

February 8, 2023

Semiconductors

Information Technology Sector

Industry Rating

Underweight

Investment Thesis

We recommend an Underweight rating for the Semiconductor industry over 2023, as the worldwide semiconductor market is expected to decline 4.1% in 2023¹⁶. This is driven by high inflation, a relatively higher interest rate regime, expected slowing demand in consumer end-markets, and restrictions on advanced chip sales to China, which is the market with the highest percentage of semiconductor sales for US-based semiconductor companies.

Industry Risks

- Semiconductor companies are seeing decreased demand in key end-markets (such as for memory chips and PCs), expected to persist through at least the first half of 2023.
- With the US seeking to limit China’s expansion of their semiconductor manufacturing industry, restrictions have been placed on exports of advanced chip sales to China. As many US-based semiconductor companies generate nearly 30% of their revenue from the Chinese market, we expect this to dampen revenue in 2023.
- Companies face a downward pressure in prices from excess inventories arising from decreased consumer demand, expected to persist through at least the first half of 2023.

Industry Drivers

- If a soft economic landing can be achieved, revenues are expected to recover in the second half of 2023, which would boost end-market demand.
- There is anticipated growth in AI, automotive, and 5G technologies which require semiconductors to function, and may increase consumer and enterprise demand for semiconductors.
- The CHIPS Act is expected to bolster domestic semiconductor production and address key supply chain vulnerabilities, which may help offset decreased revenues from export restrictions.

Industry Statistics

| Market Cap | (in \$ Billions) |
|-------------------|------------------|
| NVIDIA | 519.1 |
| Broadcom | 249.7 |
| Texas Instruments | 165.2 |
| QUALCOMM | 150.5 |
| AMD | 138.8 |
| Intel | 125.4 |

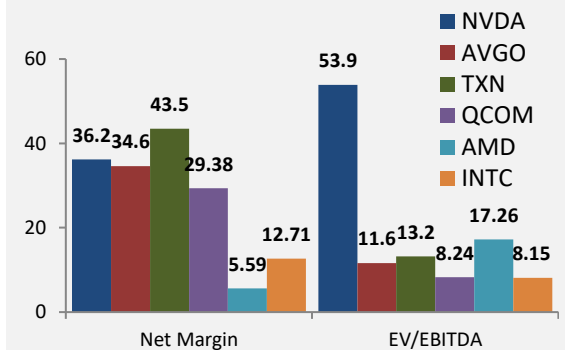
Price/Earnings

| | |
|-------------------|-------|
| NVIDIA | 59.37 |
| Broadcom | 17.82 |
| Texas Instruments | 17.57 |
| QUALCOMM | 10.65 |
| AMD | 77.11 |
| Intel | 13.59 |

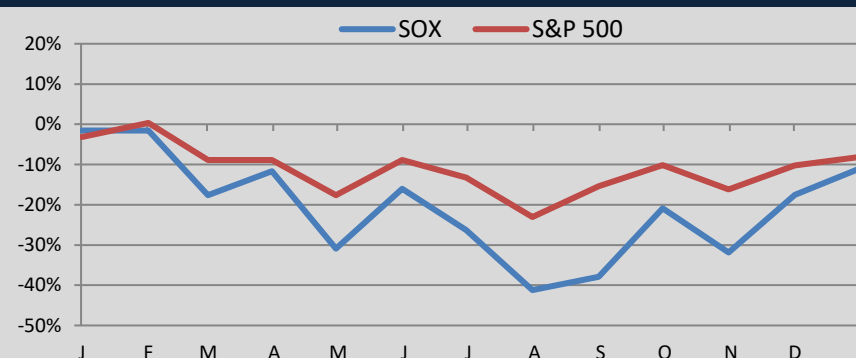
Price/Sales

| | |
|-------------------|-------|
| NVIDIA | 21.51 |
| Broadcom | 6.02 |
| Texas Instruments | 8.45 |
| QUALCOMM | 3.12 |
| AMD | 4.31 |
| Intel | 1.73 |

Source: Factset



12 Month Performance



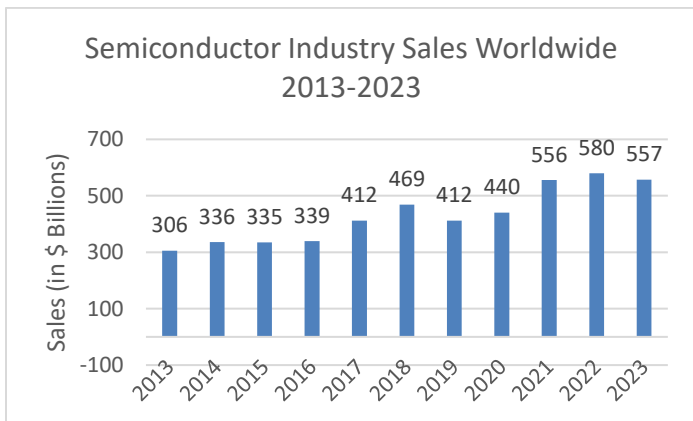
Industry Description

The semiconductor industry is a critical part of the Information Technology sector, consisting of companies engaging in the production of microchips, integrated circuits, and other components used in a wide range of electronic devices. The industry consists of three major business models: integrated device manufacturers (IDM), fabless, and foundry.¹⁰

