THE SEMICONDUCTOR INDUSTRY: MAIN PLAYERS AND TRENDS

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INTRODUCTION

PREFACE

The semiconductor industry stands at the heart of modern technological innovation, driving advancements in numerous sectors, such as artificial intelligence, computing, telecommunications, and automotive. Semiconductors, the essential components of electronic devices, are gaining recognition year over year, as they are fundamental in nearly every technology in use today.

Personally, I have been following the semiconductor market, as a gaming enthusiast, ever since 2018, with the release of Nvidia's GeForce RTX 20 series GPUs. At that time Nvidia was just a gaming and 3d model company.

As of 2024, despite semiconductor importance and their major role in today's technology, the wide public still ignore their relevance. For this reason, and to analyse my personal interest from a financial standpoint, I decided to craft this thesis, that explores the multifaceted landscape of the semiconductor industry, examining its key players, recent developments, and future trends.

In conclusion, this thesis aims to provide a comprehensive analysis of the semiconductor industry, presenting insights accessible to all readers while maintaining depth suitable for experts. By decomposing the incredible growth of the past years, examining the interplay between key players, market developments, and future trends, this thesis aims to shed light on the driving forces behind this critical industry and its impact on global technological progress.

SEMICONDUCTORS

A semiconductor is a material product with some of the properties of both insulators and conductors. Semiconductors are employed in the manufacture of various kinds of electronic devices, including diodes, transistors, and integrated circuits. Such devices have found wide application because of their compactness, reliability and power

efficiency[1]. Semiconductors are a uniquely important enabling technology as they are fundamental to nearly all modern industrial and national security activities, and they are essential building blocks of other emerging technologies, such as artificial intelligence, autonomous systems and quantum computing[2].

THE SEMICONDUCTOR SECTOR

The semiconductor industry, a cornerstone of modern technology, relies on robust financial indicators to gauge its performance and investor sentiment. Among these metrics, the Philadelphia Semiconductor Sector Index (SOX) stands out as a critical benchmark, offering insights into industry dynamics, technological trends, and market sentiment.

The SOX index is a capitalization-weighted index composed of 30 companies[3] primarily involved in the design, distribution, manufacture, and sale of semiconductors. The index serves as a benchmark for the semiconductor industry, tracking the performance of leading semiconductor stocks listed on major U.S. exchanges.

In the past 10 years, the semiconductor industry experienced a persistent positive trend that peaked in March 2024, reaching new heights. From 2014 to 2024, the percentage increase was approximately 740%[4], while the increase of S&P 500 was" just" 175%[5].

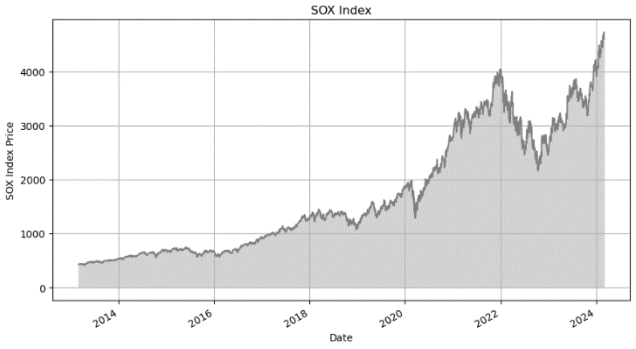

Figure 1: SOX index chart from 2014 to 2024. Source: Yahoo Finance

One thing to keep in mind is that although annual semiconductor sales have traditionally trended upward, the semiconductor industry demonstrated a high cyclicality, with

[1] *See* Britannica, The Editors of Encyclopaedia. *semiconductor*. Encyclopaedia Britannica (Jan 2024)
[2] *See* Congressional Research Service, *Semiconductors: U.S. Industry, Global Competition, and Federal Policy* (2020)
[3] full list can be viewed at Nasdaq's official website.
[4] Considering the period 01/04/2014 - 01/04/2024 with values 579 and 4962
[5] Considering the period 01/04/2014 - 01/04/2024 with values 1883 and 5243

periods of growth and contractions.[6] In contrast, the growth in chip criticality has been a steady one[7].

Among the numerous companies that comprise the semiconductor industry, some are particularly relevant to the innovation, the growth or the supply side of the market.

MAIN PLAYERS

NVIDIA

Without any doubt, the protagonist of the semiconductor industry growth in recent years is the high-end chip maker Nvidia. With an incredible growth in revenues and profits, the company has gained the spotlight, smashing expectations year over year.

Nvidia is a technology company primarily known for designing and manufacturing graphics processing units (GPUs) for gaming, professional visualization, data centers, and automotive markets. In addition to GPUs, Nvidia has expanded into other areas such as artificial intelligence, autonomous vehicles, and cloud computing[8]. Their GPUs are heavily utilized in AI training and other AI applications. Just to name one, the well-known chatbot ChatGPT is powered by an NVIDIA DGX™ AI supercomputer[9].

Nvidia has a market capitalization of 2,265 trillion dollars, making it one of the top three largest corporations in the world. This number was 1,22 trillion at the end of 2023[10] and just 355 billion in January 2023[11]. What is the reason behind this incredible growth?

There are various reasons behind such increase, the first being directly related to the business and the second related to the AI gold rush, both are strictly linked.
“Accelerated computing and generative AI have hit the tipping point. Demand is surging worldwide across companies, industries and nations,” said Jensen Huang,

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[6] Economic cycles will be analysed in detail later in the text, see p.20
[7] *See* Deloitte. *2022 Semiconductor Industry Outlook*
[8] Nvidia, *About Nvidia,* https://www.nvidia.com/en-us/about-nvidia/ Accessed April 12, 2024
[9] Nvidia, *Nvidia in brief* (2023) https://nvdam.widen.net/s/hskgjmdvwx/corporate-nvidia-in-brief-2023 accessed 12 Apr 2024
[10] Considering 29 Dec 2023 as reference date: 495,2$ closing price and 2,494 billion outstanding shares
[11] Considering 3 Jan 2023 as reference date: 143,08$ closing price and 2,477 billion outstanding shares

founder and CEO of Nvidia. The corporation has been the primary beneficiary of the recent technology industry obsession with large artificial intelligence models, which are developed on the company's pricey graphics processors for servers.

Nvidia's fiscal results were outstanding: revenue for the fourth quarter was $22.1 billion, up 265% from a year ago and fiscal year revenue was $60.9 billion, up 126% from a year ago. Data Center revenue for the fourth quarter was a record, up 409% from a year ago, while Data Center revenue for fiscal year 2024 was up 217%[12].

($ in millions)	Q4 FY24	Q3 FY24	Q2 FY24	Q1 FY24	Q4 FY23
Data Center	$18,404	$14,514	$10,323	$4,284	$3,616
Gaming	2,865	2,856	2,486	2,240	1,831

Table 1: Nvidia quarterly revenue trend by market, only main markets are visualized (excluding Professional Visualization, Auto and OEM & Other for clarity). Source: Nvidia

A data center is a physical room, building or facility that houses IT infrastructure for building, running, and delivering applications and services, and for storing and managing the data associated with those applications and services[13]. In the past years, the data center market was an important but secondary line of business, the first one being gaming, but starting from Q1 2023, the former has become the main market, with revenues that in one-year surpassed Gaming's revenues by 6 times. These increases reflect higher shipments of Nvidia platforms[14] used for the training and inference of large language models and generative AI applications. It is important to point out that more than half of the revenues were driven by large cloud providers[15].

Nvidia is at the moment the gold standard of the semiconductor industry, with a dominant position in both the CPU's market and the data center market, but the corporation is swimming with sharks, as main competitors aren't passively looking, but are trying to overtake Nvidia position to reduce their dependency on Nvidia's expensive chips or steal its market share. This situation is happening in both the chip supply

[12] *See* Nvidia, *CFO Commentary on Fourth Quarter and Fiscal Results 2024, p. 2,3* *https://s201.q4cdn.com/141608511/files/doc_financials/2024/Q4FY24/Q4FY24-CFO-Commentary.pdf*
[13] *See* IBM, *What is a data center?* https://www.ibm.com/topics/data-centers Accessed 14 Apr 2024
[14] Nvidia Hopper GPU architecture's Transformer Engine
[15] i.d. 12

industry, with other chip makers like AMD and Intel; and the AI processors, with Nvidia's actual customers like Microsoft, Google, Meta and Amazon developing their own products[16][17].

