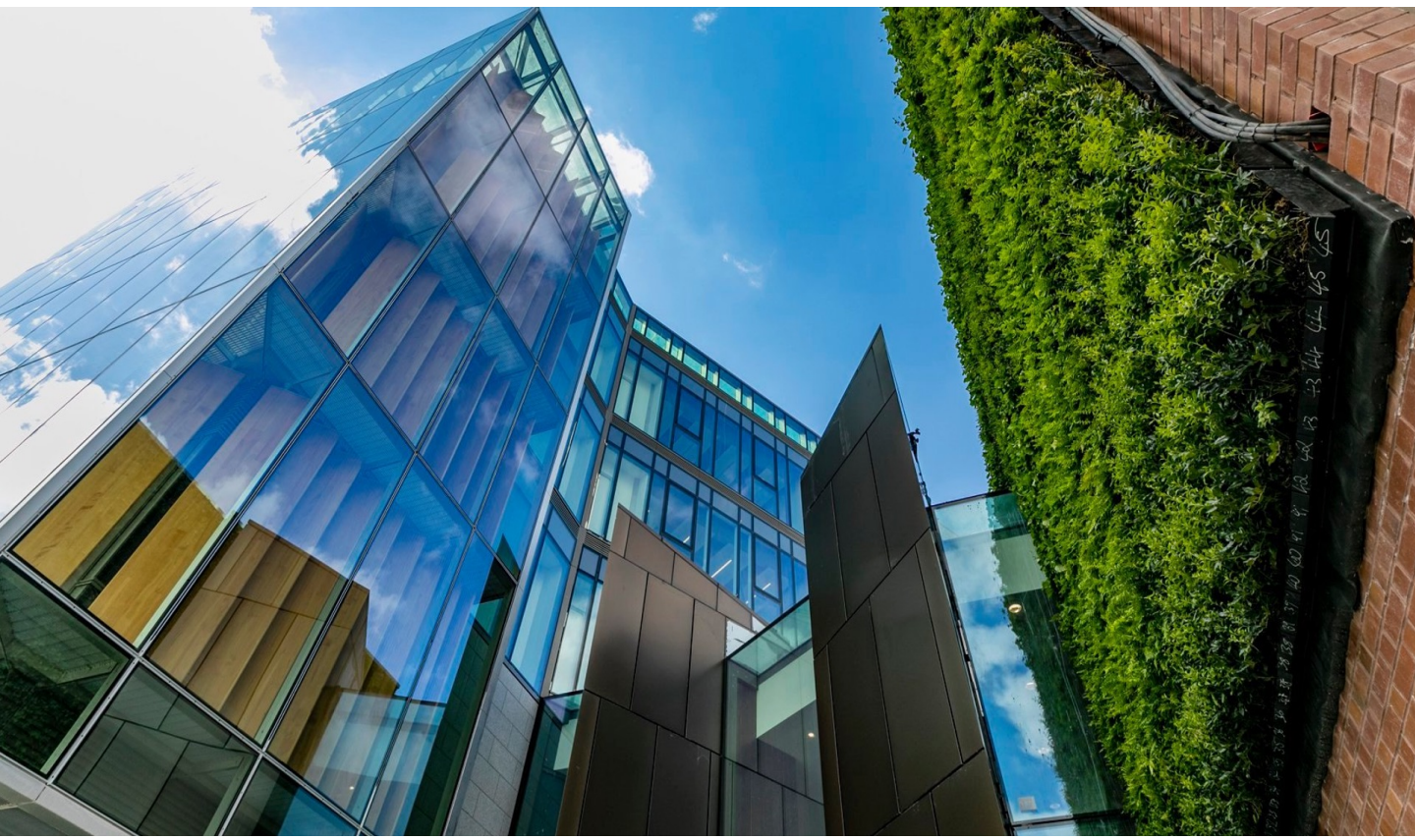
Trinity Student Managed Fund
Sector Reports