INDUSTRY OVERVIEW

The semiconductor industry is a critical part of the Information Technology sector, consisting of companies engaging in the production of microchips, integrated circuits, and other components used in a wide range of electronic devices. The semiconductors subsector, as of February 2023, accounts for approximately 11% of the overall Technology sector, based on the market-weighted composition of the S&P 500 index. The semiconductor industry makes up approximately 6% of the total S&P 500 index.

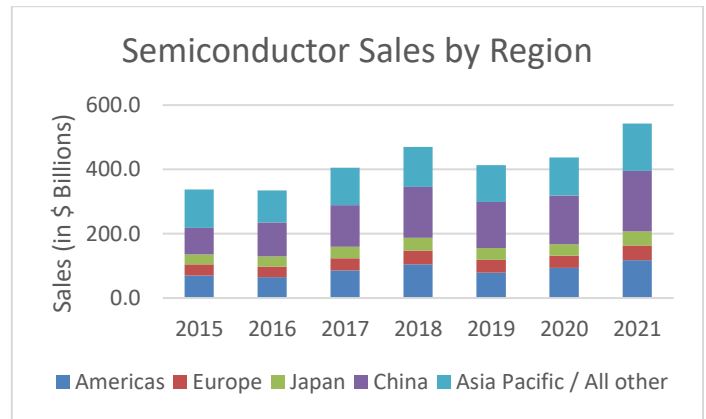
The semiconductor industry is generally considered to be a cyclical industry, as it is driven in large part by inventory, with inventory buildup driving down prices, and world economic growth, with increased GDP growth leading to and increased demand for semiconductors¹⁹. Historically, the semiconductor industry has run in “boom and bust” cycles, due to the high cyclical nature of the industry. This is driven in large part by global economic conditions and advancements in technology. In boom cycles, increased demand results in increased production and capacity expansions, which can lead to excess inventories given the relatively long lead times of semiconductors. Excess inventories can lead to lower prices, which can trigger a bust cycle until demand catches up with supply.



Source: Statista

As of 2021, China made up the largest percentage of semiconductor sales, accounting for 34.7% of total sales, followed by Asia Pacific / All Other and the Americas, respectively. While many chip designers are based in the US, including NVIDIA, AMD, and Intel, much of the semiconductor manufacturing is located in Taiwan, including Taiwan Semiconductor Manufacturing Company (TSMC) and United Microelectronics Corporation (UMC).

TSMC alone manufactures roughly 50% of the world’s semiconductors²⁴.



Source: Statista

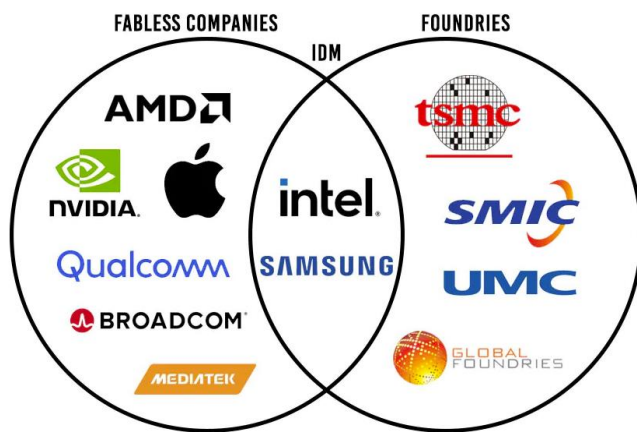
The semiconductor industry consists of three major business models: integrated devices manufacturers (IDMs), fabless, and foundry:

Fabless (non-fabrication) semiconductor companies focus solely on chip design, partnering with other foundries to manufacture chips¹¹. Examples of fabless companies include NVIDIA, AMD, Qualcomm, and Broadcom. These companies tend to have the most significant R&D expenditures, with high concentration given the limited number of companies operating in the space. These firms have the lowest capital expenditures in the industry, given their relatively asset-light business model¹⁷.

