Semiconductor Firms in the Stock Market

By

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Abstract:

My senior project is about the semiconductor sector in the stock market where I chose five specific semiconductor firms to analyze and research about. My claim is that these firms will outperform investor expectations in the long term leaving the market very bullish on the semiconductor sector in the next five to ten years. I will discuss this in a variety of ways by reviewing analyst reports, earnings reports, and scholarly articles to back up my claim as well as determine my conclusion.

Introduction:

My project focuses on the semiconductor industry in general and the performance of semiconductor companies in the stock market. The industry is the aggregate collection of companies engaged in the design and fabrication of semiconductor devices. It formed around 1960, once the fabrication of semiconductors became a viable business. It has since grown significantly to be over a $500 billion industry today. Semiconductors are made of silicon or germanium which are materials that are neither good conductors nor insulators on their own, but they conduct more electricity when heat or voltage is added. The most significant semiconductor is the transistor, which in digital circuits works like an on/off switch. In the past, semiconductors chips have been used mostly in Personal Computers (PCs), however these chips are now being used for more than just a computer. They have a wide range of applications and are now being used in every electronic device such as Smart Phones, TV's, cameras, automobiles and much more. This paper will provide an overview of the major industries and emerging technological trends ranging from Internet of Things (IoT), self-driving cars, artificial intelligence and others. The health of these industries and the progress of emerging technologies directly impact the semiconductor sector. When personal computer sales rise or fall, chipmakers are impacted. The same goes for sales of automobiles, smartphones and other end-markets. This paper will provide an overview of five emerging technologies that will demonstrate the semiconductor industry's importance in the development of these technologies and the business opportunities that these emerging technologies provide to companies in the semiconductor sector. These technologies are: Artificial Intelligence, Cloud, Autonomous vehicles, 5G, and Internet of Things (IoT).

The semiconductor industry is known to be highly cyclical for investors in the stock market. Semiconductor companies have been experiencing booms and busts in demand for their products for many years. As demand for personal computers and other electronic devices are high, the stock prices of the semiconductor companies will increase significantly but as demand slows, the share prices fall sharply lower. This paper will discuss whether the boom and bust cyclical trend is the thing of the past for this industry and whether going forward the industry will experience steady growth for many years given the enormous end market and the technological trends that the industry is enabling. I have invested in the semiconductor sector over the past several years and have followed the performance of several stocks in the sector almost on a daily basis. I frequently read analysts' reports, companies' quarterly reports and other publications and I plan to analyze the sector in depth while analyzing the business and financials of six semiconductors companies. For each of the selected stocks I will provide a business overview, their financial data such as revenue, earnings per share, balance sheet, market cap, current and projected growth, stock performance, and the challenges and risks that these companies are facing. The specific companies that I chose to analyze are Micron Technology, Intel Corporation, NVIDIA

Corporation, Advanced Micro Devices, and Qualcomm Corporation. The reason I chose these specific companies was because I've been learning a lot about the semiconductor industry from my dad who has invested in various types of technology companies in the stock market, and he has inspired me to take on this topic to research and understand even further. These are also the leading companies in this sector that produce a wide range of semiconductor products that are used in various parts of the industry. By focusing on these specific companies, I will be able to learn about the health and prospective future for the semiconductor sector. For example, Micron Technology focuses on memory chips while Nvidia focuses on GPU's which are used in the gaming industry and Artificial Intelligence. I will gather my information from scholarly articles as well as looking through quarterly earnings reports, listening to conference calls, reading transcripts from technology conferences, as well as reviewing Wall Street semiconductor analyst reports.