The objective of Nvidia in the next future is to entrench itself as the primary AI chip supplier. To achieve this result, the corporation is constantly seeking the creation of chips with better performance, capable of sweeping the competition (Nvidia recently announced the next-generation Blackwell Architecture) and the development of an Nvidia AI ecosystem[18].

AMD

In a field that is undoubtedly dominated by Nvidia, AMD sits at the second place in the sector and is fiercely opposing Nvidia dominance. With a "moderate" yearly return of 127%[19], between high-end chip makers, AMD is awarded with the silver medal for higher stock returns.

AMD is a technology company that operates in the same sector of Nvidia, so in the designing and manufacturing of graphics processing units (GPUs) and central processing units (CPUs) for gaming, notebooks and desktops, data centers and data processing.

AMD growth path follows Nvidia's one, as the reason behind such increase is the same, so the strong AI related chips demand, but there are mainly two big differences between the two corporations. The first is the market share disparity. While Nvidia benefits from its dominant position, AMD in the past years has been under Nvidia's shadow, forced to not fall behind. This is also reflected in the stock price growth curve for the two companies and the S&P. The S&P reached resistance levels in March after a strong positive trend started in October, as a result a stock retracement took place and the same

[16] Acton Michael, Hodgson Camilla, *Nvidia unveils powerfull chip in push to extend dominance in AI market,* Financial Times, (2024)
[17] David Emilia, *Chip race: Microsoft, Meta, Google, and Nvidia battle it out for AI chip supremacy*, The Verge, (Apr 2024)
[18] *See* Nvidia, *Nvidia AI Platform* https://www.nvidia.com/en-us/ai-data-science/ *Accessed 14 Apr 2024*
[19] Considering the period 0/12/2022 - 29/12/2023 with values $64,77 and $147,41. If we consider the period 01/05/2023 - 01/05/2024 with values $89,69 and $144,27 the yearly return is 61%

happened to both AMD and Nvidia. After the maximum heights of March, the two corporations stock value fell back and are now regaining ground, but while Nvidia is already nearly back to its maximum values, AMD is not even close, with the stock price still down 27% from March heights.[20] The probable reason behind this trend disparity is that investors prefer betting on the winning horse and Nvidia is in a better position.

The second main difference between AMD and Nvidia is the implementation of AI software's to support the hardware. That's largely because Nvidia provides a full-stack solution for AI computing, including its CUDA software and foundational models and libraries to jump-start development of AI applications. On the other hand, AMD focuses exclusively on hardware, which allows them to offer superior price/performance ratios due to their competitive pricing. AMD's strategic emphasis on power efficiency and cost-effectiveness makes it an attractive choice for enterprises dealing with power and space constraints, as highlighted by Jean Hu, AMD's CFO.

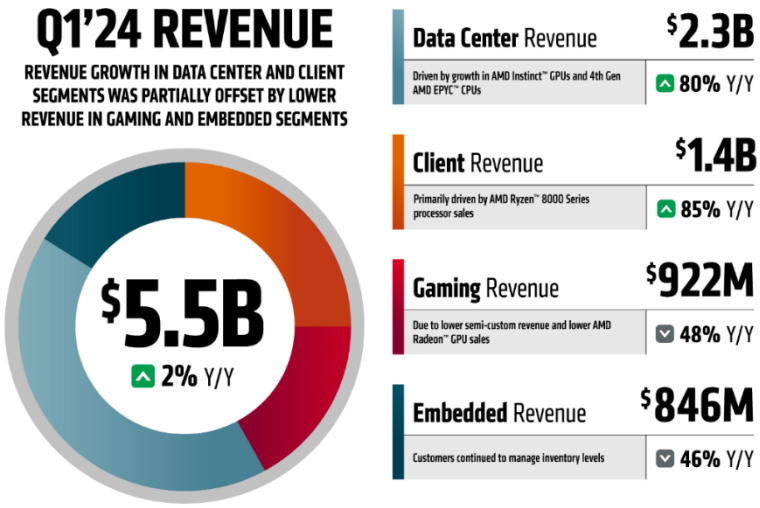

Figure 2: AMD Q1 2024 revenue decomposed by segments. Source: AMD

Nvidia dominance in the AI market is also partly given by the fact that AMD didn't really have a product to rival Nvidia in the AI market until December, when it launched its Instinct MI300 data center GPU accelerator family. By Q1 2024, AMD reported a second consecutive quarter of record data center GPU revenue, reaching $2.3 billion,

[20] Nvidia reached its peak value on the 25th of March with a closing price of $950,02; after the retracement the corporation reached its bottom level the 19th April with closing price $762,00; Nvidia stock price as of the 14th of May is $913,53. AMD reached the peak on the 7th of March with a closing price of $211,38; as of the 14th of May the closing price was $153

with an 80% year-over-year growth. The MI300 became the fastest-ramping product in AMD history, surpassing $1 billion in total sales in less than two quarters.

Despite strong competition from Nvidia in the GPUs market and Intel in the CPUs market, AMD has established itself as one of the premier technology companies globally. Its innovative products and strategic advancements have propelled it to the forefront of the tech industry as a leader in the ever-evolving landscape of computing.

INTEL

To the general public, Intel stands out as perhaps the most recognized name among semiconductor manufacturers. Much of this recognition stems from Intel's position as the leading manufacturer of CPUs globally, boasting a remarkable market share of 64% among Windows users (the double of AMD, Intel's main competitor). If you're reading this paper on a windows laptop, there's an 80% chance it's powered by an Intel CPU.[21]

Intel is an Americal technology company that supplies microprocessors to the majority of computer systems manufacturers, being one of the developers of the x86 computer architecture for CPUs.[22] The company also manufactures GPUs and other devices related to data centers and AI, thus competing with Nvidia.

Unlike Nvidia and AMD, which have a well-defined "standard" business strategy in progress. Intel decided to pursue a different path, bolder. Most companies making logic components have outsourced the manufacturing. Outsourcing significantly reduces the capital and R&D overhead by sharing the costs with other semiconductor companies through foundries. While still competing with both companies in both markets (CPUs and GPUs), Intel decided to expand upstream in the supply chain, thus moving closer to

[21] If we consider the global market share held by operating systems (OS) for desktop PCs, Microsoft Windows is the dominant OS worldwide with a market share of around 72%, followed by Apple's MacOS with 15%. Around 10 years ago, Windows market share was around 90% while Intel CPU's market share was nearly 80% (considering only laptops it was more than 90%!). To find out who made your laptop's CPU, take a look at the sticker near the mousepad. Source: Statista

[22] x86 has become the dominant architecture for personal computers and servers. The name "x86" is derived from the 8086, an early processor released by Intel. Intel's processors like the Pentium, Core i3/i5/i7/i9, and AMD's processors like Ryzen and Athlon are some of the most well-known x86 CPUs.

the source of raw materials or production, with the objective to become the American Taiwan Semiconductors[23].

In 2021 Intel showcased the strategy that the corporation will pursue, with the reveal of IDM 2.0, a major evolution of Intel's integrated device manufacturing (IDM) model, the term for semiconductor companies that both design and manufacture chips. As part of the program, the company also unveiled significant manufacturing expansion plans, starting with an estimated $20 billion investment to build two new factories in Arizona. Pat Gelsinger, Intel Chief Executive Officer, proclaimed Intel's plans to become a major provider of foundry capacity in the U.S. and Europe to serve customers globally.[24]

With the new strategy, Intel aims to become a leading developer of process technology and manufacturer of semiconductors. The new plan focuses on developing chips that are as efficient and capable as the ones developed by industry leaders, to compete with Taiwan Semiconductor and advance towards the objective of becoming the second-largest foundry producer by 2030.

