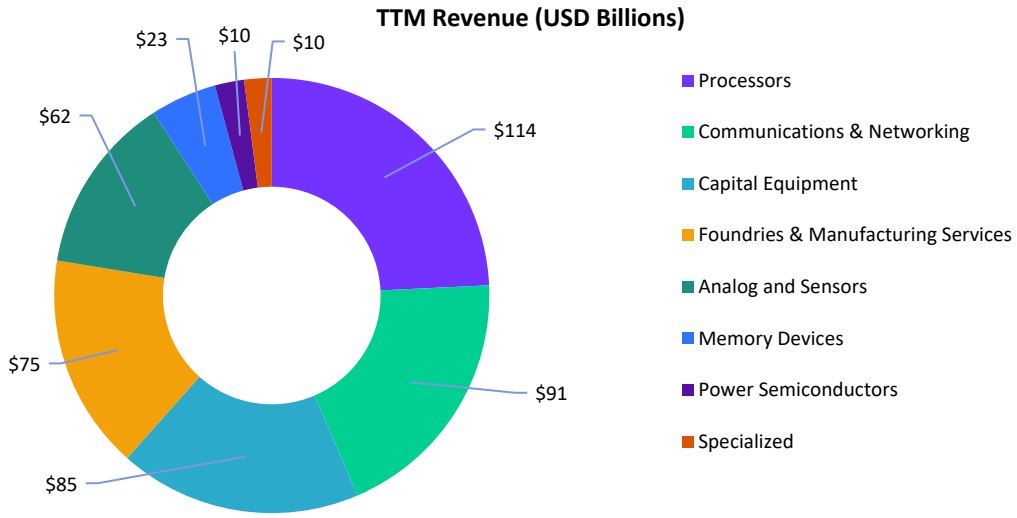
# Making Sense of a Complex Ecosystem

The semiconductor industry relies on a global network of companies to produce the semiconductors that power our world. This network ensures the availability of key materials, such as silicon, copper, and gold, and integrates highly specialized equipment across the manufacturing process, such as lithography, etching, and deposition machines. The expertise required for semiconductor design and manufacturing is highly specialized and requires a multi-disciplinary approach that draws on materials science, engineering, and physics. It is important to note that no single company has all of the resources required to deliver the end products in semiconductors independently. As a result, the semiconductor industry is fragmented, requiring collaboration from companies from around the world to produce the products and integrated devices that drive innovation in the global economy.

## Classifying Semiconductor by Product Type

Not all semiconductor companies are comparable and not all types of semiconductors follow the same industry growth cycles. MarketVector has classified semiconductor companies into eight categories. It is important to distinguish between the different types of semiconductor products to understand how various economic and technological trends can impact each group, and their use cases, differently.

**Exhibit 1: Revenue (Trailing Twelve Months) by Semiconductor Categories**




Source: MarketVector. MVSMH (components as of May 31, 2023, TTM Revenue as of June 8, 2023).

**Analog and Sensors:**
Analog semiconductors handle continuous signals, rather than discrete or digital signals, allowing for amplification, filtering, and modulation. Sensor semiconductors also handle continuous signals, but more specifically convert physical inputs like light, sounds, temperature, or pressure, into digital signals. These types of semiconductors are critical in the development of technology trends such as the Internet of Things, wearable technologies, autonomous driving and advanced driver assistance systems, industrial automation and robotics, augmented and virtual reality, and environmental monitoring, to name a few.

**TEXAS INSTRUMENTS INC (TXN.OQ)**
Texas Instruments is a leading provider of analog and embedded processing solutions. Its products are used in a wide range of applications, including industrial automation, medical devices, and consumer electronics. Texas Instruments is important because it provides the hardware that is needed to power these devices.

**Capital Equipment:**
Capital equipment is used in the manufacture of semiconductor devices and has been critical in the realization of Moore's law. It includes equipment such as lithography machines, etching machines, deposition, metrology and inspection, wafer testing, cleaning, ing, and packaging. machines. Capital equipment is crucial in advanced semiconductor manufacturing by enabling the fabrication of smaller, more complex, and increasingly integrated chips. It is also important in providing high precision and accuracy which improves the yield and decreases the cost of the semiconductor manufacturing process. As the use cases of semiconductors generally become more complex, so too do the requirements of semiconductor design. Capital equipment is important in allowing semiconductor design to keep up with the pace of innovation.