Technology Hardware

September 2024



TRINITY SMF
STUDENT MANAGED FUND

Table of Contents

Authors

Vincent Lin
Sector Manager

Sofia Meade
Senior Research Analyst

Sector Overview

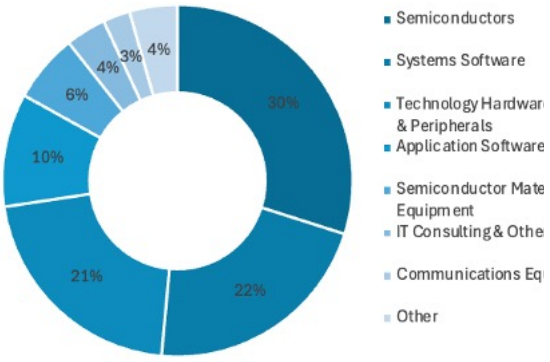
The Technology Hardware sector encompasses a broad range of industries and companies involved in the design, manufacturing, and distribution of hardware components and devices.

Tech Hardware is an indispensable driver of the global economy because of its ubiquity in every facet of modern life from consumer electronics and electric vehicles to communication networks and memory hard drives.

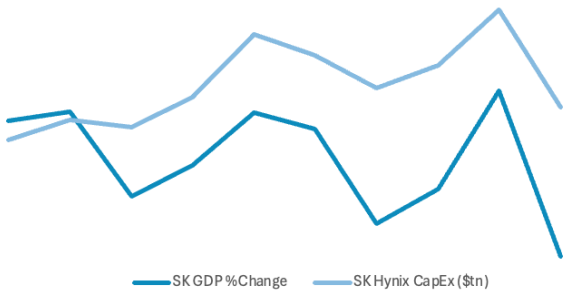
At the heart of this sector, lies semiconductors, also known as “integrated circuits” or just “chips”. On a basic level, semiconductors provide the core functionality of electronic devices like the processing and storing of data. In a sense, semiconductors are the organs of all modern electronics and so, the focus of this report will be weighted towards this specific subsector and its derivatives.

Some Facts and Stats

- Tech Hardware is a massive sector with a total **Market Capitalization of ~$6.05tn** in 2024 and a **CAGR of ~7.86%**
- Tech Hardware companies make up **~62.3% of the MSCI World Information Technology Index**, with Apple and NVIDIA (the second and third largest companies in the world by market capitalization respectively), having a combined index weighting of 35.97%
- Tech Hardware companies tend to be **highly cyclical** due to a high reliance on R&D and consumer demand. That is, capital expenditure and production tend to see a significant uptick when economic conditions are favorable, with substantial cost-cutting prevalent when conditions are unfavorable



MSCI Information Tech Industry Weight



Cyclicality; South Korean Case Study (2014-2023)

Subsectors

Hardware Segmentations

Consumer Electronics

Companies that produce devices for personal and household use such as smartphones, tablets, TVs, PCs, and laptops.

Key Players: Apple, Samsung, Sony

Networking Equipment

Companies that provide the hardware necessary for data communication and network connectivity. This includes firms supplying Wi-Fi routers, switches, modems and also fiber optic cables and glass used for networking activities.

Key Players: Cisco, Lumentum, Huawei

Industrial Automation & Robotics

Firms that provide hardware solutions for automating industrial processes and manufacturing operations. This includes robotics, programmable logic controllers (PLCs), sensors and automation systems. Because of its labor cutting potential, this subsector has been quicky growing.

Key Players: Siemens, Fanuc, ABB

Audio and Visual Equipment

Manufacturers of audio and visual technology such as speakers, headphones, microphones, projectors, and AR headsets.

Key Players: Bose, Sennheiser, Cirrus Logic

Computer Hardware

Manufacturers of PCs, servers, workstations, and related peripherals such as keyboards, monitors, and printers. Computer hardware firms design and produce components that are essential for various computing needs from personal use to enterprise data centers

Key Players: Dell, HP, Lenovo

Storage Devices

Firms in this subsector specialize in creating devices that store digital information, including hard drives and solid-state drives. Storage devices are essential for preserving data across a wide array of devices , from personal computers to cloud data centers, and ensure quick and reliable data retrieval.

Key Players: Micron, Seagate Technology, Western Digital

Semiconductor Pipeline

Fabless Manufacturers

Companies that design semiconductor chips but outsource the manufacturing process to specialized foundries. They focus on creating innovative chip designs and rely on external partners for fabrication.