To deliver this vision, Intel established a new standalone business unit, Intel Foundry Services (IFS), that will be differentiated from other foundry offerings with a combination of leading-edge process technology and packaging, committed capacity in the U.S. and Europe, and a world-class IP portfolio for customers[25].

Figure 3: Intel Foundry logo

Three years have passed since the announcement of IDM 2.0, and Intel Foundry Services was launched with a long-term vision. According to Intel CEO Pat Gelsinger, "While our ambitions will not materialize overnight, we made tremendous progress in both Q4 and fiscal year 2023 towards our goal of becoming the second-largest external foundry by 2030." This progress is largely driven by the rapid adoption of AI across

[23] *See* TSMC section p. 12
[24] *See* Intel Newsroom, *Intel CEO Pat Gelsinger Announces 'IDM 2.0' Strategy for Manufacturing, Innovation and Product Leadership* (Mar 2021)
[25] Intel offers a wide range of high-quality, advanced technologies that customers can integrate into their semiconductor designs, including x86 cores as well as ARM and RISC-V ecosystem IPs. They are all different types of processor architectures widely used in personal computers, servers, mobile devices, and embedded systems.

various industries, making high-performance computing one of the largest and fastest-growing segments of the semiconductor market.

However, achieving future goals involves taking many strategic steps in the present. One critical factor is the substantial financial investment required in the early stages of the IDM 2.0 strategy. The realization of this ambitious project is extremely expensive and demands significant upfront capital, while the anticipated profits are expected to materialize many years later.

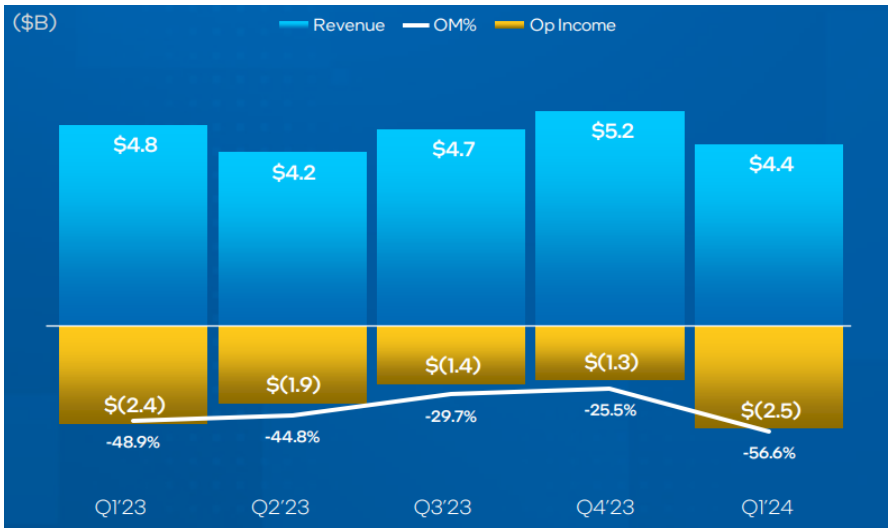

Figure 4: Intel Foundry quarters summary. Source: Intel

Intel has been investing heavily to catch up to its primary chipmaking rivals, TSMC and Samsung. The company reported that the manufacturing unit had $7 billion in operating losses for 2023, a steeper loss than the $5.2 billion in operating losses the year before. The unit had revenue of $18.9 billion for 2023, down 31% from $27.49 billion the year before. The main reason behind such increase in operating losses is the adoption of extreme ultraviolet (EUV) lithography machines from the Dutch company ASML[26]. Despite their high cost (over $150 million each), these machines are more cost-effective and advanced compared to older chip-making tools, making EUV technology essential for producing cutting-edge semiconductors more efficiently and competitively. While the transition from pre-EUV wafers to post-EUV wafers has significantly impacted revenue in the short run, the foundry market is expected to grow from $110 billion

[26] *See* ASML section p.14

today to $240 billion by 2030, with almost 90% of the growth coming from EUV nodes and advanced packaging.

Intel's IDM 2.0 strategy represents a pivotal shift in the company's approach to semiconductor manufacturing, aiming to regain technological leadership and expand its market influence. Despite initial setbacks, Intel has made significant progress with substantial investments in new fabs and the establishment of Intel Foundry Services. These efforts are geared towards meeting the growing demand for high-performance computing driven by AI advancements. As Intel navigates the complexities of this transition, its focus on innovation and strategic investments positions the company for long-term success and competitiveness in the global semiconductor market.

TSMC

Moving upstream in the supply chain of the semiconductors used by the aforementioned companies we find Taiwan Semiconductor Manufacturing Company Limited (TSMC). As the name suggests, TSMC is located in Taiwan and operates in field of semiconductors manufacturing and design. Its products are used for applications covering a variety of end markets including high performance computing, smartphones, the Internet of Things.

Taiwan Semiconductor created the semiconductor Dedicated IC Foundry business model when it was founded in 1987. Ever since then it has been as a beacon of innovation and excellence in the semiconductor industry, commanding a dominant position from a business standpoint. As the world's largest dedicated semiconductor foundry, and second largest semiconductor industry company[27], TSMC's dominates the supply side of the industry, accounting for about 60% of all semiconductors manufactured worldwide and over 90% if considering only high-end semiconductors.

By choosing not to design, manufacture or market any semiconductor products under its own name, TSMC ensures that it never competes with its customers, which include Apple, Nvidia, Advanced Micro Devices, Intel, Amazon and many more. So, a growth

[27] Considering a market cap of $717 Billion as of 27 Apr 2024, considering 5,19B outstanding shares and a closing price of $138

of sector as a whole and other corporations means that Taiwan Semiconductors is also growing, without harming each other. The main competitor of Taiwan Semiconductors is Samsung, which ranks second, ahead of Intel. Despite a solid first place position, TSMC is facing competition from both Samsung and Intel, that are aggressively trying to overtake the leadership, with little success.

There is no sign that TSMC dominance in the semiconductor foundry business could end anywhere soon, but this statement is conditioned by two conditions: 1) TSMC keeps producing the best available chips in the market, and 2) TSMC's customers keep buying the chips, without producing them on their own. While the second point is highly improbable, as it is more convenient for corporations to buy chips from others than producing them, the first point depends entirely on Taiwan Semiconductors' ability to surpass competitors. At the moment TSMC is a key enabler of AI applications. AI technology is evolving to use ever increasingly complex AI models, which needs to be supported by more powerful semiconductor hardware. Thus, the value of its technology position is increasing as customers rely on TSMC to provide the most advanced process and packaging technology.

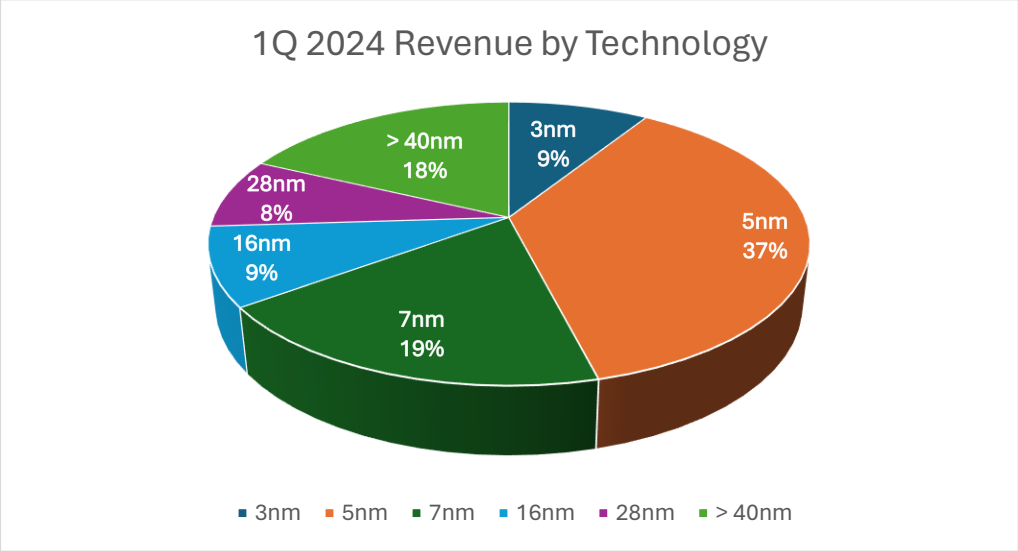

Figure 5: 1Q24 TSMC revenue by Technology. Source: TSMC

TSMC recently announced the new advanced chips that will join the production line in the next few years. The semiconductor hardware differentiates by their size, which is indicated in nanometers (nm, one nanometer is equal to one billionth of a meter). The smaller the size, the higher the efficiency and power, as in the same space more

semiconductors can be placed[28]. At the moment most high-tech chips vary in size from 7-nm to 3-nm. On April 24 TSMC officially announced that it will start 1.6-nm production in 2026. Previously, TSMC had announced its plans for 2-nm mass production in 2025 (the chipset in Apple's iPhone 17 Pro series would be the first to use TSMC's 2-nm fabrication process) and 1.4-nm in 2027. Samsung also plans to begin 2-nm production in 2025 and 1.4-nm in 2026, while Intel announced its next-generation 1.8-nm foundry process expected to go into mass production by the end of this year, and it has secured Microsoft as a major customer.