**ASML (ASML.OQ)**
ASML is the world's leading supplier of lithography machines, which are used to manufacture semiconductors. Its machines are essential for the production of advanced semiconductors. ASML is important because it provides the tools that are needed to manufacture the most advanced semiconductors.

**Communications & Networking:**
Communications & networking semiconductors are specifically designed for data transmission and connectivity in a range of communications systems. This category includes integrated circuits, transceivers, modems, network processors, and wireless communication chips. By facilitating high-speed data transfer, voice and video communication, the internet, and telecom infrastructure, these companies enable technological trends such as 5G cellular networks, cloud computing, and media streaming.

**BROADCOM INC (AVGO.OQ )**
Broadcom is a leading provider of semiconductor and software solutions for the communications, enterprise, and industrial markets. Its products are used in a wide range of applications, including networking, storage, and data center. Broadcom is important because it provides the hardware and software that is needed to power these networks and devices.

**Memory Devices:**
Memory devices are used to store and retrieve data. Moreover, the proliferation of connected devices and IoT, and data-driven applications like machine learning and big data analytics require enormous memory capacity. Other trends such as cloud computing, 5G networks virtual/augmented reality, and autonomous vehicles require real-time data processing and storage. Memory devices can be broken down into several categories including DRAM (providing high-speed data access), SRAM (faster data access typically used in cache memory and high-performance applications), NAND Flash (provides high storage capacity with fast read and write speeds), and NOR Flash (primarily used in microcontrollers and embedded systems).

**MICRON TECHNOLOGY INC (MU.OQ)**
Micron Technology is a leading provider of memory and storage solutions. Its products are used in a wide range of applications, including personal computers, servers, and smartphones. Micron Technology is important because it provides the memory that is needed to store data and run applications.

**Foundries & Manufacturing:**
Foundries are companies that manufacture semiconductor devices for other companies. They are essential for the development of new products, as they allow companies to focus on design rather than manufacturing. There are three major areas of innovation impacting the semiconductor foundry market today: 1- advanced processing technologies including executing on the achievement in shrinking transistor sizes, performance improvement, and power efficiency; 2- packaging technologies, such as 3D stacking and wafer-level packaging, which helps address the need for smaller and more compact devices; and 3- specialized manufacturing processes, which cater to specific markets such as the manufacture of chips used for artificial intelligence, automotive, and IoT applications.

**Taiwan Semiconductor (TSM.N)**
TSMC is the world's largest semiconductor foundry. It provides contract manufacturing services to a wide range of customers, including Apple, Qualcomm, and Nvidia. TSMC is important because it enables other companies to design and manufacture semiconductors without having to invest in their manufacturing facilities.

**Power Semiconductors:**
Power semiconductors are used to control and convert electrical power. Power management is becoming an increasingly important concept in integrated circuit design as more data-intensive processes utilize more electricity which needs to be managed not only to enable the execution of these processes but to control costs. This is especially critical in the data center, which consumes an enormous amount of energy. Additional growth drivers for these types of semiconductor devices include the automotive industry (which now includes more complex and capable infotainment centers, electrification, and autonomous driving/advanced driver assistance systems features), and renewable energy power conversion solutions.

**ON SEMICONDUCTOR CORPORATION (ON.OQ)**
ON Semiconductor is a leading provider of power management, analog, and logic solutions. Its products are used in a wide range of applications, including automotive, industrial, and consumer electronics. ON Semiconductor is important because it provides the power and control that is needed to run these devices.

**Processors:**
Processors are the brains of computers and other electronic devices. Processors can be broken down into a few key categories: central processing units (responsible for executing instructions and performing calculations), graphics processing units (responsible for graphic/image rendering, processing, and video encoding/decoding, as well as more efficiently executing complicated calculations- discussed more in the artificial intelligence section), and field programmable gate arrays (programmable chips used to perform specific tasks such as for prototyping, high-performance computing, and digital signal processing.

**Nvidia (NVDA.OQ)**
Nvidia is a leading provider of graphics processing units (GPUs). GPUs are used in a wide range of applications, including gaming, artificial intelligence, and machine learning. Nvidia is important because it provides the hardware that is needed to power these applications.