Key Players: NVIDIA, AMD, Qualcomm

Architecture/ IP Core Providers

Firms that own and license chip architectures/intellectual property. They create foundational designs and standards that can be adapted by various manufacturers. The most notable architectures are ARM, x-86 and RISC-V, which is open source.

Key Players: ARM, Intel, Imagination Technologies

Pure Foundries

These companies specialize in the manufacturing of chips designed by other companies. They do not design chips themselves but provide the manufacturing services.

Key Players: TSMC, GlobalFoundries, USJC

Electronic Design Automation

EDA companies provide software tools and solutions used for designing and simulating semiconductor chips. These tools help engineers create complex chips with high precision and efficiency..

Key Players: Synopsys, Cadence, Mentor

Semiconductor Equipment

Companies that produce the machinery and tools required for manufacturing semiconductor wafers and chips. This includes lithography machines, etching equipment, deposition systems, and inspection tools.

Key Players: ASML, Applied Materials, Tokyo Electron

Integrated Device Manufacturing

IDMs are companies that both design and manufacture their own chips. They have in-house fabrication facilities (fabs) and handle the entire process from design to production.

Key Players: Samsung, SK Hynix, Texas Instruments

Current Holdings

Apple (NASDAQ: APPL)

Apple Inc. is a massive US multinational corporation, known for their innovation and ubiquitous household products such as the iPhone.

In recent times, Apple has been lauded for the launch of 'Apple Intelligence' in partnership with OpenAI, as well as their R&D into AR technologies and products like the Vision Pro.

However, weak sales in markets like China coupled with stake slashed by companies like Berkshire Hathaway and legal trouble in the US and EU has led to questions over the firm's value.

Key Performance Indicators: Chinese Consumer Demand, Consumer Retention, iPhone Sales

ASML (ENXTAM: ASML)

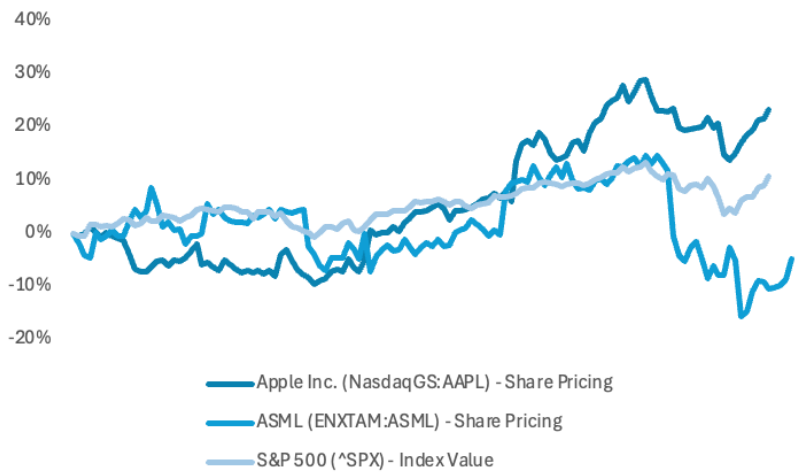
ASML Holdings N.V. is a Dutch chip equipment company, who specialize in Extreme Ultraviolet lithography and who hold a 100% monopoly over the R&D of the technology.

EUV lithography is required to produce the most advanced chips, making ASML an indispensable player in the semiconductor supply line.

Despite currently holding a monopoly, competition from Japanese firms like Tokyo Electron and Canon is catching up, boosted by state subsidies. Moreover, ASML faces growing pressure from the US to stop all exports to China, their largest customer in 2022.

Key Performance Indicators: Interest Rates, Index of Economic Freedom, CapEx

Apple & ASML Share Price vs. S&P 500 (Six Months)



INFICON Holding AG (SWX: IFCN)

INFICON is a Swiss company engaged in the development, manufacture and supply of instruments, sensor technology and process control software for the semiconductor and vacuum-coating industries. The equipment used in these industries is required to be of high precision and reliability.