Foundries are responsible solely for semiconductor manufacturing, and do not engage in the design of chips. These companies tend to have higher capital expenditures, as constructing a semiconductor plant can cost 10 times more than establishing a fabless company¹⁰. Examples of foundries include Taiwan Semiconductor Manufacturing Company (TSMC) with 55% market share¹², GlobalFoundries (GFS), and United Microelectronics Corporation (UMC).

IDMs are responsible for the full manufacturing process, including both designing and manufacturing. Examples of IDMs include Intel, Texas Instruments, and Samsung.

Types of Semiconductor Companies



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Source: Phillip Capital Management

The main types of semiconductors produced based on functionality include memory chips, microprocessors, standard chips, and System-on-Chip (SoC)²³. Among the primary uses of these chips are:

Memory chips: Store data for fast access by electronic devices, including computers, smartphones, and gaming systems.

Microprocessors: The “brain” of a computer, used for complex calculations for use in computer servers, PCs, tablets, and smartphones.

Standard chips: Simple, mass-produced chips used for performing repetitive processing routines.

SoCs: Integrate all components of a computer or other electronic device on a single chip.

Growth in the semiconductor industry is largely driven by demand in key end-markets, including computer and data storage, wireless communication, automotive electronics, industrial electronics, and wired communication⁶, as these end-markets require semiconductors for their operations. Around 70% of growth is expected to be driven by the automotive, computation and data storage, and wireless alone in the long-term. This is due to a projected growth in demand for autonomous vehicles, servers to support AI and cloud computing applications, and for 5G in the coming future.⁶

INDUSTRY TRENDS

COVID-19 Impact

The COVID-19 pandemic caused significant supply chain disruptions in the semiconductor industry, which culminated in a chip shortage that affected the entire industry, notably the automotive industry. With the initial lockdowns in China, both a large market and major producer of semiconductors, semiconductor trade was restricted, which prompted automotive manufacturers to decrease their semiconductor chip orders, awaiting a significant downturn in sales²⁰.

With semiconductor production largely shifting to meet demand for consumer products during the lockdowns, they were unable to meet automotive chip orders as foundries were at capacity. Semiconductor manufacturers prioritized the existing orders to meet demand, which combined with longer lead times led to increasing capacity being insufficient to meet demand, prompting a shortage in semiconductors.²⁰

Currently, many semiconductor companies are faced with excess inventories, with firms generally forecasting improvements over this fiscal year, though these are expected to persist through the first half of this fiscal year.

Excess Inventory Concerns

In 2022, semiconductors experienced a shortage of chips arising from the COVID-19 pandemic, the Russo-Ukrainian War which adversely impacted neon supply (used for lithography – used to set the size of transistors on a chip) as Ukraine was a major neon supplier, and subsequent supply chain disruptions. However, many semiconductor companies are now facing excess inventories, driven by falling consumer demand for electronics with concerns over rising interest rates and a potential recession²¹. Inventory concerns are likely going to be an issue for semiconductor companies until consumer confidence improves and spending increases, which we do not anticipate occurring in the first half of 2023.

CHIPS and Science Act

In August 2022, the Biden Administration passed the CHIPS and Science Act, expected to help bolster domestic semiconductor manufacturing in the US through a \$52 billion investment, including 40 new semiconductor

ecosystem projects,¹¹ and \$24 billion worth of tax credits for chip production⁶, as well as addressing key supply vulnerabilities that came to light at the onset of the pandemic.

So far, we have seen stark investments from semiconductor manufacturers into domestic manufacturing. Micron has announced a \$40 billion investment in memory chip manufacturing, which is expected to boost US market share of memory chip production from 2% to 10%²⁵. GlobalFoundries, in partnership with Qualcomm, is expanding their upstate New York facility through a \$4.2 billion purchase agreement from Qualcomm to further expand their US manufacturing footprint⁸. TSMC, the world's largest contract chip maker, announced plans to invest \$40 billion to build a second semiconductor manufacturing plant in Arizona, though has cited concerns regarding expected building and operating costs²⁶.

This act is expected to greatly benefit both US-based semiconductor manufacturers and fabless companies in the long-term.

For US semiconductor manufacturers, including Intel, Micron Technology, GlobalFoundries, this could allow them to increase domestic production capacity, through the act's provisions for funding new semiconductor fabrication facilities. Additionally, through funding research and development, US manufacturers have greater capacity to develop new technologies to remain competitive in the global market.

For US semiconductor fabless companies, through provisions for funding research and development we expect companies such as NVIDIA, AMD, Apple, Qualcomm, and Marvell Technology to benefit as this would allow them to remain competitive in the global market. This includes continued technological development for chips in certain high growth areas including artificial intelligence, high performance computing, and 5G.