**Specialized:**
Specialized semiconductors and semiconductor-related companies are used in a variety of niche applications, such as medical devices, industrial automation, and defense. They are a growing market, as the demand for more customized and specialized solutions increases. This also includes semiconductor design software, which can be thought of as CAD for the semiconductor industry.

**SYNOPSYS INC (SNPS.OQ)**
Synopsys is a leading provider of software and IP solutions for the semiconductor industry. Its products are used in a wide range of applications, including design, verification, and manufacturing. Synopsys is important because it provides the tools that are needed to design and manufacture semiconductors.

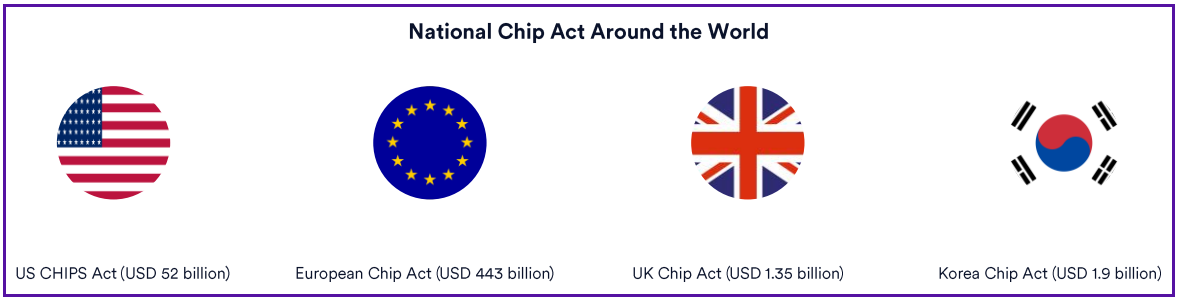
## Drivers of Growth

By classifying semiconductors, we can more easily trace the impact of growth (and risk) drivers. The semiconductor industry is known for its highly-cyclical nature, with periods of rapid growth followed by sharp retrenchment. One of the main factors contributing to the high volatility of the semiconductor index is its sensitivity to macroeconomic factors. The industry's performance is closely tied to global economic conditions, trade policies, geopolitical tensions, and technological advancements. Economic downturns or disruptions in the supply chain can impact semiconductor companies' revenues and profitability.

## Government Initiatives, Investment, and Incentives

Countries looking to increase domestic semiconductor output have directed policies targeting investments and providing subsidies to semiconductor companies, building new semiconductor manufacturing facilities, and enacting trade policies that favor domestic production. The global nature and interconnectedness of the semiconductor supply chain mean that national strategic policies have a significant impact on the industry. These can take various forms, including directing growth back home or imposing restrictions abroad for various reasons, including concerns over national security and the need to enhance Defense resilience. This dynamic interplay between strategic policies, defense investments, and restrictions around foreign usage of semiconductors, has the potential to shape both domestic and global demand.

### Exhibit 2: Chip Acts Investment (USD billion)



**Government Investments:**

- The United States: The CHIPS and Science Act, which will provide USD 52 billion in funding for semiconductor research and development and manufacturing (July 2022).
- The European Union: Europe followed with the European Chips Act, which will provide USD 43 billion in funding for semiconductor research and development and manufacturing (Dec 2022).
- Britain: Under the National Semiconductor Strategy, Britain unveiled plans to invest up to USD 1.25 billion in microchip design, research and development, and compound semiconductors to help the country's chip industry grow (May 2023).
- Korea: South Korea has passed legislation giving tax breaks to its semiconductor companies in a bill labeled the "Korean Chips Act" creating savings of USD 1.9 billion in taxes (May 2023). This is in addition to previously announced plans to support local companies to invest USD 450 billion towards domestic semiconductors by 2030 (May 2021).
- Japan: Ministry of Economy, Trade and Industry released a statement to strengthen efforts to develop and produce advanced semiconductors critical for economic security measures and advanced technology like generative AI to triple sales of domestically produced semiconductors to more than 15 trillion yen (USD 108 billion) by 2030 (June 2023).

