

The Semiconductor Shortage

Since the invention of the first integrated circuit chip in 1959, advances in chip design have followed Moore's Law which is an observation that the number of transistors on a chip will double every two years. As a result, semiconductor chips have become smaller and faster. They have also become a lot cheaper. Today, semiconductors are an essential part of the economy and are used in almost all industries (Figure 1)¹. The investment implications due to the widespread use of semiconductors were especially pronounced in 2020 and are likely to continue in 2021. The 2020 COVID pandemic changed global work and learning environments. Due to social distancing requirements, most of us were required to work from home. Similarly, most students had to shift to remote learning. Work from home and remote learning has continued in 2021. In addition to the pandemic, the U.S. China trade war has also had a significant effect on the demand for semiconductors. In this piece we will explore some dynamics of the semiconductor industry.

Figure 1: 2019 Semiconductor Marketshare by End Use¹

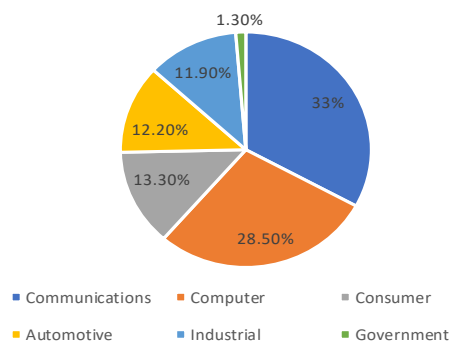
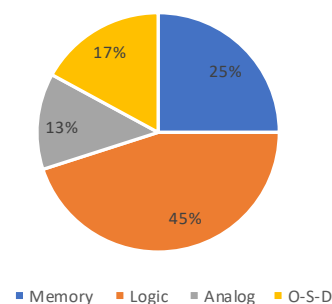


Figure 2: Types of Semiconductor Chips²



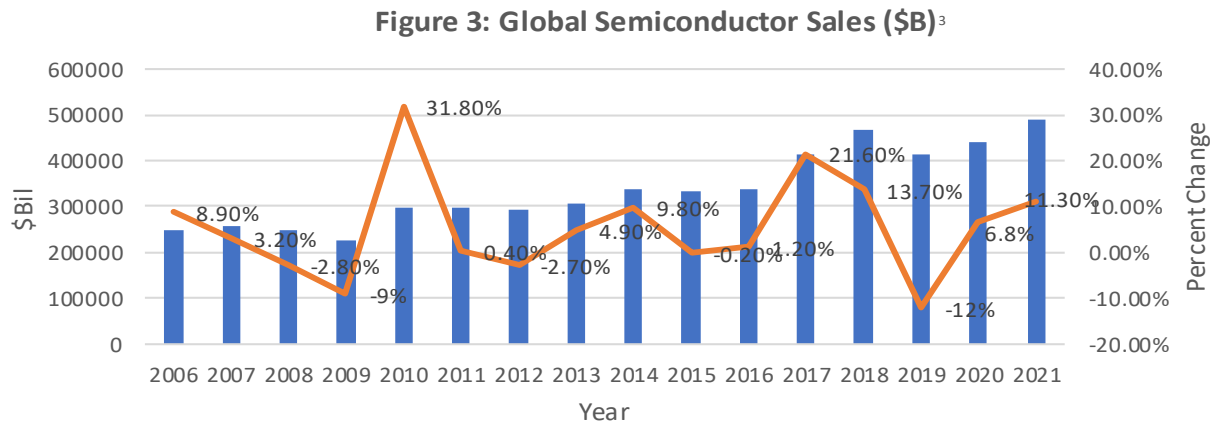
1. 2020 State of the Semiconductor Industry: Semiconductor Industry Association.
2. <https://fas.org/sgp/crs/misc/R46581.pdf>

Industry Overview

Semiconductors are generally classified based on their functionality. There are four major types of chips. These are Memory chips, Microprocessor or Logic chips, Analog chips and Optoelectronics, Sensor and Discrete (O-S-D) chips (Figure 2)². Memory chips store data and software programs. Random Access Memory chips (RAM) provide for temporary memory whereas flash memory chips allow for permanent storage. Memory chips account for about 25% of semiconductor sales. Microprocessor chips process data and are also known as central processing units (CPU) or logic chips and are the main computing unit. A Graphic Processor Unit (GPU) is a type of a logic chip that enables graphic displays. GPUs also allow for faster analysis of big data and are important for artificial intelligence (AI). Microprocessor chips account for 45% of semiconductor sales. Analog chips convert analog signals like light, touch and sound into digital signals. Analog chips account for about 13% of semiconductor sales. Optoelectronics and sensor chips are used for sensing light and are used in traffic signals, cameras and cars. Discrete chips consist of transistors, diodes and resistors.