Before focusing on semiconductor companies, I will now discuss in detail each of the emerging technologies mentioned in my opening paragraph. I will start by discussing the technology called Artificial Intelligence (AI). AI is an area of computer science that emphasizes the creation of intelligent machines that work and react like humans. Some of the things that can be accomplished with artificial intelligence are speech recognition, learning, planning, and problem-solving. AI works by combining large amounts of data with fast, repeat processing and intelligent algorithms, allowing the software to learn automatically from patterns or features in the data. AI is currently one of the most frequently discussed topics in both the business and scientific communities as this technology influences our lives in a significant way, affecting how we live, work, and entertain ourselves. The market for AI is growing rapidly at a rate of 150% annually and is expected to be worth $16 billion by 2022. AI is currently being developed and implemented in almost every industry to help improve productivity in businesses as well as their services and quality products that are provided to their customers. These industries, to name a few, include agriculture, call centers, energy and mining, autonomous vehicles, retail, travel, manufacturing, technical support, government & military as well as in healthcare as they are now used as tools to help medical professionals diagnose certain types of diseases. According to the article, *Artificial intelligence improves diagnosis of lung disease: study*, it explains how AI uses very complicated algorithms to help diagnose lung disease. They created a study with multiple Pulmonologists in different hospitals to test how accurate this data actually was. “The study included 120 pulmonologists from 16 hospitals and researchers used historical data from 1,430 patients from 33 Belgian hospitals.”[1] According to the study, the AI algorithms was a key performance indicator in helping these doctors determine the diagnosis for patients since they were twice as accurate as the doctor’s recordings. This is the perfect opportunity for doctors to use AI and to create algorithms, which will help them potentially find cures for diseases seen as untreatable today. AI has the potential to outperform humans in almost every cognitive task once AI fully expands to its potential. According to the article *Benefits and Risks of Artificial Intelligence,* “Such a system could potentially undergo recursive self-improvement, triggering an intelligence explosion leaving human intellect far behind. By inventing revolutionary new technologies, such a superintelligence might help us eradicate war, disease, and poverty, and so the creation of strong AI might be the biggest event in human history.”[2] There are many examples of Artificial Intelligence that have already been implemented in consumers lives such as “Alexa” and

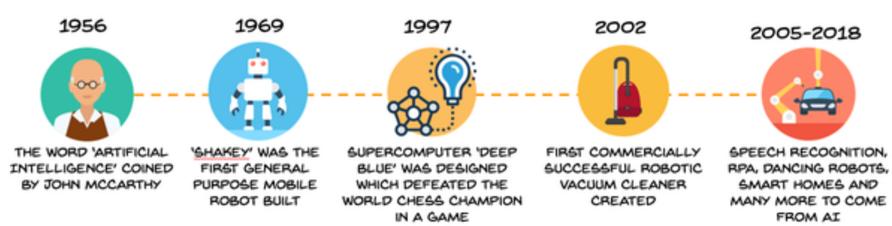
[1] "Figure 2f From: Irimia R, Gottschling M (2016) Taxonomic Revision of Rochefortia.

[2] "Benefits & Risks of Artificial Intelligence." Future of Life Institute.

"Siri" that are able to talk to users and provide them with up to date information whenever their services are "requested". There are also vehicles that have AI features that keep vehicles within their lane in case they ever veer off the road. This technology was created from a company called Mobileye, which was bought out from Intel a couple of years ago. As corporations struggle to fight off hackers some are looking to artificial intelligence for solutions. According to the article in WSJ "*How AI can stop Hackers*" (2018) by Adam Janofsky they are using machine learning to sort millions of malware files, searching for common characteristics that will help them identify new attacks. They are analyzing people's voices, fingerprints and typing styles to make sure that only authorized users get into the system. According to Mathew Newfield, Chief Information Security Officer at Unisys corp. "Trying to analyze that information is impossible for a human, and that's where machine learning can come into play".[3] Microsoft Corporation the largest software company in the world has been developing AI to help solve some of the biggest challenges facing society. Last year they announced AI for Earth, a program to apply artificial intelligence toward providing solutions to climate, water, agriculture and other issues facing our planet. They also launched this year's "AI for Accessibility", a program that will provide AI solutions to more than 1 billion people with disabilities around the world. There are many potential benefits to having strong AI in our societies. Big names in science and technology like Elon Musk, Bill Gates, and Stephen Hawking however, have expressed concern about the potential negative effects that could occur if we cannot control what AI can do in terms of weaponry and war, since it can outperform or outthink the smartest people in today's society. Another cause of concern with the addition of AI is the threat to blue and white collar workers across the world who have a chance of losing their jobs to a more productive technology that can perform their

[3] Janofsky, Adam. "How AI Can Help Stop Cyberattacks."