**Government Restrictions:**

- United States: U.S. government rolled out extensive restrictions on China's access to advanced semiconductors and the equipment used to make them. (Oct 2022)
- Netherlands: The Netherlands' government laid out restrictions on exports of semiconductor technology to protect national security, joining the U.S. effort to curb chip exports to China. (March 2023)
- Japan: Japan announced that it will supplement the Wassenaar Arrangement and impose export controls on 23 types of semiconductor manufacturing equipment that were not subject to prior restrictions. (March 2023)
- China: China's first major move against a US chip maker, includes a ban on major US chip maker Micron from key infrastructure projects (May 2022).

## Disruptive Technology Themes

The semiconductor market size is estimated to have been USD 500 billion in 2022 and is projected to double in size to USD 1 trillion in 2029 at an annual growth rate of 12.2% per year. (Source: Fortune Business Insights™, "Semiconductor Market Forecast", 2023-2029). But when you look under the hood, it's the disruptive tech themes driving this top-line number. As new technology themes emerge, they disrupt existing industries and create new opportunities for growth and demand for semiconductors:

- **Artificial Intelligence (AI)**

  AI is driving semiconductor growth due to the increasing demand for high-performance chips capable of handling complex computations. According to a report by Yahoo Finance, the AI chip market is projected to grow USD 263.6 billion by 2031, with a compound annual growth rate of 37.1%. This growth is fueled by the need for AI processors in applications such as robotics, natural language processing, and computer vision. (Source: Yahoo Finance Artificial Intelligence (AI) Chip Market Size to Grow USD).

- **5G and Internet of Things (IoT)**

  The combination of 5G and IoT is driving semiconductor growth due to the increasing connectivity and demand for high-performance chips. According to a report by Global Market Studies, the IoT chip market is projected to grow to USD 127 billion by 2028, with a compound annual growth rate of 15%. This growth is fueled by the deployment of 5G networks, which require advanced semiconductor solutions to enable faster, more reliable wireless communication and support the massive influx of IoT devices. (Source: Global Markets Studies | LinkedIn: IoT Chip Market).

- **Electric and Autonomous Driving**

  The growth of electric and autonomous driving is driving semiconductor growth as these technologies heavily rely on advanced semiconductor components. According to a report by KPMG, the automotive semiconductor industry is projected to surpass USD 250 billion by 2040. The firm also projects the automotive semiconductor market to reach USD 200 billion by the mid-2030s, five years sooner than KPMG's previous outlook, published in 2019. Key drivers for this change include a spike in oil prices, chip shortage, EV adoption, and others. (Source: KPMG: Automotive Semiconductor Market).

- **Streaming Content & AR/VR**

  Streaming content and augmented reality/virtual reality (AR/VR) are driving semiconductor growth due to their increasing demand for high-performance chips that can handle complex graphics rendering, real-time data processing, and high-speed connectivity. Statista Market Data projected revenue in the AR & VR market to reach USD 31.12 billion in 2023 at a compounded annual growth rate of 13.72%. The growth of streaming services, online gaming, and immersive AR/VR experiences require advanced semiconductor technologies. (Source: Statista Market Forecast: AR & VR – Worldwide).

- **Quantum Computing**

  Quantum computing is driving semiconductor growth as it requires advancements in semiconductor materials, fabrication techniques, and control systems. According to an article by McKinsey, the global quantum computing market is projected to gain up to USD 1.3 trillion in value by 2035. The development of practical and scalable quantum computers is further driving semiconductor advancements to build qubits, control their interactions, and perform quantum operations. (Source: McKinsey & Company: Quantum technology sees record investments, progress on talent gap).

MarketVector maintains indexes related to all the above growth themes, providing further opportunities to showcase the drivers fueling semiconductor growth. These indexes have a high correlation to the pureplay semiconductor index the MVIS® US Listed Semiconductor 25 Index (MVSMH), providing investors with alternative exposures to the semiconductor industry.