If these efforts prove to be successful, we expect lower cyclicity in the US semiconductor industry in the future, as there will be lower supply chain risk as US-based semiconductor companies will be able to have chips manufactured domestically to meet demand. However, this does have the potential to fuel greater geopolitical

tensions between the US and China, as semiconductor manufacturing is bolstered by the US.

Export Restrictions to China

In October 2022, the US government imposed restrictions on advanced chip sales to China, in an effort to limit the expansion of their semiconductor manufacturing industry. Many US-based semiconductor companies (including NVIDIA, Broadcom, and AMD) generate a significant portion of their revenue from the Chinese market, comprising near or above 30%, we expect revenues to be negatively impacted for semiconductors while these restrictions remain in place.

In October 2022, the US government issued restrictions on exports of advanced computing and semiconductor manufacturing items to China²⁷. The aim of these restrictions is to limit China's access to advanced semiconductors, supercomputers, and semiconductor manufacturing equipment²⁸, with the US citing national security concerns.

This is expected to have a stark negative impact on Chinese foundries, which This is expected to have a negative impact on US-based semiconductor producers which have benefited from spending from China's semiconductor sector, including Lam Research, Applied Materials, and KLA Corporation²⁹. However, this may reduce competition for US-based semiconductor manufacturers, such as Micron Technology²⁵.

Regarding fabless companies, these restrictions include new licensing requirements for exports of discrete graphics processing units, or GPUs. Discrete GPUs are capable of powering AI applications. As these have military and national security implications that could threaten the US, these GPUs are subject to restrictions as well. Currently, the discrete GPU market is dominated by NVDA and AMD, with these restrictions expected to have a negative impact on these firms.

Moore's Law Uncertainty

Moore's Law, created by co-founder of Intel Gordon Moore, states that the number of transistors on a microchip roughly doubles every two years, whereas its cost is halved over that same timeframe. This has significant implications for the semiconductor industry, as it is used for long-term planning and setting targets for

research & development targets²³, notably for chip designers such as Intel, NVIDIA, and AMD. However, there is uncertainty regarding the future of Moore's Law, with NVIDIA's CEO Jensen Huang stating that Moore's Law is over, citing slowing advances in technology manufacturing and shortages during the pandemic. Others, including Intel's CEO Pat Gelsinger stating that Moore's Law is "alive and well"¹⁸.

Moore's Law ending would have negative implications on the semiconductor industry, with growth expectations needing to be lowered in the future. To circumvent Moore's Law, innovative engineering solutions will be required, such as further development in artificial intelligence (AI), neuromorphic computing (creating a semiconductor that functions like a human brain), and quantum computing. We believe that while Moore's Law is unlikely to be indefinitely sustained, we are already beginning to see stark developments in AI and neuromorphic computing that provide an optimistic outlook for future semiconductor growth.

MARKETS AND COMPETITION

Barriers to Entry

We do not expect new entrants to disrupt the semiconductor industry. The semiconductor industry has very high barriers of entry for new entrants, due to regulatory, financial, and employee challenges⁴. For new entrants, significant capital expenditures are required to be able to manufacture semiconductors. For instance, Intel requires approximately 3 years, \$10 billion, and 6,000 construction workers to create one semiconductor factory.⁹ Existing chip designers also hold patents that new entrants will need to avoid, paired with consumer skepticism towards unfamiliar brands in the computer chip market. Semiconductor manufacturing and designing is a capital-intensive activity, requiring high employee compensation, often with six-figure salaries⁴.

Even given the incentives provided by the CHIPS and Science Act, we expect these funds to be primarily allocated towards existing US semiconductor

manufacturers and designers, such as Intel, Micron Technology, and GlobalFoundries.

Competitive Environment

Companies in the semiconductor industry face high internal competition with other industry players, but little external competition due to the uniqueness of computer chips⁴. The internal competition is driven primarily by major players in the semiconductor sub-industry (such as Intel, AMD, Qualcomm, Texas Instruments), who differentiate themselves based on chip performance, power consumption, and life expectancy⁵. The following

section we will focus primarily on US-based fabless and IDM semiconductor companies.