tasks more efficiently and quicker than what a regular human can produce. According to the WSJ article, *The Human Promise of the AI Revolution* (2018) by Dr. Lee states that "For cognitive tasks, this ability to learn means that computers are no longer limited to simply carrying out a rote set of instructions written by humans. Instead, they can continuously learn from new data and perform better than their human programmers perform. For physical tasks, robots are no longer limited to repeating one set of actions (automation), but instead can chart new paths based on the visual and sensor data they take in (autonomy)."[4] Societies can utilize these technologies to focus on other parts of life such as poverty, education, etc. Dr. Lee suggests that there should be a payment called "The Social Investment Stipend, a respectable government salary for those who devote their time to three categories of activities: care work, community service and education."[5] Because of the enormous increase of the AI technology across most industries, the demand for semiconductor chips that is enabling this technology has being growing substantially. Companies like NVIDA and AMD that are selling GPUs used by AI are enjoying substantial revenue growth and see their stock prices increasing significantly in the last few years. We will discuss these companies and the other selected semiconductor companies mentioned in the introductory section later in this paper.



[4] Lee, Kai-Fu. "The Human Promise of the AI Revolution."

[5] Lee, Kai-Fu. "The Human Promise of the AI Revolution."

Figure 1

Artificial Intelligence Timeline; How AI evolved from 1956-Present[6]

The next emerging technology mentioned in my opening paragraph is going to significantly affect the way humans live on a day to day basis within the next few years. This technology is called 5G, or as we say the 5th generation of mobile networks. As people already know, we currently have a 4G LTE wireless network that is used in most of our smartphone devices. The LTE network has certainly been an upgrade from 1G, 2G, and 3G mobile networks, which was the technologies used by mobile phones for many years before 4G was released. When Mobile networks and cellphones started to enter the market, we first started off with 1G, which focused strictly on voice communication between one another wirelessly. 2G introduced in the early'90s focused on instant messaging and text messages on mobile devices, while on 3G, people were able to start using smartphones sending snapshots and photos from their mobile devices. Then as 4G LTE was introduced, its technology focused on live/streaming video and wireless broadband from our smartphone's. 5G however, is going to deliver life -changing technologies through the buildup of next-generation networks. It will provide more speed, data transfer rates of 20 gigabits per second – several hundred times faster than the speed available today with significantly larger bandwidth and better connectivity that will enable many new technological innovations that will soon be developed due to the ability to have instantaneous connectivity to billions of devices all around the world. According to Verizon, "The connectivity benefits of 5G will make business more efficient and give consumers access to more information faster than

[6] Negrotti, Massimo. "Introduction: Artificial Intelligence: Its Future and Its Cultural Roots." *Understanding the Artificial: On the Future Shape of Artificial Intelligence*,

ever before. Autonomous cars, smart communities, industrial IoT, and immersive education will all rely on 5G."[7]

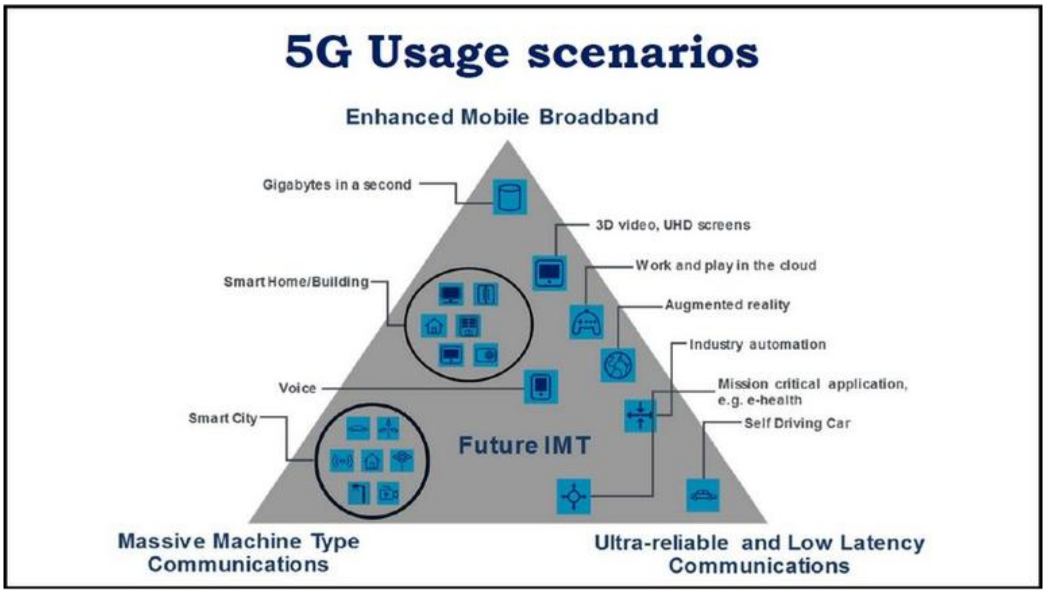
5G comes with a suite of new technologies that allows it to have the bandwidth and power to really change the world's human experience. These are known as Small Cells, Millimeter Waves, MIMO, Beamforming, and Full Duplex, which are all technologies that help the connectivity and speed capabilities of 5G. Small Cells are miniature cell phone towers that can be placed in light poles and roofs. These small cells are able to transmit data through millimeter waves that occupy frequencies that range from 30 – 300 GHz. According to the article, *5G is coming- here's what to expect, and when to expect it on your carrier*, 5G's technology called "MIMO (Multiple Input, Multiple Output) is a wireless system that uses multiple radios to send and receive data simultaneously. The 4G LTE networks of today support a maximum of eight transmitters and four receivers, but 5G cell towers can theoretically support dozens."[8] The last two technologies within the 5G network are called beamforming and full duplex where they use algorithms that "choreograph" wireless signal movements that increase in strength more and more. This is also while "full duplex phones" which can help route incoming and outgoing signals at the same time and can double the bandwidth of multiple devices at the same time.