Despite weaker results for the first quarter of 2024, with a sequential decrease in quarterly revenues by 3.8%, for the second part of 2024, the guidance is positive, with TSMC business to be supported by strong demand for TSMC's industry-leading 3-nanometer and 5-nanometer technologies. Expected second quarter revenue are between USD 19.6 billion and USD 20.4 billion, which represents a 6% sequential increase and a 27.6% year-over-year increase. Continued smartphones seasonality negatively impacted both first quarter results and second quarter guidance[29].

ASML HOLDING

ASML is the only European company of the list, and it is the one that allows all the previous mentioned companies to exist and grow, as it stands at the top of the semiconductor sector supply chain. Ever since 1984, when the electronics giant Philips and the chip-machine manufacturer Advanced Semiconductor Materials International (ASMI) created a new company to develop lithography systems for the semiconductor

[28] The fact that the number represents the actual chip size is misleading, as this was true at least a decade ago, but not nowadays. While corporation and the wide public still use the "size" in nanometres to differentiate different chips, such number does not refer to the actual size but to the efficiency. Advanced chips are in fact so small that measurements are extremely difficult. As a result, the commonly accepted way to name these new transistors has been to estimate the size of a planar transistor needed to achieve the same logic density. It is important to point out that while measures are generally comparable, each manufacturer is different, so for example TSMC's 10-nm is different from Intel's 10-nm, and a higher nm might be better than a lower one. To sum up, in general, the lower the number in nm, the better, as it means a better optimization, efficiency, density or design.

[29] *See* Huan Wendell, Senior VP of Finance & CFO, Q1 2024 Taiwan Semiconductor Manufacturing Co Ltd Earnings Call Transcript (Apr 2024) pp.3

market[30], ASML embodied the essence of the semiconductor industry by developing and assembling revolutionary machines.

ASML is the world's leading tool manufacturer with a strong market position in the semiconductor lithography systems, with a revenue market share of over 90%. This unchallenged Lithography leadership is emphasised with a de facto monopoly in sophisticated extreme ultraviolet (EUV) lithography systems. These tools are critical to produce the most advanced vanguard chips necessary to develop and optimize technologies like AI and virtual reality.

ASML dominance reigns uncontested as no firm can oppose to such domain. In fact, other corporations have no intention nor the power to oppose, and their products aim to the creation of a niche because of the affordability and the higher efficiency of their products. One example is Canon with its new lithography machine that use a nanoimprint technology to make chips at low cost. The process, says Canon, will be "one digit" cheaper and use up to 90 percent less power than ASML's EUV technology. However, the new technology won't grab share away from EUV technology, as it cannot achieve the chip specifications needed for complex microprocessors.

2023 was an incredible year for the company, with total net sales that increased 30% from the previous year[31]. But as of Q1 2024, results were not what investors expected, in fact, while profit increased, net sales fell nearly 22% while net income dropped 37%. While this could be a potential warning sign for the whole industry, ASML didn't modify its 2024 outlook, that should be similar to 2023, as they expect the second half of the year to be stronger than the first one. Expecting a 2025 even greater, with an upturn of the industry and the openings of new semiconductors manufacturing plants[32], as declare by Roger Dassen, chief financial officer of ASML.

[30] At that time ASML (ASM Lithography) was just a joint venture between Philips and ASM. In 1988, the corporation became independent, keeping the abbreviation ASML as official name.
[31] Total net sales 2023: 27,6bn vs 2022: 21,2bn
[32] Samsung, TSMC and Intel are ramping up production capacity in America, with the support of funding from the U.S. CHIPS and Science Act

RECENT DEVELOPMENTS

GLOBAL CHIP SHORTAGE

In the years 2020-2023, the world experienced a major chip shortage that became a notable obstacle, impacting industries on a global scale[33]. At the earth of the global chip shortage lies a confluence of factors, each exacerbating the other. One primary cause is the surge in demand for semiconductor chips driven by the rapid digital transformation and technological advancements. Simultaneously, the COVID-19 pandemic intensified existing vulnerabilities within the semiconductor supply chain.

Coronavirus was indeed the match that ignited the fire, causing a strong mismatch between demand and supply. Lockdown measures affected both demand and supply. Demand for remote working and entertainment technologies, such as PCs, tablets and videogame consoles soared. At the same time, the supply of chips that was already struggling to keep up with demand, suffered a disruption in manufacturing operations, leading to production delays and shortages. To make things worse, chip shipment themselves were delayed due to the reduced number of flights and closure of airways, natural disasters, such as a drought in Taiwan[34] and plant fires in Japan between 2019 and 2021[35], contributed to raw materials shortages.

Geopolitical tensions and trade disputes have also played a significant role in exacerbating the chip shortage. The U.S.-China trade war in particular has disrupted the flow of semiconductor materials and components, leading to increased uncertainty and volatility in the market. Furthermore, the complexity of the semiconductor supply chain amplified the ripple effects of disruptions as most companies making logic components have outsourced the manufacturing. With multiple layers of suppliers spread across different regions, any disturbance in one part of the chain can cascade through the entire ecosystem, magnifying the impact of the shortage.

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[33] According to a research by Goldman Sachs more than 160 industries were affected by the global chip shortage. *See* Howley Daniel, *These 169 industries are being hit by the global chip shortage* (Apr 2021)
[34] *See generally* the Taiwan drought of 2021. Water scarcity was so severe that water supply was cut for chip making hubs.
[35] *See generally* Renesas fire damage at Naka plant of Jun 2021 or AKM factory fire of Oct 2020.

SEMICONDUCTOR SURPLUS AND INVENTORY BUILD UP

How the world went from a semiconductor shortage to a glut? The transition from a semiconductor shortage to an oversupply can be attributed to several key factors that unfolded during this period. The primary catalyst was the COVID-19 pandemic, which caused major disruptions in both the demand and supply of semiconductors and electronic devices. The emergency status for the pandemic lasted three years[36] and it continually modified the global economic landscape.

Demand surged in few weeks, overwhelming the supply chain. However, production takes time to adjust so the supply response was sluggish. To cope with the shortage, semiconductor manufacturers ramped up production and expanded their capacities. In addition, companies began stockpiling chips to avoid future shortages, thus reducing the immediate need to purchase more semiconductors. When the immediate impact of the pandemic began to wane, the demand for electronics started to normalize. However, the increased production capacity and large inventories built up during the shortage period resulted in an oversupply of semiconductors.

Another significant factor that led to the oversupply was the economic slowdown caused by increased interest rates in response to rising inflation. Central banks around the world raised interest rates to combat inflation, which in turn led to higher borrowing costs for businesses and consumers. This dampened economic activity and reduced spending on electronic goods, including smartphones, computers, and automobiles that heavily rely on semiconductors. Consequently, the demand for semiconductors dropped sharply, further exacerbating the imbalance between semiconductor supply and demand.