Peer Comparisons

Below, we highlight comparable fabless semiconductor firms based on a variety of key metrics:

Market Valuation

| Company | Market Cap (B) | P/E FY2022 |
|---------|----------------|------------|
| AMD | 138.8 | 77.11 |
| AVGO | 249.7 | 17.82 |
| INTC | 125.4 | 13.59 |
| NVDA | 519.1 | 59.37 |
| QCOM | 150.5 | 10.65 |
| TXN | 165.2 | 17.57 |

Source: FactSet

Profitability Ratios

| Company | Oper. Margin | Net Margin | ROA (%) | ROE(%) |
|---------|--------------|------------|---------|--------|
| AMD | 6.84 | 5.59 | 3.30 | 4.24 |
| AVGO | 43.03 | 34.62 | 15.45 | 48.20 |
| INTC | 3.70 | 12.71 | 4.57 | 8.14 |
| NVDA | 37.31 | 36.23 | 26.73 | 44.83 |
| QCOM | 33.49 | 29.38 | 28.78 | 92.88 |
| TXN | 51.91 | 43.48 | 33.57 | 62.41 |

Source: FactSet

Industry Ratios

| Company | R&D %Sales | EV/EBITDA |
|---------|------------|-----------|
| AMD | 21.21 | 17.26 |
| AVGO | 14.81 | 11.63 |
| INTC | 27.80 | 8.15 |
| NVDA | 19.57 | 53.87 |
| QCOM | 18.54 | 8.24 |
| TXN | 8.34 | 13.17 |

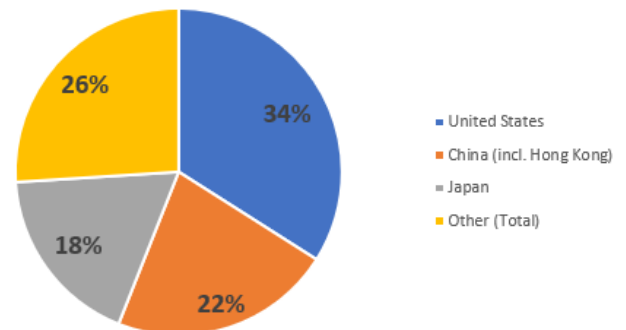
Source: FactSet

Advanced Micro Devices, Inc. (AMD)

AMD designs microprocessors for use in the computer and consumer electronics industries²⁴. The company operates two key business segments: Computing & Graphics (57% of total revenue) and Enterprise, Embedded, and Semi-Custom (43% of total revenue). The former includes computer processors and chipsets, discrete and integrated GPUs, data center and professional GPUs, and

development services. The latter includes server and embedded processors, semi-custom System-on-Chip (SoC) products, and development services and technology for game consoles¹. In 2022, AMD acquired Xilinx for \$50 billion, allowing them to increase their presence in the data center market, AI, and 5G communications⁸. We view AMD's further expansion into these markets as positive, given positive growth prospects in the data center end-market and for AI.

AMD Geographic Segments



Source: Factset

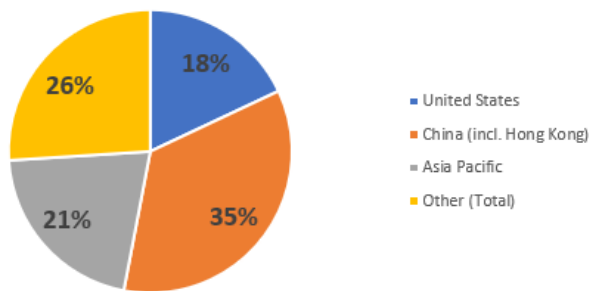
Broadcom, Inc. (AVGO)

AVGO is a US-based company that designs, develops, and supplies semiconductor and infrastructure software products¹. The company generates 78% of its revenue from its Semiconductor Solutions segment, which manages movement of data in data center, telecom, enterprise, and embedded networking applications¹. In May 2022, AVGO announced their intention to buy VMware Inc, a cloud-computing and virtualization

technology company, for \$61 billion, though this is pending EU regulatory approval.

Moore's Law, we anticipate decreased revenues for INTC for this fiscal year.

AVGO Geographic Segments

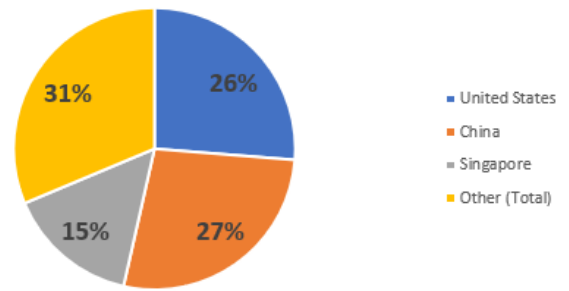


Source: FactSet

Intel Corporation (INTC)

INTC is world's largest chipmaker, engaging in the business of processor manufacturing for the global personal computer and data center markets²⁴. INTC's revenue primarily comes from its Client Computing segment, consisting of platforms designed for computing devices, wireless and wired connectivity products, and mobile communication components¹. INTC generates a significant portion of their revenue from their United States and China geographic segments, making up 26% and 27% of their total revenue, respectively. As of their most recent earnings announcement, INTC reported weak Q4 results driven by weak consumer demand for the PC and server end-markets, as well as lowering expectations for full year results. Given our consensus of negative real GDP growth in the first half of 2023 and potential concerns surrounding