This leads one to ask what exactly does 5G have the potential to do to our society? According to the article, *How 5G technology will transform the way we live* written by Theodore Rappaport "5G promises almost unimaginable capabilities that have never been available before, as it will bring the power of the Internet and ubiquitous fiber-optic communication

[7] "What Is 5G?" What Is 5G? | About Verizon.

[8] "5G's Arrival Is Transforming Tech. Here's Everything You Need to Know to Keep up."

speeds to the pocket of every human being. Immersive virtual reality, real-time television viewing, see-in-the-dark cameras, hard drives that provide nearly infinite content for instant downloads from any location, and virtual meet-ups with friends and family—where they appear in the space in front of your phone."[9] These are just a few of the many features that we will experience from 5G.



<u>Figure 2</u>

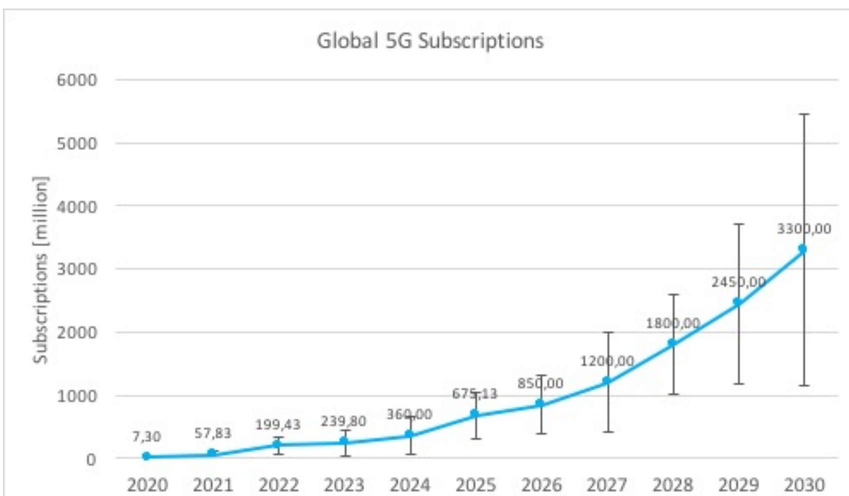
5G Usage Scenarios; How 5G can implemented throughout multiple industries[10]

Two innovative technologies that will be discussed later in the paper are autonomous vehicles and IoT (Internet of Things), which are next generation technologies that are set to change how companies from various industries run their businesses since these innovations will significantly help them increase productivity in manufacturing, product development, transportation etc. However, all of this wouldn't be possible without the presence of 5G that provides speeds up to 30-50 times faster than 4G as well as latency (the time taken for

[9] Theadore Rappaport. "How 5G Technology Will Transform the Way We Live."