In summary, the world went from a semiconductor shortage to a glut due to a combination of the pandemic-induced surge in demand, rapid expansion in production capacity, strategic stockpiling and an economic slowdown triggered by increased interest rates. These factors collectively resulted in an excess supply of semiconductors once demand returned to normal levels.

[36] The World Health Organization ended the global emergency status for COVID-19 on the 5th of May, more than three years after its original declaration in March 2020

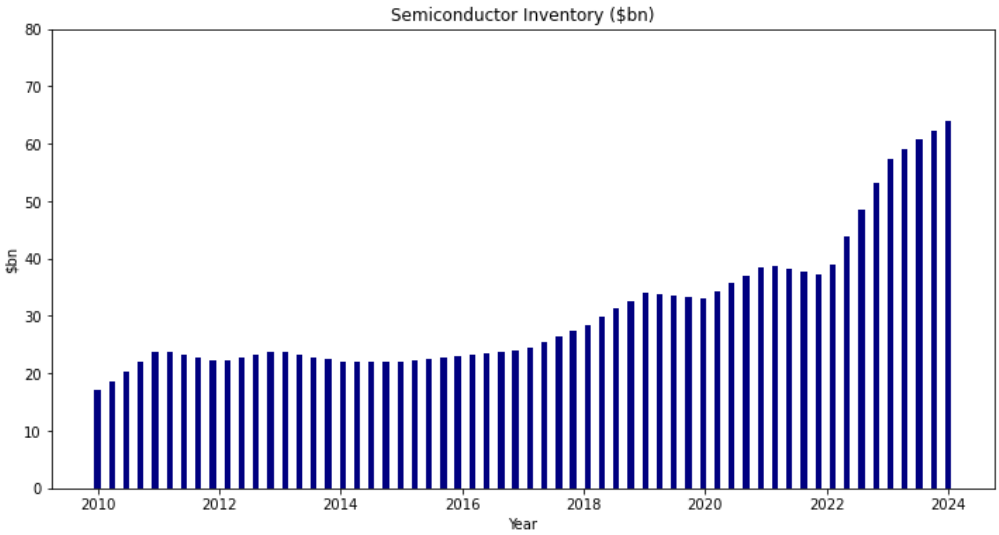

Figure 6: Semiconductor inventory levels from 2010 to 2024. Source: Bloomberg

The semiconductor industry is currently facing significant challenges due to high inventory levels and sluggish demand in end markets. These conditions might create several notable risks for companies within the sector. To manage the excess inventory, companies might lower their prices to boost sales and improve inventory turnover. While this strategy can help reduce inventory levels, it can also lead to weakened revenue and profitability. In addition, the rapid pace of technological advancements in the semiconductor industry leads to new models being launched on a yearly or bi-yearly basis. This rapid cycle can make older chips obsolete more quickly. High inventory levels of these older models can become problematic as they lose their market value and demand diminishes.

Considering the prevailing challenges in the semiconductor industry, insights taken from a recent survey conducted by KPMG[37] shed light on executives' perceptions and planned responses. According to the survey, a notable 30% of semiconductor executives identify an overabundance of inventory within the industry. Moreover, 45% of respondents indicate that their primary course of action, either already initiated or anticipated within the next year, is to reduce on-hand inventory levels.

[37] Annual survey of 172 senior executives from global semiconductor companies. Source: Clark Lincoln & Gibson Mark, G*lobal Semiconductor Industry Outlook 2024*, KPMG and Global Semiconductor Alliance (2024)

These results highlighting the widespread acknowledgment of inventory challenges and the efforts to mitigate associated risks, in order to increase resilience and adaptability to uncertain market condition.

AI GOLD RUSH

The years 2023 and 2024 marked a pivotal moment in the history of artificial intelligence (AI), characterized by what has been dubbed the "AI gold rush." AI is one of the most revolutionary technological advancements in recent history and this period witnessed an unprecedented surge in the adoption and integration of artificial intelligence technologies.

For the moment, the main beneficiaries of AI growth are the so-called AI enablers, such as big tech companies including Amazon, Microsoft, Alphabet, Meta, and OpenAI. These companies train AI solutions, integrate them into their software, and offer the final product as a service to their clients and end users. Also included in this category are high-end chipmakers like Nvidia, AMD, and ASML, which supply the market with the advanced hardware necessary to support and accelerate AI applications.

However, much of the unrecognized value in AI lies in software and applications, focusing on "adopters." AI adopters integrate AI solutions offered by enablers into their production processes to automate and enhance the efficiency of existing operations. Industries such as customer service, healthcare, finance, and logistics are poised for significant transformation through AI, benefiting from increased efficiency, cost reduction, and improved outcomes.

Manufacturing firms increased their investment in AI-driven automation and robotics. For instance, the conglomerate giant Siemens enhanced its production lines by integrating AI-powered robots capable of performing complex assembly tasks with precision and speed, resulting in a 20% increase in production efficiency.[38][39]

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[38] *See* Siemens, *AI-enhanced robotics and the future of manufacturing.*
[39] *See* Siemens, *Siemens revolutionizes engineering simulation with HEEDS AI Simulation Predictor and Simcenter Reduced Order Modeling*

The “buy now, pay later” company Klarna in February 2024 began using an AI assistant powered by OpenAI. In the first month, it had 2.3 million conversations, 60% of Klarna’s customer service chats. The company estimates that the chatbot could help improve its profits by $40 million in 2024.[40]

In logistics, companies like Amazon and DHL invested heavily in AI algorithms for supply chain optimization. Amazon implemented machine learning models to predict demand more accurately and optimize inventory management.[41]

Financial institutions have also ramped up their AI spending. For example, JPMorgan Chase developed an AI-based fraud detection system that analyses transactions in real-time, significantly reducing fraudulent activities. They also introduced an AI-powered virtual assistant that allows consumers to request information, such as account balances, on demand. Machine learning enables this virtual assistant to adapt to clients' behaviour over time, making insightful and personalized recommendations.[42]

The AI journey is in its early stages, with numerous opportunities expected to emerge across the ecosystem in the coming years. AI will soon transform the way we think, work, and solve problems, opening the way for groundbreaking innovation and significant change.

PRESENT AND FUTURE TRENDS

ECONOMIC CYCLES

The semiconductor industry experiences significant cyclical fluctuations, largely driven by supply and demand forces. Upturns occur during periods of high demand, leading to supply shortages, increased prices, and revenue growth. Conversely, downturns result from inventory buildups, causing falling prices and stagnant or negative revenue

[40] *See* Zara Christopher, *Klarna says its AI assistant does the work of 700 people after it laid off 700 people* (Feb 2024)
[41] *See* Amazon Web Services (AWS): demand forecasting & planning, AI-powered inventory management
[42] *See* JPMorgan Chase & Co, *This $12 Billion Tech Investment Could Disrupt Banking, How AI will make payments more efficient and reduce fraud*

growth. Several key factors drive this cyclicality, the main ones being inventory surplus and economic growth.

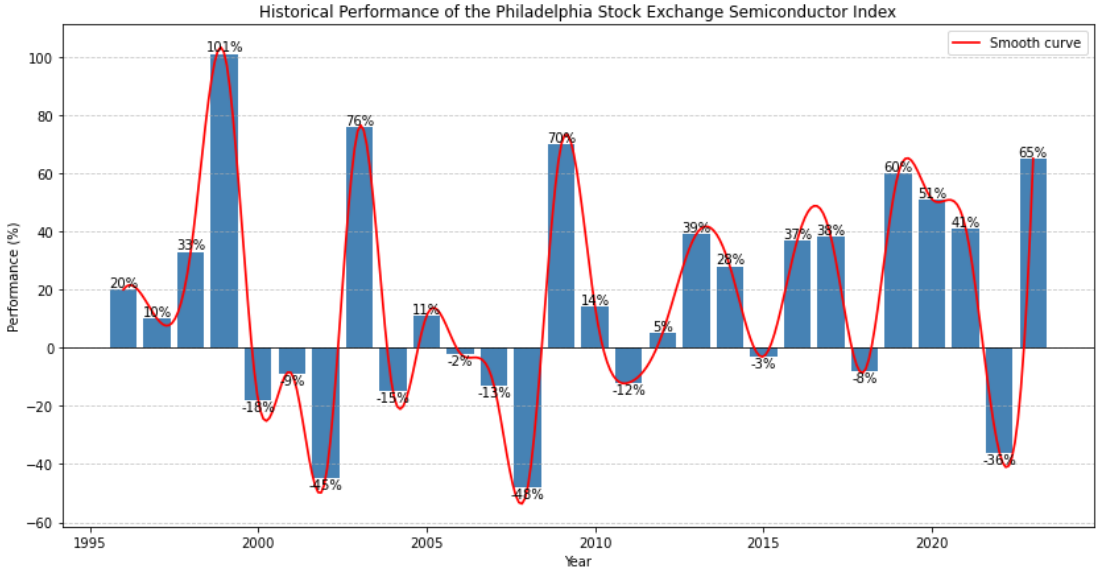

Figure 7: historical performance of the Philadelphia stock exchange semiconductor index (SOX). Data from 1996 to 2023. Source: Bloomberg