The semiconductor industry is a cyclical industry where revenue growth is driven by two main factors. The first is inventory. Increasing demand leads to higher revenue and profits which semiconductor manufacturers typically use to add production capacity. As this capacity comes online, supply starts to outweigh demand leading to falling prices. This leads to the downturn in the semiconductor cycle. This was seen in the second half of 2018 through 2019 when growth in cloud infrastructure capex slowed down. The second factor is the global economy. During economic expansions, corporations tend to have higher IT budgets. In addition, consumers tend to spend more on electronic devices. As a result, semiconductor revenues increase. During slowing economies, companies reduce or freeze spending and individuals postpone upgrades. This results in a revenue decline for the semiconductor industry. This was seen in the 2008-2009 recession due to the financial

crisis (Figure 3)³.



3. Semiconductor and SPE Sector: Reflecting changes to forecast by J P Morgan Memory Team; J P Morgan February 16, 2021.

Semiconductor manufacturing is very capital intensive. As a result, over the past several decades there has been a shift in the industry with most companies outsourcing the actual chip manufacturing to specialized companies known as “foundries”. This has allowed chip companies to focus on the design and marketing while reducing costs. Leading semiconductor companies like Nvidia (NVDA) and Qualcomm (QCOM) outsource all their manufacturing and are considered to be “fabless”. Notable exception is Intel (INTC) which manufactures mainly in the U.S. Micron Technology (MU) also manufactures all its memory (DRAM) chips in the U.S. Chip manufacturing is dominated by few foundries which are mostly located in Asia.

Semiconductor Shortage

In 2020, global economies were forced into a recession due to the COVID-19 pandemic. Despite this, the semiconductor industry was one of the few that experienced growth with a 6.8% increase in revenue to \$439 billion. The main reasons for this demand were:

1. Personal Computing: Work from home and remote learning due to the pandemic resulted in high demand for laptops, tablets, smart TVs and gaming consoles. In fact, global PC shipments grew 13% to over 300 million units in 2020, which was the highest growth in a decade. This unprecedented demand caused severe backlog.
2. The U.S. China Trade War: In 2020 due to national security concerns, U.S. imposed a ban on exporting chips to Huawei, China’s largest smart phone maker. As a result, Huawei stockpiled chips ahead of the mid -September 2020 deadline. In an effort to gain market share, other smart phone manufacturers also started stockpiling chips. This added to the backlog.

In 2021, the semiconductor industry is expected to grow at an even faster pace at 11%. Demand is expected to be strongest for memory chips, followed by discrete and sensor chips (Table 1)³: The chip shortage is expected to continue in 2021. Continued demand for semiconductors is forecast due to the following:

1. 5G: With the introduction of new 5G phones (Apple) in 4Q2020 along with the continued roll out of 5G networks, demand for 5G phones is expected to increase. The stockpiling by Huawei competitors is also expected to continue.
2. Information Technology (IT) Spending: According to Gartner Inc., due to the pandemic, global IT spending in 2020 was focused on essential technology to allow for

Table 1: Semiconductor Revenue Growth³

Chip	2020 y/y	2021e y/y
Discrete	-0.3%	12%
Optoelectronics	-2.8%	6%
Sensor	10.7%	10%
Analog	3.2%	10%
Micro/Logic	8.7%	5.6%
Memory	10.4%	23.7%
Total	6.8%	11.3%

3. Semiconductor and SPE Sector: Reflecting changes to forecast by J P Morgan Memory team; J P Morgan February 16, 2021.

employees to work from home. As a result, IT spending declined about 3% to \$3.69 trillion. Gartner Inc. expects 2021 IT spending to increase by 6.2% to \$3.92 trillion as the ongoing vaccine rollout is expected to aid a global economic recovery.