[10] Irimia R, Gottschling M (2016) Taxonomic Revision of Rochefortia Sw. Biodiversity Data Journal

devices to respond to each other over the wireless network) that will be dramatically lowered to just 1 millisecond. (Verizon 2018)[11]. Lastly, one may ask how this introduction of this new technology will affect job creation, industry growth, and global GDP when 5G is fully rolled out in the next 10 – 15 years? According to a report by Qualcomm, 5G will benefit multiple industries as well as economies and societies around the globe. According to the data they gathered, by 2035 when 5G is in full effect, various industries across the globe can potentially produce $12.3 trillion worth of goods due to its capabilities and influence on the world. Also, according to Qualcomm, "The 5G mobile value chain alone could generate up to $3.5 trillion in revenue in 2035 and support up to 22 million jobs."[12] In terms of global GDP, it has the potential to increase global growth by over $3 trillion, which is estimated to be equivalent to a country like India, which is currently one of the largest economies in the world today.



Graph 1

(The Edge of the Cloud - 5G Technology Blog- June 2017)

***Global 5G Subscriptions*; The Amount of Users Subscribed to 5G from 2020-2030**[13]

[11] "What Is 5G?" What Is 5G? | About Verizon.

[12] "The 5G Economy | 5g Value Chain." Qualcomm.

[13] Yurtoğlu, Nadir. *History Studies International Journal of History*10, no. 7 (2018).

5G technology will provide tremendous driver for growth to many semiconductor companies for many years to come, some of which I will discuss in greater detail further in this paper.

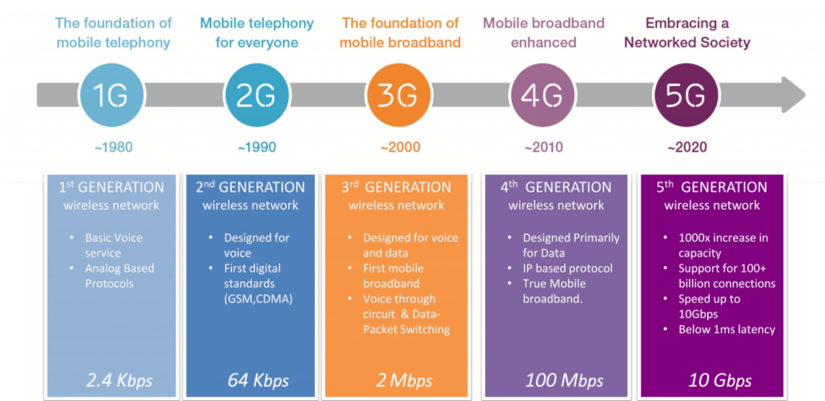


Figure 3

5G Timeline; How 5G has slowly evolved since 1980

Another emerging technology that has been developing in recent years and is projected to see tremendous growth in the upcoming years while having the potential to significantly impact our lives and provides a significant growth catalyst to the semiconductor industry, is what's called Internet of Things (IoT). IoT is defined as the concept of connecting any device with an on and off switch to the Internet and to each other, it is changing the way we interact with devices at home, at work and in the world around us. Their Sensors are designed and built by semiconductors manufacturer, are imbedded in billions of physical devices (Things) around the world enabling them to connect to the internet thus making them smart devices, collecting and sharing data. Thanks to cheap sensors and wireless networks, it's possible to turn anything, from a pill to an airplane, into part of the IoT. This adds digital intelligence to devices that would be otherwise dumb, enabling them to communicate without a human being involved. According to SourceToday “Gearing up for IoT: Semiconductors and Sensors” [14](May, 2017) the IoT is pushing more electronics manufacturers to think about how their devices such as coffee makers, refrigerators, Mobile Phones and wearable devices will connect to one another. These devices can simultaneously work together in many instances since they’re all at the end of the day connected with one-another so it knows what functions to perform during certain hours of the day if they all follow a human’s specific schedule. According to Source Today, research firm Gartner estimated that in 2017 there were 6.4 billion connecting “things” and projected that that the number will skyrocket to 20.8 billion by 2020. The IoT is a giant network of connected "things" (which also includes people). The relationship will be between people-people, people-things, and things-things.”[15] On an industry perspective, IoT is expected to drive growth throughout multiple economies within multiple industries. For example, according to Forbes (Columbus, 2018) McKinsey predicts the IoT market for Information and Communication Technologies to be worth over $581 Billion by 2020, growing between 7 and 15% annually , The Industrial IoT market is predicted to reach $123B in 2021 while other industries like Manufacturing and Transportation are expected to spend over $40 Billion to switch to IoT platforms that will benefit their businesses in terms of efficiency which can overall help with spending, revenue, and profitability. Capgemini Digital Transportations Institute issued extensive report “Unlocking the business value of IoT in operations”[16] that provides some examples of the benefit IoT provide to organizations. According to the report, Harley Davidson, the leading global motorcycle manufacturer, was able to reduce its

[14] 04, May. "Gearing Up for IoT: Semiconductors and Sensors."