Inventory buildup can arise from either increased supply or declining demand. During high-demand periods (e.g., 1998-2000 or 2019-2021, as shown in Figure n), semiconductor manufacturers achieve high profitability and typically reinvest profits to expand capacity. Once this increased capacity becomes effective, supply often exceed demand, leading to inventory buildups and falling prices, which in turn cause revenue growth to decline and the industry to enter a downturn. Similarly, weak product demand can also lead to inventory buildups and subsequent downturns.

The second main factor is economic growth. In fact, there is a strong correlation between gross domestic product (GDP) and the semiconductor industry cycle. Economic growth boosts industrial output and stimulate spending and investment[43], thus increasing the demand for semiconductors and triggering an upturn in the industry. Conversely, during periods of economic stagnation or decline (e.g., 2008-2009), reduced IT spending by corporations and lower consumer spending lead to a downturn in the semiconductor industry.

[43] In this case, investments refer to the definition used by economists. So, the term refers to the purchase of new capital goods, like plants or machinery, to produce output in the future.

The cyclical nature of the semiconductor industry is notorious. Strong evidence from the past 30 years has led firms to adapt by closely monitoring inventory levels and aligning production with economic trends. In 2023, the semiconductor industry reached new heights due to the high demand for chips needed to develop and train AI. This trend continued strongly in 2024, with skyrocketing demand for AI data center graphics processing units.

While the current trend is clear, the sustainability of such robust growth in the future remains uncertain. Looking ahead, firms must navigate potential challenges such as geopolitical tensions, supply chain disruptions and evolving technological advancements to maintain their competitive edge and sustain growth.

GEOPOLITICS OF SUPPLY

As we already mentioned, most companies making logic components have outsourced the manufacturing. Outsourcing significantly reduces the capital and R&D overhead by sharing the costs with other semiconductor companies through foundries.[44] TSMC is the largest foundry in the world and dominates the supply side of the industry, accounting for about 60% of all semiconductors manufactured worldwide and over 90% if considering only high-end semiconductors.

Most tech companies, such as Nvidia, Apple, and Amazon, rely heavily on TSMC for their chip supply. While Taiwan Semiconductor has consistently met its clients' needs, the dependence on a single supplier is inherently risky. The global chip shortage of 2020 highlighted existing vulnerabilities within the semiconductor supply chain, drawing attention to the dangers of overreliance on a single, foreign supplier. When that supplier is based in Taiwan, this industry risk quickly escalates into a global geopolitical concern.

Taiwan, officially known as the Republic of China (ROC), is a relatively small island - slightly larger than Belgium- located at the junction of the East and South China Seas in

[44] See Intel section p. 9

the northwestern Pacific Ocean. Long story short,[45] China sees the self-ruled island as a part of its territory and insists it should be unified with the mainland, by force if necessary. Taiwan sees itself as distinct.

As years passes, the tension between the two sides increases. In 2016, the Democratic Progressive Party (DPP), pro-independence, won the presidential election and secured a majority for the first time in history. In response, Beijing cut off official contacts with Taiwan. The situation exacerbated in 2024, with the election of William Lai as president. In fact, shortly after being sworn in May, he urged Beijing to replace confrontation with dialogue, calling on China to stop threatening the island and to acknowledge its democratic existence. In response, China has started two days of military exercises around Taiwan, with its military[46] calling them "a strong punishment for the separatist acts of Taiwan independence forces and a serious warning against interference and provocation by external forces.".

The situation is very delicate, as Taiwan plays a crucial role in the global economy. Despite its small size, Taiwan was the United States' eighth-largest trading partner in 2023.[47] Taiwan finds itself at the center of U.S.-China tensions, caught amid a technological and geopolitical competition between these rival powers. It is a key link in global semiconductor and technology supply chains and serves as the global center for advanced chip production. Taiwan's dominance in the semiconductor supply chain is one of its most critical geopolitical assets. The island's chip industry has earned the nickname "silicon shield" because its production capacity is believed to protect Taiwan from a potential Chinese military invasion.

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[45] Taiwan was administered by China's Qing dynasty ever since 1683, before it was ceded to Tokyo after Japan won the First Sino-Japanese War in 1895. After World War Two, Japan surrendered and relinquished control of territory it had taken from China. Afterwards, Taiwan was officially considered occupied by the Republic of China (ROC), which began ruling with the consent of its allies, the US and UK. But in the next few years a civil war broke out in China, and then-leader Chiang Kai-shek's troops were defeated by Mao Zedong's Communist army. Chiang and the Kuomintang (KMT)-led ROC government retreated to Taiwan in 1949 and the Communist Party of China established the People's Republic of China on mainland China. Chiang established a dictatorship that ruled Taiwan until the 1980s. Following his death, Taiwan began a transition to democracy and held its first elections in 1996. Source: BBC, Congressional Research Service

[46] PLA Naval Colonel Li Xi, spokesperson for the command

[47] *See* Roberts Ken, *U.S. Does More Trade With New No. 1 Mexico In 2023 Than Ever, Data Shows*, Forbes (Feb 2024)

To reduce dependency on Taiwanese production, China, US and EU are increasingly investing to secure their supply chains. Consequently, a growing amount of funds is being allocated to developing major programs supporting domestic chipmakers.

GEOPOLITICS OF RESHORING

Geopolitical tensions, U.S.-China trade disputes, and supply chain disruptions caused by the pandemic have heightened global awareness of semiconductor supply chain vulnerabilities. Rising uncertainty creates incentive for firms to reduce exposures to foreign suppliers by moving production and distribution processes to domestic producers.

Many governments are prioritizing chip security by proposing new incentives to support and protect domestic semiconductor manufacturing industries. They are backing this strategy with substantial funding and active intervention. The goal is to produce critical technology closer to home, reducing dependence on foreign supplies. Among the incentive programmes, the most relevant are the subsidies of US, China and EU.

Metric	S. Korea	Japan	China	U.S.	EU
Programme	K-Chips Act	National Semis Project	14th Five-Year Plan	CHIPS and Science Act	European Chips Act
Time frame	2022–2031	2022–2025	2021–2025	2022–2026	2023–2030
Broad value of incentives (USD billions)	$20	$15	~$142	$53 ($280)	$46

Table 2: summary of the incentive programmes implemented by various nations. The table is constructed using data from various sources that have been cross matched to create a table as accurate as possible. Main sources: RCB Wealth Management, Boston Consulting Group, Semiconductor Industry Association, European Commission.

China was the first country to actively try to reduce dependence on foreign produced chips and boost the development of a domestic industry. In 2014 the government established the China Integrated Circuit Industry Investment Fund (ICF), a China Government Guidance Fund[48]. The fund aims to help China reach its national goal of

[48] An investment vehicle set up as a public–private partnership that aims to further China's industrial policy goals. The fund operates as a corporate entity under Ministry of Industry and Information Technology and the Ministry of Finance.

achieving self-sufficiency in the semiconductor industry. While the actual value of incentives is unclear, since the Chinese government doesn't make those numbers public, an estimate from the Semiconductor Industry Association puts the figure at $142 billion between executed and planned financing. While, according to Bloomberg, China now has more semiconductor fabrication plants under construction than any other country.