INTC Geographic Segments

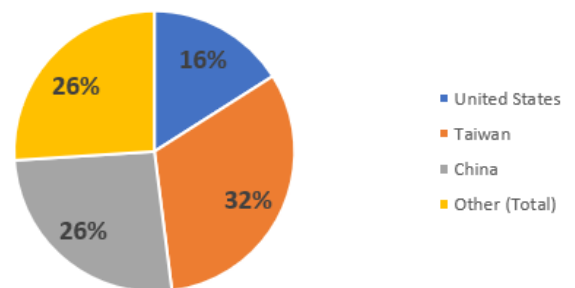


Source: Factset

NVIDIA Corporation (NVDA)

NVDA is the market leader in discrete graphics processing units (GPUs), while also designing chips for use in PCs, data centers, as well as increasingly focusing on autonomous driving and artificial intelligence opportunities²⁴. NVDA operates two key business segments: Graphics and Compute & Networking, comprising 59% and 41% of total revenue, respectively. We believe NVDA to be in a strong position for the long-term, given their dominance of graphics chips needed to power AI applications, namely ChatGPT, an AI-chatbot that has reached over 100 million users². If NVDA continues to develop and be a leader in chips for artificial intelligence, we believe that the company will fare well in the long-term.

NVDA Geographic Segments

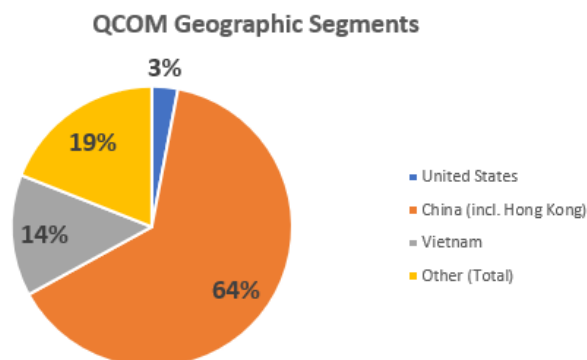


Source: Factset

QUALCOMM Incorporated (QCOM)

QCOM develops and licenses wireless technology and designs semiconductors. The company generates a majority of their revenue (86%) from their CDMA

Technologies segment, which develops and supplies integrated circuits and system software for use in voice and data communications, networking, application processing, multimedia, and global positioning systems products¹. QCOM is seen as a leader in 5G technology²⁴, which we believe positions the firm well competitively to capitalize on expected growth in 5G technologies.

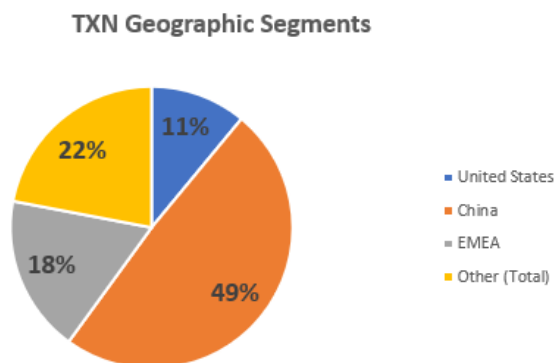


Source: Factset

Texas Instruments Incorporated (TXN)

TXN is an IDM that focuses on the design and manufacturing of semiconductors, operating through primarily their Analog segment (77% of total revenue), which makes semiconductors that is used for real-world signal processing, such as sound, temperature, or images^{24,1}. As of their most recent earnings call, TXN is facing issues with excess inventory without providing a date as to when this is expected to resolve.² Given the lack

of near-term outlook provided by players in the industry, we expect these inventory issues to persist in 2023.



Source: Factset

ESG Analysis

ESG, or Environment, Social, and Governance, is a framework to assess the sustainability and ethical impact of companies based on those three metrics. A lower ESG risk rating score is considered better. Of our fables/IDM peer group used, ESG risk ratings fare relatively well, ranging between low and medium risk ratings.

| Company | ESG Risk Rating | |
|---------|-----------------|--------|
| AMD | 20.35 | Medium |
| AVGO | 22.11 | Medium |
| INTC | 18.97 | Low |
| NVDA | 13.62 | Low |
| QCOM | 14.60 | Low |
| TXN | 21.79 | Medium |

Source: Morningstar Sustainalytics

In general, fables companies have a lower environmental impact compared to other firms, due to these firms outsourcing chip manufacturing to third-party foundries. These firms, as shown in the geographic segments above, often have complex global supply chains which may bring rise to social risks including labor standards and supply chain transparency.