The performance of INFICON, by the nature of their supplying to cyclical industries, is closely tied with the current chip cycle as well as general macroeconomic conditions. However, by way of their business model, INFICON revenues tend to be less cyclical compared to other firms in the industry.

Key Performance Indicators: GDP growth, Inflation, Interest Rates

Ultra Clean Holdings (NASDAQ: UCTT)

Ultra Clean Holdings is a mid-cap, US-based critical supplier of sub-systems, parts cleaning and analytical services to wafer fab equipment (WFE) companies.

The company is well positioned to capitalize on a potential upcycle in the Logic and DRAM (memory) chip market - which many analysts predict is coming - since Ultra Clean sells to large WFE companies like Applied Materials, ASML and Lam Research.

However, the firm still has exposure to the Chinese market, making the threat of potential sanctions and embargos loom quite over the company's share price - further details in 'Chip War' section

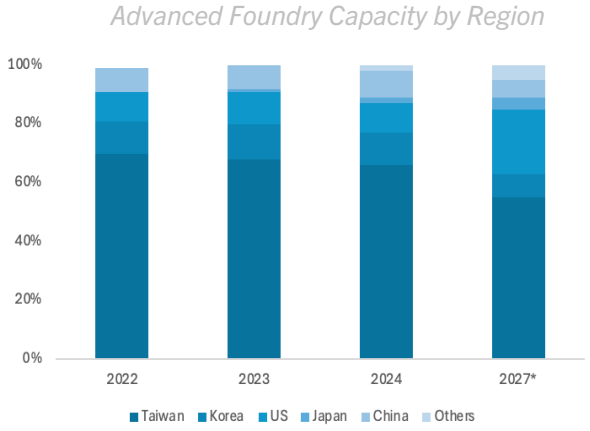
Key Performance Indicators: Consumer Demand, Government Spending, CapEx

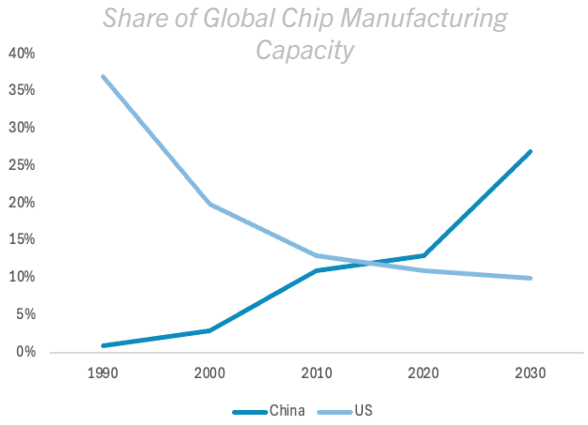
INFICON & UCTT Share Price vs. S&P 500 (Six Months)

Global Outlook

While the chip industry is global and involves many moving parts, for historical reasons, it is really an ensemble of a few very specialized suppliers which dominate the supply chain. The journey of a typical advanced chip today can be summed up as follows:

Designed in the US by firms like Nvidia & AMD, **fabricated by TSMC** (Taiwan), via **machinery supplied by ASML** (Netherlands), Tokyo Electron (Japan) and an oligopoly of US firms (Applied Materials, Lam Research, KLA) and **tested, packed and shipped through channels in Malaysia.**





Chip War

As with everything, there is a political element to the chip industry. Because advanced chips represent technological edge and are controlled by only a handful of companies, there is a growing tension between powerful countries. Most notable is the ongoing conflict between the US and China commonly dubbed the 'Chip War'.

The US, who lead chip design, require the continued cooperation of Taiwanese firms like TSMC, who fabricate ~90% of all advanced chips, in order to maintain their economic, technological and military dominance in the world. Meanwhile China, ever expansionist and skeptical of relying on Western design, wants to increase their global influence and surpass the incumbent global superpower through technology.

These opposing ideologies have led to rising animosity as both parties pass policies that aim to promote their own chip firms while crippling those of the other.

More specifically, the US and China have both heavily invested in their domestic chip industries through the CHIPS Act and 'Big Fund' respectively. Moreover, the US has placed a ban on the export of advanced chips and chip-making tools to China in an attempt to slow its development –Chinese retaliation is yet to be seen, but likely.