3. Autos: At the start, the COVID pandemic caused rolling shutdowns at auto plants. Auto dealers were also closed. This caused U.S. auto sales to drop by about 34% in the second quarter of 2020⁵. As U.S. car companies use “just in time” system for all inventory, they cancelled semiconductor orders during the factory shutdowns. Chip foundries used that capacity to meet increased demand for personal computing. Due to attractive financing and an increased desire for road trips, car demand rebounded in 3Q2020. This has resulted in a backlog for automotive chips. CNBC reports that auto demand in 2021 is expected to grow by 7-10%⁶.
4. Personal Computing: In 2021, remote learning is expected to continue in many parts of the world and schools are expected to build inventory of laptops and tablets. Consumer spending on notebooks as well as gaming devices is also expected to continue. As a result, demand is expected to continue in 2021 albeit at a much slower pace.

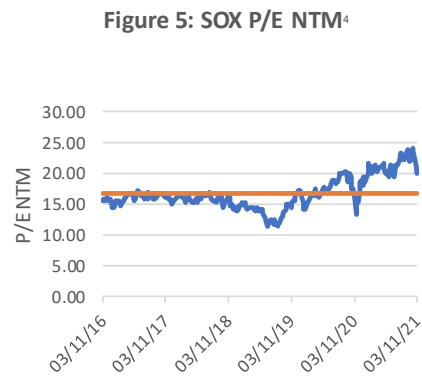
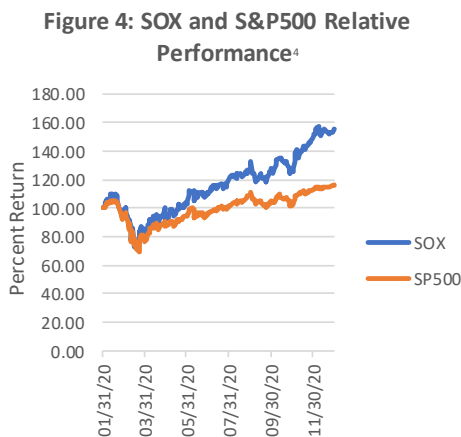
While demand for semiconductors has been strong, the semiconductor supply chain has suffered significant disruptions. Due to the pandemic, manufacturing was affected due to factory shutdowns. As most foundries are located in Asia, the supply chain was also affected due to pandemic related travel and transportation restrictions. Air freight, which is the preferred mode of transportation for chips, continues to be supply constrained as most of the capacity is being used to transport COVID-19 vaccines. These constraints affect all end markets and are expected to continue in 2021. Analysts expect that it will take at least 4-6 quarters for supply to catch up to demand.

In the 2016 -2018 upturn in the semiconductor cycle, there were 10 quarters of positive revenue growth. After the downturn in 2019, revenue growth turned positive in the first quarter of 2020. Due to the ongoing chip shortage, this cycle may last for another 4-6 quarters before the next downturn.

The Philadelphia Semiconductor Index, SOX, is typically used to track the industry. In 2020, as a result of increased demand, the SOX was up 51% and it outperformed the broad market which was up 16% (Figure 4)⁴. For most of 2020, it traded at a premium to its 3 year average P/E of 16.89. Rising interest rates in 2021 have had a negative effect on the technology sector and SOX has sold off from its peak. Its valuation has also come down and it is currently at a P/E of 22.65 (Figure 5)⁴.

Summary

The 2020 COVID pandemic forced employees to work from home and for students to attend school online. This caused an unprecedented demand for personal computing, gaming and other smart devices. At the same time, semiconductor manufacturing was disrupted due to factory shutdowns. The chip supply chain was also disrupted due to travel and transportation restrictions. The U.S. China war also contributed to the stockpiling of chips by Huawei and its competitors. This has caused a significant shortage of chips for all industries. We have a favorable outlook for the industry as the semiconductor shortage and resulting revenue growth may last for another 4-6 quarters.



4. Factset

References:

1. 2020 State of the Semiconductor Industry: Semiconductor Industry Association.
2. <https://fas.org/sgp/crs/misc/R46581.pdf>
3. Semiconductor and SPE Sector: Reflecting changes to forecast by J P Morgan Memory Team; J P Morgan February 16, 2021.
4. FactSet
5. <https://www.cnbc.com/2020/07/01/coronavirus-is-expected-to-tank-us-auto-sales-in-the-second-quarter.html>
6. <https://www.cnbc.com/2021/01/14/with-a-lot-of-optimism-and-vaccine-hopes-us-auto-sales-could-increase-as-much-as-10percent-in-2021.html#:~:text=Automotive%20executives%20and%20analysts%20are,and%2010.3%25%20compared%20with%202020.>

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