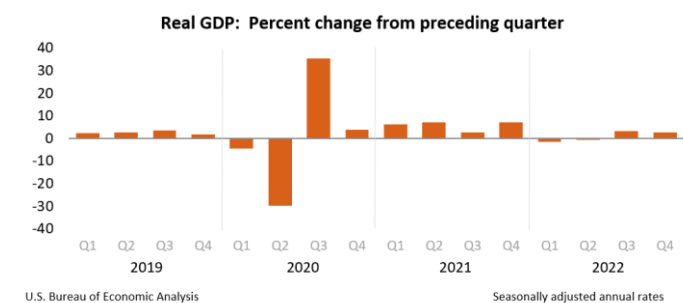
ECONOMIC OUTLOOK

Real GDP Outlook

In Q4 and Q3 of 2022, the real gross domestic product (GDP) increased at an annual rate of 2.7% and 3.2%, respectively³². Looking forward, the Conference Board

forecasts real GDP growth to be 0.3% in 2023³³, though this may be negative if the US fails to achieve a soft landing for the economy. Among the key risks facing the economy currently that we expect to negatively impact GDP growth in the short-term include higher levels of inflation and increasing interest rates, negatively impacting consumer spending. This is paired with the heightened probability of recession in 2023, a hypothesis that is supported by the current inverted yield curve, which have historically preceded recessions.

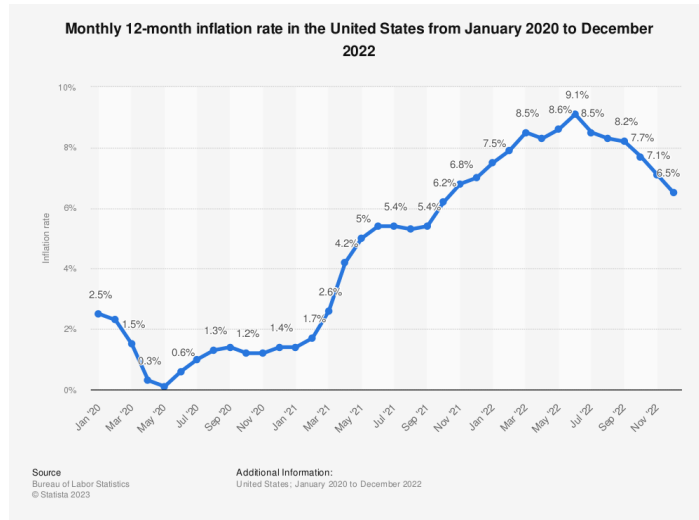
For the semiconductor industry, lower GDP growth could result in decreased demand in the end-markets that use semiconductors. In particular, a decline in demand is expected in the consumer electronics end markets, in particular for PCs, smartphones, and tablets³⁰.



Source: Bureau of Economic Analysis

Inflation

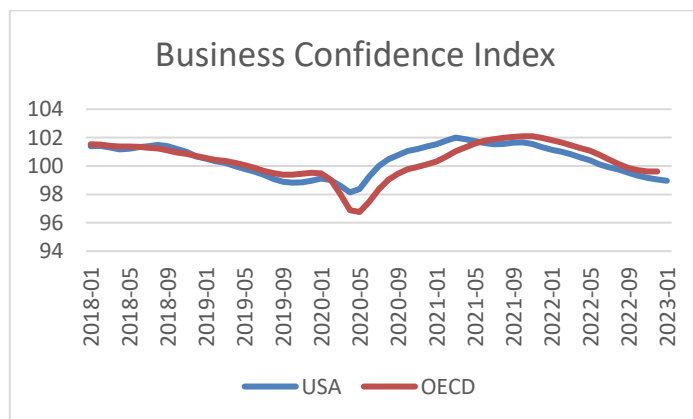
While the inflation rate has decreased from its high of 9.1%, it remains well above the Fed’s 2% target, sitting at 6.5% as of December 2022. The IMF estimates US inflation to be 3.5% and 2.2% in 2023 and 2024, respectively. Our consensus estimate is less optimistic, with a 6-month inflation estimate of 5.36% and a 2-year estimate of 2.63%. For the semiconductor industry, higher inflation can lead to higher input costs, reduced demand, and potentially reduced spending from enterprises and consumers.



Source: Statista

Business Confidence Index

The BCI is a leading economic indicator that provides insight on future developments, based on opinion surveys on developments in production, orders, and stocks of finished goods. Numbers above 100 suggest confidence in near future business performance, while numbers below 100 suggest pessimism¹³. Currently, both the global and the US BCI values are below 100, suggesting a majority pessimistic outlook towards business performance in the near future. For the semiconductor industry, this pessimistic outlook is likely driven by issues relating to excess inventory, which we expect to persist throughout at least the first half of 2023.