Sector Drivers

AI Gold Rush

The rapid advancement, dissemination, and hype around artificial intelligence technologies, such as ChatGPT and other large language models (LLMs), are by far the biggest recent driver in Tech Hardware.

AI applications require substantial computational power, fast connection speeds, and reliable servers. As such, this demand has fueled the growth of high-performance hardware such as logic chips (GPUs, CPUs, TPUs), networking equipment, and data servers.

However, the existential question of how to monetize this hype still lingers.

Cyclicality

Tech Hardware is inherently cyclical, experiencing regular periods of growth and contraction because of the "high Cap. Ex. and consumer demand reliant" business models of many tech companies.

Tech Hardware is thought to be currently entering or in the early phases of an upcycle. The DRAM memory market, for example, is said to be entering into an 'unprecedented super cycle' according to Dan Nystedt, a financial analyst specializing in semiconductors, and Morgan Stanley, an investment bank.

State Subsidies

Another driver of Tech Hardware is the Government. As detailed previously, many countries have massive incentives to increase their domestic chip producing capacity, leading to the creation of a multitude of 'Big Funds' and financial subsidy programs for domestic chip firms.

While in general, these loans and subsidies have not been as efficient as initially desired (over 80% of CHIPS Act programs have been delayed in the US and China's Big Fund has created a glut in the mid memory chip market), some recipient firms have been able to greatly expand their production and capture domestic market share at an unprecedented rate.

Investment Themes

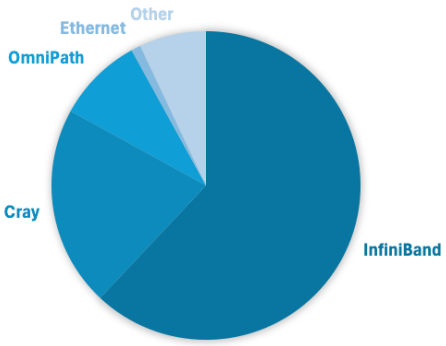
Networking 'Picks and Shovels'

Artificial intelligence relies heavily on vast amounts of data that need to be transmitted, processed and analyzed in real time. Applications such as deep learning and natural language processing require seamless data flow across distributed computing environments - the more complex the model, the smoother the network needs to be. The efficiency and effectiveness of AI systems are directly tied to the quality of the underlying network infrastructure, making networking equipment the backbone of advanced AI technologies.

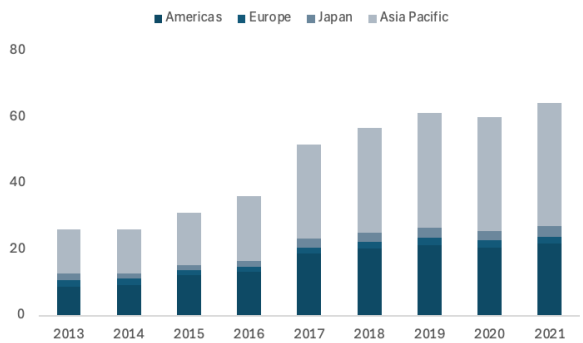
Currently, NVIDIA's InfiniBand architecture and equipment leads the market. However, opportunities exist further down the supply chain since, in order to be truly effective, architecture necessitates things such as routers, modems, fiber optic cables. Companies that supply such equipment - the 'picks and shovels' - are likely well positioned to capitalize as AI companies grow more ambitious with their systems.

East Asia

The importance of East Asia to tech hardware cannot be overstated as the region holds most of the vital 'choke points' in the semiconductor supply chain and produces ~90% of all memory chips and ~75% of all logic chips. Countries such as Japan and South Korea are already seeing large influxes of both private and public investments, leading to promising growth trajectories for their technology industries making it paramount to find ways to ride this tech wave.