- **Artificial Intelligence (AI):** BlueStar® Artificial Intelligence Index (BAI)
- **5G and Internet of Things (IoT):** BlueStar® 5G Communications Index (BFIV)
- **Electric and Autonomous Driving:** BlueStar® Autonomous Driving Index (BAUT)
- **Streaming Content & AR/VR:** MarketVector™ Global Metaverse and e-Games ESG Index (MVMETV)
- **Quantum Computing**: BlueStar® Machine Learning and Quantum Computing Index (BQTUM)

**Exhibit 3: Correlation across Semiconductor Themes (12/31/2018-5/31/2023)**

| | MVIS® US Listed Semiconductor 25 Index | BlueStar® Artificial Intelligence Index | BlueStar® 5G Communications Index | BlueStar® Autonomous Driving Index | MarketVector™ Global Metaverse and e-Games ESG Index | BlueStar® Machine Learning and Quantum Computing Index | MSCI World |
|---|---|---|---|---|---|---|---|
| MVIS® US Listed Semiconductor 25 Index | 1.00 | | | | | | |
| BlueStar® Artificial Intelligence Index | 0.85 | 1.00 | | | | | |
| BlueStar® 5G Communications Index | 0.92 | 0.87 | 1.00 | | | | |
| BlueStar® Autonomous Driving Index | 0.88 | 0.84 | 0.90 | 1.00 | | | |
| MarketVector™ Global Metaverse and e-Games ESG Index | 0.79 | 0.88 | 0.79 | 0.73 | 1.00 | | |
| BlueStar® Machine Learning and Quantum Computing Index | 0.94 | 0.90 | 0.94 | 0.93 | 0.81 | 1.00 | |
| MSCI World | 0.84 | 0.83 | 0.91 | 0.88 | 0.73 | 0.89 | 1.00 |

Source: MarketVector. Data as of May 31, 2023; MSCI World (iShares MSCI World ETF, URTH US).

# Index Design and Architecture

Designing a complex industry benchmark requires deep knowledge and precision. The MVIS® US Listed Semiconductor 25 Index (MVSMH), tracks the performance of the 25 largest and most liquid US exchange-listed companies in the semiconductor industry. The following key attributes of the index have enabled it to become one of the world's leading benchmarks for the semiconductor industry.

- **Global**: Companies may be domiciled in any country as long as it has a US stock listing.
- **Pure-Play**: Companies must derive at least 50% of their revenue from the semiconductor industry including from the manufacture of semiconductor services, capital equipment, or related software and services.
- **Focus on Investability and Capacity**:
  - Companies are ranked by their float-adjusted market cap ***and*** their average daily value traded. Companies are selected based on their average score.
  - The ten top-ranked companies are always included in the index, the remaining 15 come from current index components which rank in the top 40.
- **Weighting Strategy**:
  - Companies are weighted by float-adjusted market capitalization with a maximum component weight of 20% and a maximum aggregate weight of 50% for companies with a weight of 5% or more.

### Exhibit 4: MVIS® US Listed Semiconductor 25 Index (MVSMH) Characteristics

**Classification Profile**

| Category | Aggregate Wt |
|---|---|
| Processors | 30% |
| Capital Equipment | 18% |
| Communications & Networking | 14% |
| Analog and Sensors | 12% |
| Foundries & Manufacturing Services | 11% |
| Specialized | 8% |
| Memory Devices | 4% |
| Power Semiconductors | 3% |

**Top 10 Names**

| Company | Category | Weight |
|---|---|---|
| NVIDIA CORP | Processors | 17.0% |
| TAIWAN SEMICONDUCTOR-SP ADR | Foundries & Manufacturing Services | 11.2% |
| ADVANCED MICRODEVICES | Processors | 5.9% |
| BROADCOM INC | Communications & Networking | 5.5% |
| ASML HOLDING NV-NY REG SHS | Capital Equipment | 5.2% |
| LAM RESEARCH CORP | Capital Equipment | 4.8% |
| INTEL CORP | Processors | 4.7% |
| APPLIED MATERIALS INC | Capital Equipment | 4.3% |
| TEXAS INSTRUMENTS INC | Analog and Sensors | 4.2% |
| MICRON TECHNOLOGY INC | Memory Devices | 4.2% |

Source: MarketVector. Data as of May 31, 2023.