[15] 04, May. "Gearing Up for IoT: Semiconductors and Sensors.".

[16] "Unlocking the Business Value of IoT in Operations | Research Report." Capgemini Worldwide.

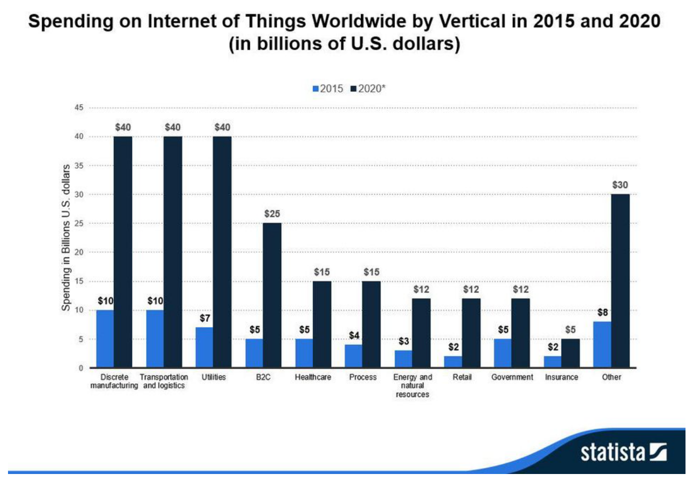
build-to-order cycle and grow overall profitability by 3% to 4% by shifting production to a fully IoT enabled plant, the impact resulted in $200 million reduction in operating costs and increase in operating efficiency. Rolls -Royce one of the largest jet engine manufacturers, uses the IoT to increase the fuel efficiencies of jet engines, optimize flight paths, and improve maintenance. The company utilizes information from sensors fitted inside the engine to track engine health, air traffic control, route restrictions and fuel use to diagnose potential faults in aircraft engines. This helps the company to improve engine efficiency and lower fuel consumption by 1% which translated to a saving of $250K per plane per year. Hershey's, a leading chocolate manufacturing company, added IoT sensors to its candy -making manufacturing facilities to improve production efficiency. Royal Dutch Shell, a leading oil and gas company, realized a $1 million return on a $87,000 investment in remote IoT, the company installed sensors in 80 oil fields in West Africa, which produce $600,000 barrels of oil per day.[17] The company reported immediate savings from reduce site visits for equipment maintenance and reduce downtimes. When IoT becomes fully implemented in society, researchers are starting to plan "smart cities" where everything is fully connected with each other through 5G network where everything is able to connect a thousand times quicker, so cities are able to rely on machines and technology to help our society become a more efficient and productive place to live. According to McKinsey, the semiconductor industry is poised to benefit from the IoT's growth over the coming years. In The Internet of Things: Sizing up the Opportunity" the research firm points to some of the applications of IoT such as the area of energy optimization, insurance industry as some insurance companies for example, now offer plans that requires drivers to install a sensor in their cars, allowing insurers to determine premiums on actual driving behavior, and physicians can use information collected from wireless

[17] Team, Insights. "5 Areas Where The IoT Is Having The Most Business Impact."

sensors in their patients' homes to improve management of chronic diseases. McKinsey states that the connected devices rely on innovations from semiconductor companies and that the IoT market represents a significant growth opportunity for semiconductor players.[18] The semiconductor companies that will be discussed in depth further in this paper are all expecting to benefit from the growth of the IoT. For example, in mid- May 2018 Micron raised its revenue and earnings per share guidance for its fiscal third quarter according to The Street, "Micron CEO: Internet of Things and Data Economy will drive company's growth" (May 2018). Micron Technology CEO Sanjay Mehrotra said that as the Internet of Things expands, the world becomes more digital, there will be continually growing demand for storage and memory that will benefit Micron in the future, "The key market that will drive Micron's growth are data center, mobile, automotive and Internet of Things".[19] Despite however, all the endless opportunities that IoT has in store to change the way our societies are ran today, many people in this industry are very concerned about the security threat this technology may cause for people and companies that have everything connected to the internet which may be able to get hacked into. This has led people to question what data security and privacy measures will be implemented to prevent this from happening? This could potentially be a big issue that needs to be solved before this technology reaches its full capabilities across the world.