China entered the semiconductor industry decades after the U.S., but with substantial subsidies and expertise from Taiwan, it now manages to produce a growing share of the world's chips. Among the many domestic semiconductor companies, the domestic leader is Semiconductor Manufacturing International Corporation (SMIC), the largest chip manufacturer in China.

In 2023 SMIC has achieved a 7nm process node and aims to develop 5nm chips this year. Despite this achievement, next-gen chips remain distant as China is encountering significant challenges in scaling up the production of next-generation advanced chips. While process nodes reduce in size, poor optimization and performance, in addition to high costs, make analysts and engineers sceptical, as they consider it more likely a political project than a commercially feasible one.[49][50]

Manufacturing advanced semiconductor chips, such as those below the 7-nanometer process, is an extremely complex and precise process. It requires sophisticated equipment and technology, which China is still in the process of developing. To add on that, export controls and restrictions, influenced by geopolitical tensions, have limited China's access to specialized equipment and machineries. On the other hand, China is making incredible progress in the development of legacy chips,[51] expanding capacity with the acquisition of older equipment from ASML.

While China struggles with the development of highly advanced chips, US is the undisputed leader of cutting-edge technology. In 2022, the U.S. announced the CHIPS[52] Act, a bipartisan legislation aimed at supporting domestic manufacturing of semiconductor chips. It incentivises domestic chip production to narrow the cost gap

[49] *See* Shilov Anton, *US officials doubt China's SMIC foundry can produce enough 7nm chips to satisfy Huawei's demand* (Dec 2023)
[50] *See* Pao Jeff, *SMIC to sell Huawei costly, inefficient 5nm chips* (Feb 2024)
[51] The Chips and Science Act of 2022 defines legacy devices as those produced with 28-nanometer (nm) technology or larger.
[52] Acronym for: Creating Helpful Incentives to Produce Semiconductors for America

between domestic and foreign. It proposes around $52 billion in subsidies and another $24 billion worth of tax credits. The strategy also includes implementing various export restrictions on China and conducting international lobbying with European partners to limit China's access to crucial technology necessary for developing the most advanced semiconductors.

Company	Federal Grant Amount	Anticipated Investment From Company
Intel	$8,500,000,000	$100,000,000,000
TSMC	$6,600,000,000	$65,000,000,000
Samsung	$6,400,000,000	$45,000,000,000
Micron	$6,100,000,000	$50,000,000,000

Table 3: summary of CHIPS Act's manufacturing incentives with main recipients (excluding GlobalFoundries, Microchip and BAE systems for clarity). Source: Semiconductor Industry association, Visual Capitalist

Thanks to these incentives, semiconductor companies are building fabs in the US. Intel is receiving the largest share, with $8.5 billion in grants and an additional $11 billion in government loans. The incentives are in fact a key element in enabling Intel's IDM 2.0 strategy.[53] The company plans to invest a total of $100 billion to construct new fabs in Arizona and Ohio, while also modernizing and expanding existing facilities. TSMC will also build two new fabs in Arizona, to achieve a production capacity in US of around 5% of total TSMC production.[54] The total investment from private companies and the government should reach the incredible amount of $280bn.

In the EU, the European Chips Act aims to generate more than $46 billion in public and private investment for semiconductor R&D and production. The goal is to double the EU's global market share from 10% to 20% by 2030, secure its supply chains, prevent future semiconductor shortages, and promote investment in the industry. Europe's semiconductor industry does not have as high a profile as that of the US, partly because no European firms currently manufacture leading-edge chips. This is due to over half of the continent's capacity being dedicated to chips with structures of at least 180nm, which are used by continent's industrial firms. Although Europe is home to a titan in the semiconductor industry, ASML, a monopolistic leader in EUV machinery, it does not

[53] *See* Intel section p. 9
[54] in 2023, TSMC produced approximately 16mn 12-inch wafers. The US plants will have an expected monthly capacity of 60k 12-inch wafer.

produce its own chips. With the Chips Act, The EU aims to attract foreign investment into its semiconductor market.

While the investments made by governments to secure part of their supply chains and prevent future semiconductor shortages may be practical, an hypothetical semiconductor self-sufficiency is just an ideal. The estimated costs to achieve self-sufficiency are immense, requiring an upfront investment of over one trillion dollars (1'000bn). For comparison, the entire semiconductor industry is currently valued at around $400 billion and is projected to reach one trillion dollars by 2030.

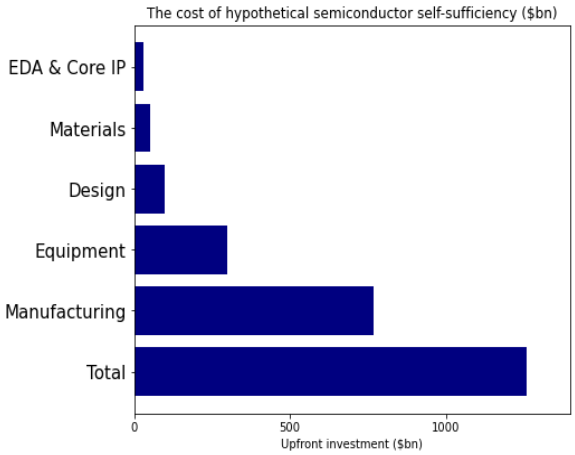

Figure 8: the cost of a hypothetical semiconductor self-sufficiency. Source: Bloomberg

Moreover, government efforts are aiming to replicate a business model that companies, focusing on optimising capital utilisation, had previously chosen to exit by offshoring. As the cost to manufacture chips domestically is undoubtedly higher that outsourcing.

Having this view in mind, all that glitters is not gold, as the western incentives have clearly a second objective in mind. In a period of rising tensions between US and China, the competition for semiconductor supremacy has become a critical battleground. The US's semiconductor policy is a multifaceted strategy designed to secure the nation's technological future. It isn't solely focused on subsidizing local manufacturing processes but also aims to hinder China's efforts in developing advanced chips. This approach is intended to ensure that the U.S. retains its technological superiority. A significant concern driving this policy is the potential for China to develop technology that could provide a military advantage. By implementing export controls and leveraging international partnerships, the U.S. seeks to maintain a strategic edge in the global semiconductor industry and protect national security interests.

FIRMS COMPARISON

Based on the analysis conducted on individual firms and the overall market conditions, we are now able to perform a comprehensive comparative analysis of these firms over time.

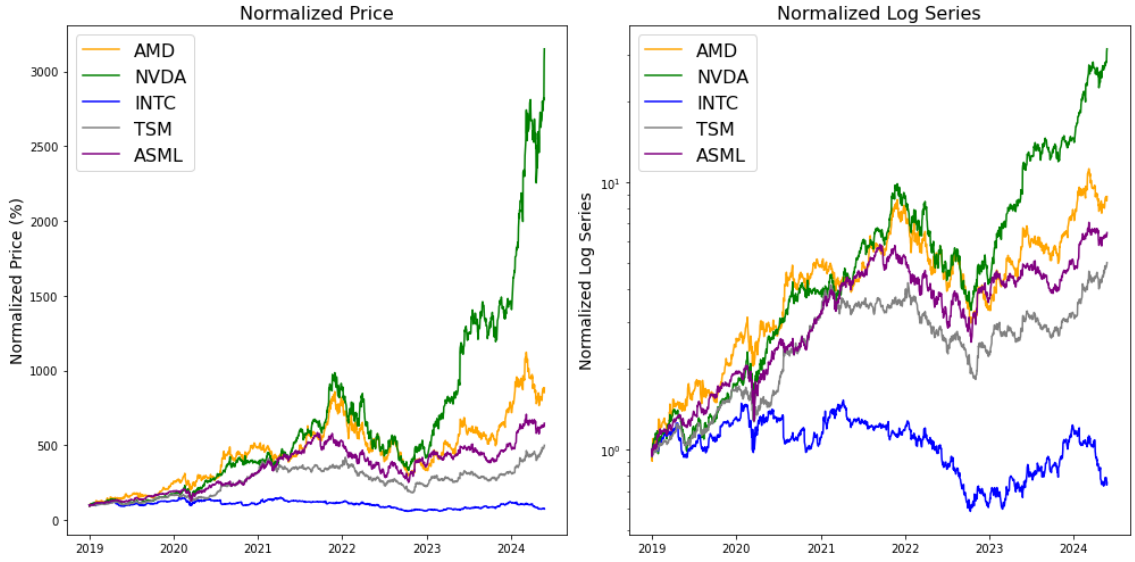

Figure 9: on the left (a), normalized price (%) plot. The plot normalizes the adjusted closing prices to 100 on the first observation for each stock. Each line represents the percentage change in the stock's price over time relative to its value on the first date. On the right (b), normalized log series plot. The plot first normalizes the adjusted closing prices to 1 on the first date and then takes the natural logarithm of these normalized prices. Each line represents the relative change in the stock's price over time on a logarithmic scale, compared to its value on the first date. Both graphs have the same time interval 2019-01-01, 2024-05-25. Source: Yahoo Finance