Interconnects of Top 100 Supercomputers



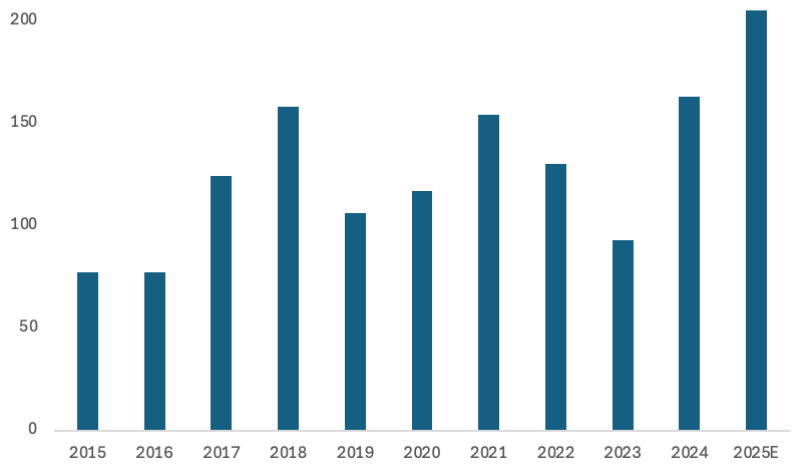
NAND Memory Market by Region

Memory Market

Memory chips store information. There are two main types of memory in any device. The first is Dynamic Random Access Memory (DRAM); DRAM is the 'working memory' of a device and is used for short term data storage. The second is NAND memory, or simply 'flash'; NAND is used for longer-term data storage.

As mentioned before, the memory market, especially DRAM, is expected to enter into an 'unprecedented super cycle' this year, caused by a lack of built-up capacity over the last 2 years. The market is expected to grow 44.8% to $130bn in 2024, while memory Cap. Ex. is forecasted to increase by almost 70% from 2023 to 2025.

Notably, prices for memory chips have bottomed out since COVID meaning firms that produce memory chips, like Micron and SK Hynix, and firms that supply the memory fabrication equipment, like UCT and Ichor.



Global Memory Chip Market

Risks

Existential

Monetizing Artificial Intelligence

The trillion-dollar question around AI today is how to make money from it. There is a growing concern in the tech world about whether or not the current AI hype is warranted since generative AI has not yet been able to radically transform businesses by eliminating labor costs while still costing companies billions in R&D. Recently, Elliott Management, a hedge fund, said that AI was in a 'bubble' and Goldman Sachs, an investment bank, issued a skeptical report titled "Gen AI: Too Much Spend, Too Little Benefit?"

However, although it is true that gen AI has not been generally profitable as of yet, history has shown that truly paradigm breaking technologies often find their own ways to monetize themselves; e.g. railways and the Internet. Even if AI is overhyped, in the words of Sundar Pichai, the boss of Alphabet, "the risk of under-investing is dramatically greater than the risk of over-investing".

Limit to Small

The increase in complexity of chips is entirely contingent on fitting more and more transistors onto smaller and smaller surfaces, resulting in a race to the smallest since the tiniest chips are the most capable. There may come a point, however, where the chips are so small that the laws of physics prevent any further shrinkage, forever limiting processing capacity.

However, 'Moore's Law', which predicted that the processing power of chips will increase exponentially each year, has been correct for the last decade. If the past can predict the future, it is likely that chips will continue to shrink.

Memory Wall

Even as processing speed of data increases year on year, the improvements in bandwidth memory are much slower, leading to significant gains of computer power being masked since chips are essentially too slow at communicating with each other. This 'wall' has continually increased, meaning that the true processing potential of chips may be entirely limited by memory speed.

However, new memory architectures, such as High Bandwidth - Processing in Memory (HBW-PIM), look processing and could potentially solve the 'Memory Wall' problem. But even if it cannot, improvements in memory are still growing each year, allowing for continuous processing advancements, though a little slower.

Practical

Talent Shortages

Semiconductor manufacturing requires a high degree of skills and knowledge, and the industry is in the need for talent with specialist capabilities. Yet, the rapid growth of the semiconductor industry in recent years has only exacerbated the talent shortage. Demand for semiconductors is surging, and each launch of a new manufacturing plant or R&D location can result in an additional crunch for talent, particularly in the West where STEM degrees are scarce.