# Incorporating Semiconductors into an Investment Solution

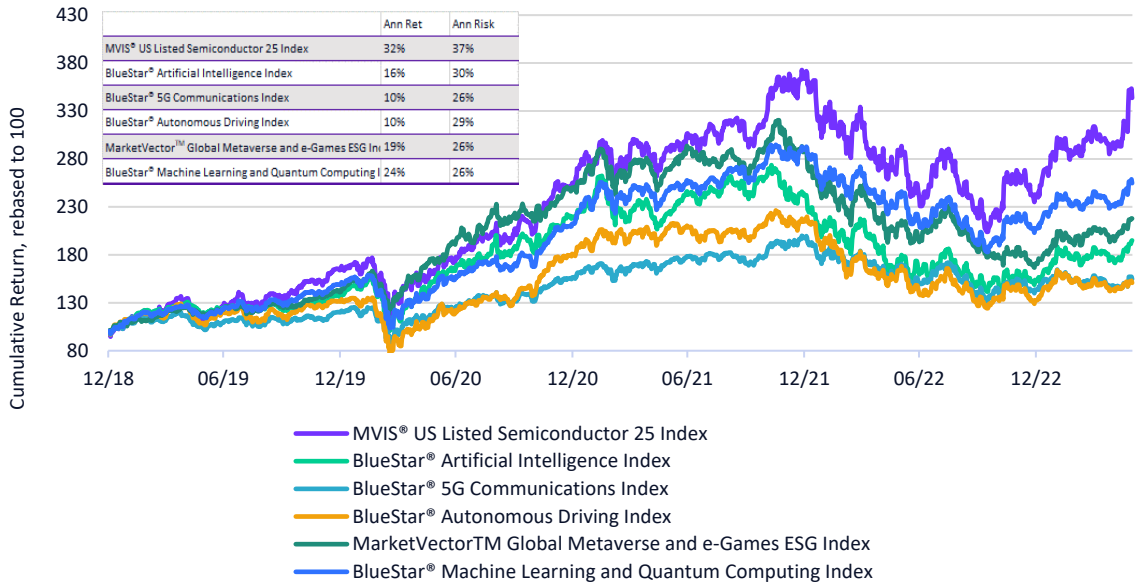
The semiconductor industry can be cyclical and highly volatile in performance. The pace of development can make it difficult for the semiconductor industry to keep up with changes in demand and the cyclical and uncertain growth trajectory can create supply issues anywhere across the semiconductor production chain. The macro drivers outlined can be both tailwinds as well as headwinds for the industry with some themes never materializing expectations. Semiconductors, like any other growth investment, have the potential for significant returns but investors must understand and manage the high associated risk.

In 2023, Nvidia (NVDA) joined the trillion-dollar club, delivering over 30x return since its IPO in January 1999 at USD 12/share[5], and it is now the highest-weighted company in the MVSMH index. By contrast, Intel, which was once regarded as the most innovative and pervasive semiconductor company in the world, was the highest weighted stock in the index reaching as high as 18% in 2010. But it has since fallen dramatically in value relative to its peers as the computing industry growth has turned from the PC market which Intel dominated, toward data center and artificial intelligence which more intensively utilize other types of semiconductors like GPUs and FPGAs.

One way to capture the semiconductor exposure, without betting on any single stock is to target exposure through a diversified basket of pureplay semiconductors, such as MVSMH. This reduces risk through diversification. Another way to minimize the risk is by targeting semiconductor exposures through broader diversified themes where semiconductor companies are key components of the broader thematic growth story. In Exhibit 4, we show other MarketVector indexes with exposure to the semiconductor industry and their performance over time.

[5] On May 30, Nvidia (NVDA) closed at USD 401 to reach US USD 1 trillion valuation, joining Apple, Alphabet, Microsoft and Amazon in the trillion dollar club. Yahoo finance, as of June 2023.

## Exhibit 5: Performance December (31, 2018 – May 31, 2023, rebased to 100)




Source: MarketVector. Data as of May 31, 2023.

As we look to the future, the semiconductor industry will continue to be a driving force in shaping our world, and in improving the quality of life for millions. The innovation of this industry will power endeavors and products that we have not even dreamed of yet, fueling technological breakthroughs and massive economic efficiencies. Given the industry's prominent role in powering innovations, the companies at the forefront of the industry also serve as bellwethers for the global economy. Investors can use the MVIS® US Listed Semiconductor 25 Index (MVSMH), to track this growth or inform their allocation decisions.

# IMPORTANT DEFINITIONS AND DISCLOSURES

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