The graphs represent the stock charts of the firms. The left graph emphasizes percentage changes relative to the initial value, while the right graph emphasizes relative changes on a logarithmic scale. Nvidia is the undisputed winner, its advanced chips are the best currently available and boasts expertise derived from a long story of technological advancements, ever since 1999 when it launched "the world's first GPU"[55].

Despite efforts by AMD and Intel to capture some of Nvidia's market share, the leader's position remains robust. In fact, Nvidia not only excels in technology but also dominates the stock market. The difference in market capitalization has been present for many years, but as firms grow, the difference becomes exponential. Currently the market cap difference is enormous, with Nvidia being seven times bigger than AMD

[55] *See NVIDIA Launches the World's First Graphics Processing Unit: GeForce 256*, Nvidia (Aug 1999)

and Intel combined[56]. This substantial financial advantage provides Nvidia with access to resources and a level of popularity that its competitors can only dream of, further solidifying its dominance in the industry.

Despite its considerable size, Nvidia price to book ratio surged in recent years, showing that the market values the company's stock at a premium relative to its book value. This surge is likely to be the result of market expectations of growth, robust financial performances, and a strong brand image. However, while a high price to book ratio can be a sign of positive market sentiment and investor confidence, the sustained increase in Nvidia's price to book ratio should awaken some concerns, especially when compared to competitors in the same industry.

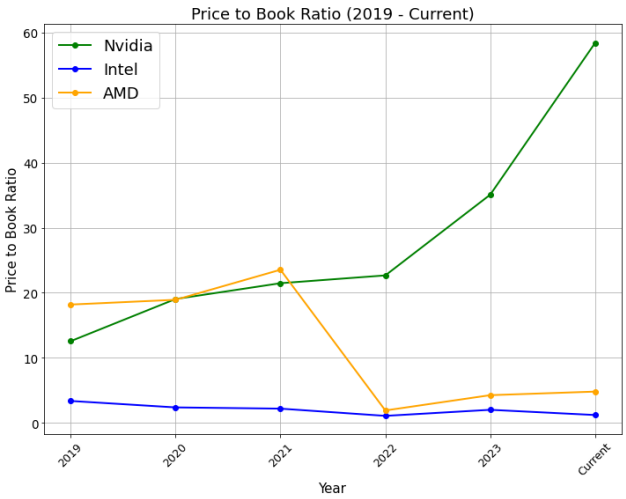

Figure 10: yearly price to book ratio for Nvidia, AMD and Intel from 2019 to 2024 (latest quarter). Source:Stock Analisys

In such landscape, Intel is in a peculiar situation, among all other firms, it is the only one that performed so badly that stock returns were negative. Before 2019 Intel had a market cap greater than Nvidia and AMD combined[57], had a strong dominant position in the CPU market and could boast from a long story of technological innovation leadership. Few factors lie behind Intel negative performance. The first one is the adverse economic environment of the post pandemic years (2021-2022). The chip manufactures TSMC and Intel were the first to be affected. TSMC, as a major semiconductor manufacturer, had an incredible performance in 2020[58], benefiting significantly from the chip shortage. In contrast, Intel, being a smaller self-

[56] As of 2024-05-31 Nvidia has a market cap of $2.71T, AMD $268.71B, Intel $128.45B
[57] In 2019 Intel had a market cap $256.75B, while Nvidia $144B and AMD $53.65B. The difference increases if considering previous years. In 2018 Intel had a market cap $211.93B, while Nvidia $81.43B and AMD $18.55B
[58] TSMC stock price increased by 101% in 2020. Considering closing prices 2020-01-06 $58.86 and 2021-01-04 $118.69

manufacturer, couldn't capitalize on the situation to the same extent and was hindered by other market segments.

The semiconductor surplus and slowing demand affected both TSMC and Intel in a similar way, the logarithmic graph (figure 9b, blue and grey lines) shows that both companies follow a strongly related path. The correlation matrix confirms such assumption, showing a strong positive correlation of 0.91 between the two firms in the years 2021-2022.

Correlation Matrix:		
	INTC	TSM
INTC	1.00	0.91
TSM	0.91	1.00

Table 4: correlation matrix for Intel and TSMC, period 2021-01-01, 2023-01-01. Source: Yahoo Finance

	2023	2022	2021	2020
Capital Expenditures	-25,750	-25,050	-20,329	-14,453
Free Cash Flow	-14,279	-9,617	9,127	21,411

Table 5: Intel capital expenditures and free cash flow, yearly values. Source: Stock Analysis

The second reason for the bad stock performance is the substantial financial investment required in the early stages of the IDM 2.0 strategy. The realization of this ambitious project is extremely expensive and demands significant upfront capital, while the anticipated profits are expected to materialize many years later. Investors generally dislike two things: risk and waiting. In addition, if we consider that Intel is few years behind Nvidia and AMD in GPU technology, the full picture begins to make sense.

The Dutch company ASML aligns itself with the trajectory of its clients, serving as a pivotal enabler of technological advancement for semiconductor manufacturers. Its de-facto monopoly in the EUV lithography machines might justify the relatively high price to book ratio. With an average of 24.16[59] over the past four years, ASML holds the second position, placing only behind Nvidia (58.7). The acquisition of ASML's lithography machines is one of the reasons behind Intel's high capex.

[59] The price to book ratios from "current" (latest quarter) to 2021 are, in order: 25.43, 19.92, 23.10, 28.18. Source: Stock Analysis

CONCLUSION

Artificial intelligence is at the centre of innovation. Powerful trends like data growth, machine learning and smart devices ensure AI adoption spreads across industries. Enthusiasm is among the stars, despite the AI journey still being in its early stages, with numerous opportunities expected to emerge across the ecosystem in the coming years.

AI fuelled a semiconductor boom in 2023, with a growing demand for semiconductors, key electronics in the production of data centers and graphic processing units (CPUs) required for developing and training AI applications. While the demand for the AI chips remains robust, the main beneficiaries are the semiconductor manufacturers, which easily exploited the situation by standing ready to supply the markets with cutting-edge chips.

Key players in the semiconductor industry panorama, such as Nvidia, AMD, Intel, TSMC and ASML emerged as winners, leading global industry growth and expansion. Outlook remains optimistic for 2024 and beyond. Revenues are projected to jump, and competition is expected to support a more sustainable and healthier long-term sector growth.

Despite optimism, 2024 has been defined by many a transaction year, macroeconomic and geopolitical uncertainty persists, and cyclical dynamics should play a major role in shaping the semiconductor industry on consumer-exposed markets and inventories. In addition, the US-China relationship is more tense than ever, adding uncertainty about semiconductor supply chain vulnerabilities.

Considering all factors, AI-related tailwinds continue to boost the leading companies in the sector, offsetting weaknesses in other markets that have yet to see improvement and uncertainties. Upward trends in generative AI, cloud computing, data centers, the increasing number of semiconductors in automobiles, and growing aerospace and defence budgets should combine to help the industry overcome some of the broader economic and geopolitical market risks. Looking toward future years, while some challenges persist, the overall industry outlook is strong.

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