However, governments are quite aware of this issue and have established plans to increase the number of engineering graduates and specialists. The EU commission, for example, has established the European Chips Skills Academy for this purpose.

Tariff on Trade

As geopolitical tensions over the Chip War heighten, there are undoubtedly going to be more trade barriers regarding chips either restricting companies from selling in certain markets or significantly increasing the cost to do so.

However, barriers to trade are imperfect and often many loopholes exist. For example, NVIDIA recently sold billions of dollars worth of chips to China in spite of the US's CHIPS Act, by designing chips slightly below what the regulation forbade. Moreover, tariffs cut both ways and could even present opportunities for domestic firms, who were once out competed by their multinational rivals, to gain market share and profit.

Energy Use

The chip fabrication process is extraordinarily energy intensive which could impose a hefty expense to vital companies like TSMC - who get 80% of their energy through fossil fuels - if energy prices rise because, for example, there is increased demand from companies training AI models, or if new environmental rules are passed.

Higher energy costs are almost always a big concern for the tech sector. However, it is likely that these potential costs are merely a hindrance to Fabs as opposed to something substantial, especially when you consider that governments globally, but in particular in Taiwan where this problem is greatest, have an incentive to keep Fabs 'on' and producing at capacity.

Case Study

TSMC (NYSE:TSM)

Taiwan Semiconductor Manufacturing Company (TSMC) is recognized as the preeminent entity in the global semiconductor foundry sector. In 2023 alone, it held holding a substantial market share of approximately 56%. TSMC possesses an unmatched technological advantage, manufacturing nearly 90% of the world's most sophisticated chips, including the state-of-the-art 3nm process technology, which is essential for the current AI revolution. TSMC's dominance in this industry is reinforced by its position as the main supplier for major technology firms such as Apple, NVIDIA, and AMD. These companies play the important role of being vital contributors to the rapidly expanding AI and high-performance computing markets.

Key Drivers

AI and High-Performance Computing Demand

The surge in demand for AI-based solutions has greatly enhanced TSMC's standing in the market. NVIDIA's recent Q2 earnings report has reinforced TSMC's essential position. As AI increasingly influences diverse industries, ranging from cloud computing to self-driving vehicles, TSMC's sophisticated manufacturing capabilities will remain essential.

Financial Strengths & Investment in R&D

TSMC consistently showcases strong financial results, reporting a 36.3% rise in net income YoY. The company's CapEx of $32 billion in 2024 underscores its commitment to aggressively enhancing and expanding its manufacturing capabilities, thereby securing its position as a leader in semiconductor innovation.

Global Expansion & Geopolitical Risk Mitigation

TSMC's strategic global expansion represents a proactive measure in response to the increasing tensions between the United States and China. The company's initiative to establish a €10 billion facility in Dresden, Germany, which is anticipated to commence operations by 2027, marks a crucial step towards diminishing reliance on operations centered in Taiwan. This facility, bolstered by €5 billion in state aid from the EU and in collaboration with firms such as Infineon, Bosch, and NXP, plays a pivotal role in the EU's goal of manufacturing 20% of the world's semiconductors by 2030. Furthermore, TSMC's investment of $65 billion in new facilities across the United States and Japan highlights its dedication to broadening its geographic presence, thereby enhancing both technological and geopolitical resilience.

TSMC’s technological leadership, coupled with its strong financial performance, positions it as a key company to monitor over the course of the year.

Disclaimer

The content presented in this publication is for informational purposes only and should not be considered as investment advice. The Trinity Student Managed Fund does not endorse, recommend, or provide any warranties regarding the accuracy, completeness, or reliability of the information provided herein. All opinions expressed in this publication are those of the respective authors and do not necessarily reflect the views of the Trinity Student Managed Fund.

Readers are strongly advised to conduct their own research and consult with qualified financial professionals before making any investment decisions. The Trinity Student Managed Fund disclaims any liability for any financial loss or damage arising from reliance on the information contained in this publication.