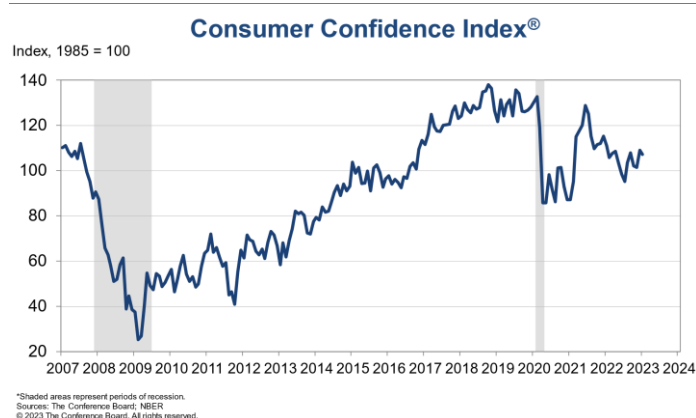


Source: OECD

Consumer Confidence Index

The Consumer Confidence Index (CCI) provides a measure of consumers’ attitudes towards economic and labor conditions, and is oftentimes used as a metric to gauge the

health of the US economy. An index of over 100 implies that consumers are more optimistic than the benchmark set in 1985²³. As of January 31, 2023, the CCI has decreased from its December value, with consumers being more pessimistic about the US business outlook more confident in income stability²⁵. Our consensus remains that consumer confidence will decrease over the next six months, driven by concerns regarding inflation and lower savings from the pandemic. For the semiconductor industry, lower consumer confidence indicates a lower anticipated spending in key end-markets, which could negatively impact firms' revenues. Specifically, firms with more consumer-focused segments, such as NVDA's Gaming segment, may be more hurt than those focused on enterprises, such as NVDA's Data Center segment.



Source: The Conference Board

Interest Rates

Interest rates are among the most important aspects that impact the economy, as they influence borrowing, savings, and inflation. In the United States, the Federal Reserve is responsible for setting the federal funds rate, which is the target interest rate at which at which banks lend and borrow money from each other²³. This has ripple effects on the economy, impacting longer-term interest rates such as mortgages, loans, and savings, which significantly impact consumer wealth and confidence⁷.

The Fed has been consistently hiking interest rates since early 2022, in an effort to bring down inflation to a 2% target. Currently, the fed funds rate is at a target range of 4.50-4.75%, with the market consensus estimating a 93.7% probability of a 25 basis point increase in March and a 69.9% probability of another 25 basis point increase in May¹⁴. While we believe these hikes are necessary to reduce inflation, this is expected to result in short-term

growth and revenue decline for firms in the semiconductor industry, as a result of decreased consumer spending on discretionary products, as well as reducing the value of companies' future profits.

Given the Fed's current guidance, the Fed is likely to increase interest rates above these levels in 2023, with these rates likely to remain at elevated levels until the Fed's target inflation rate is reached at around 2%.

Federal Funds Rate



Source: FRED

KEYS TO MONITOR

Headwinds

- The restrictions on exports of advanced chips to China are expected to negatively impact revenues of semiconductor firms who have receive a high percentage of their revenue from China.
- The Fed has expressed an intention to keep raising interest rates to reduce inflation, which is expected to have a negative impact on consumer spending as well as reducing the values of companies' future profits.
- Excess inventories continue to affect semiconductor companies, driven by a decrease in consumer demand for electronics amid recessionary fears.

Tailwinds

- The CHIPS Act is expected to help bolster domestic semiconductor manufacturing in the US through a \$52 billion investment, as well as addressing key supply vulnerabilities that came to light at the onset of the pandemic. If these efforts are successful, it may lead

to semiconductor firms becoming less reliant on the Chinese semiconductor manufacturing industry in the long-term.

- AI applications have seen strong high growth since the beginning of 2023, such as ChatGPT which has already reached over 100 million users, and Google recently unveiling their ChatGPT rival “Bard”. These applications require power graphics chips to run, which may increase demand for certain semiconductor companies such as NVDA.

Summary

Overall, we recommend an Underweight rating for the semiconductor industry. This is driven by estimated global declines in the semiconductor industry in 2023, with a relatively higher interest rate regime, expected slowing demand in consumer end-markets, and restrictions on advanced chip sales to China, a major end-market for many semiconductor companies. However, key points to monitor that may affect our rating include macroeconomic conditions and the likelihood of a soft landing for the economy, as well as the growth in technologies such as AI, automotive, and 5G. Depending on the growth of these industries, the level of enterprise and consumer spending towards semiconductors will be affected as well.

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