References

(1) MSCI. (2024). MSCI World Information Technology Index (USD). https://www.msci.com/documents/10199/69aaf9fd-d91d-4505-a877-4b1ad70ee855

(2) MSCI. (2024). MSCI World Information Technology 20/35 Custom Index (USD). https://www.msci.com/documents/10199/543e73bb-dbc5-c638-bd53-14010eaf118d

(3) AlphaSpread.com. (2024). SK Hynix Inc (KRX:000660). https://www.alphaspread.com/security/krx/000660/financials/cash-flow-statement/capital-expenditures

(4) Federal Reserve Bank of St. Louis. (2024). Real Gross Domestic Product for Republic of Korea. https://fred.stlouisfed.org/series/NGDPRSAXDCKRQ

(5) Varas, A., Varadarajan, R., Goodrich, J., & Yinug, F. (2020). Government Incentives and US Competitiveness in Semiconductor Manufacturing. https://www.semiconductors.org/wp-content/uploads/2020/09/Government-Incentives-and-US-Competitiveness-in-Semiconductor-Manufacturing-Sep-2020.pdf

(6) Palma, R., Varadarajan, R., Goodrich, J., Lopez, T., & Patil, A. (2022). The Growing Challenge of Semiconductor Design Leadership. https://web-assets.bcg.com/3f/b4/fd384ccd46dc8a381bd61a648105/bcg-the-growing-challenge-of-semiconductor-design-leadership-nov-2022-r.pdf

(7) Miller, C. (2022). Chip War: The Fight for the World's Most Critical Technology. Simon and Schuster.

References cont'd

(8) Irwin-Hunt, A. (2021, March 24). In charts: Asia's manufacturing dominance. https://www.ft.com/content/2b0c172b-2de9-4011-bf40-f4242f4673cc

(9) Esposito, R. (2023) The Chip War Has Started. https://www.natofoundation.org/wp-content/uploads/2023/02/NDCF-Paper-The-Chip-War-has-Started-Esposito.pdf

(10) The Economist. (2022, February 12). In the global chips arms race, Europe makes its move. https://www.economist.com/business/in-the-global-chips-arms-race-europe-makes-its-move/21807603

(11) The Economist. (2024, June 13). The Semiconductor Chokepoint. https://www.economist.com/asia/2024/06/13/the-semiconductor-choke-point

(12) The Economist. (2024, July 28). What could kill the $1trn artificial-intelligence boom?. https://www.economist.com/business/2024/07/28/what-could-kill-the-1trn-artificial-intelligence-boom

(13) The Financial Times. (2024, May 27). China raises $47bn for chip industry in drive for self-sufficiency. https://www.ft.com/content/175a36b0-c928-4285-bbc1-41b6026e4f92

(14) Market Research Future. (2023). Flash Memory Market Size, Share, Industry Trends, Global Analysis, 2032 | MRFR. https://www.marketresearchfuture.com/reports/flash-memory-market-986

(15) Econ Market Research. (2023). Network Equipment Market. https://www.econmarketresearch.com/industry-report/network-equipment-market/#:~:text=The%20Global%20Network%20Equipment%20Market

(16) Statista. (2021). Global flash memory market by region 2013-2021. https://www.statista.com/statistics/553658/worldwide-flash-memory-market-size-by-region/

(17) D'Souza, A., & Singh, R. (2022). Global Network Devices Market Size, Share & Industry Trends Analysis Report By Type, By Connectivity (WiFi, Cellular, WiFi + Others, Long Range Radio (LoRa)), By Application, By Device Type, By Regional Outlook and Forecast, 2022 - 2028. KBV Research; KBV Research. https://www.kbvresearch.com/network-devices-market/

(18) Brian, & Brian. (2021). What is InfiniBand Network and the Difference with Ethernet? Fibermall.com. https://www.fibermall.com/blog/what-is-infiniband-network-and-difference-with-ethernet.htm#What_is_the_InfiniBand_Network

(19) Fitch, A. (2024). Nvidia Q2 Earnings Report 2025. The Wall Street Journal. https://www.wsj.com/business/earnings/nvidia-nvda-q2-earnings-report-2025-16fc82a2

(20) The Wall Street Journal. (2024). Nvidia Q2 Earnings Report 2025. The Wall Street Journal. https://www.wsj.com/business/earnings/nvidia-nvda-q2-earnings-report-2025-16fc82a2