[18] "The Internet of Things: Sizing up the Opportunity." McKinsey & Company.

[19] Fontana, Francesca. "Micron CEO: Internet of Things and Data Economy Will Drive Company's Growth."



Graph 2[20]

***Spending on IoT 2015-2020*; The Projected Investment increases in IoT by 2020**

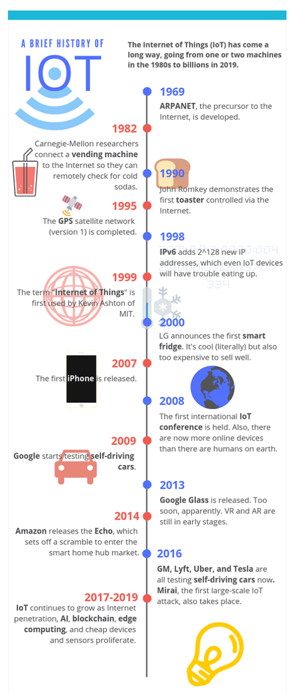


Figure 4 [21]

IoT Timeline; How IoT evolved since 1969

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[20] Columbus, Louis. "2017 Roundup Of Internet Of Things Forecasts." Forbes. December 11, 2017.

[21] Braun, Andrew. "History of IoT: A Timeline of Development." IoT Tech Trends. January 27, 2019.

Another emerging technology that has experienced accelerated growth in the past few years and has demonstrated its importance in the corporate world and in our day- to-day lives is known as the "Cloud" or Cloud Computing. Most consumers are already using this technology through the use of Apple's iCloud, or through a Google Drive that stores your information in the cloud and allows you to access your data through the internet. This is used instead of a hard-drive, which was the way users used to store their information before the Cloud was introduced. Also, Microsoft Corporation, for example, offers its popular Office that includes Words, Excel, PowerPoint and OneNote over the internet without installing any software through a service called Microsoft Office 365; this service is available to corporations and directly to consumers. According to Microsoft, some of the top benefits of the cloud computing is Cost – Cloud Computing eliminates the capital expenses of buying hardware and software and setting up and running on-site datacenters and eliminates the cost of maintaining the servers at the data center and the cost of paying for electricity for power and cooling. Instead, one can purchase exactly the right type and size of computing resources needed to run the operation. One can access as many resources as needed and only pay for what is used. Speed- most cloud computing services are provided on a self-service basis, on demand, so that large amounts of computing activities can be provided in minutes, giving business a lot of flexibility. Cloud computing, stores data in large data centers that are in remote locations around the world and are built with thousands of computer servers to store and access data through the internet. These cloud data centers are owned and maintained by cloud computing service providers such as IBM, Microsoft, Google and Amazon. According to Steve Ranger from ZD Net, "driven by the rapid increase in use of cloud apps, data center traffic is growing fast, expected to reach 19.5 zettabytes (ZB) per year by 2021, up from a mere 6.0ZB per year in 2016, according to Cisco. Cloud data center traffic will represent 95 percent of total data center traffic by 2021, compared to 88 percent in 2016."[22] Additionally, according to the article "All of this demand has led to the rise of what a networking giant is calling 'hyper scale data centers' -- large-scale public cloud data centers. It said there will be 628 hyper scale data centers globally by 2021, compared to 338 in 2016."[23] This may lead one to ask how Cloud technology will affect the growth of semiconductor industry. According to an article in Cloudtech, "How cloud computing, AI and IoT will transform semiconductor companies' revenue in 2018" by James Bourne, February 16, 2018, KPMG reported that based on its study IoT, AI and cloud computing are among the key drivers for revenue streams over the coming year for the semiconductors industry. In its 2018 third quarter earnings report Micron's CEO stated "Data Center trends are also driving momentum for Micron's DRAM and NAND solutions, with combined revenue up 87 percent year-over year. In the third quarter, ongoing demand for our memory and storage solution in cloud computing was a key highlight."[24] In its 2018 third quarter report Intel posted better -than-expected earnings in what CFO called "the best quarter in our 50-year history". Intel's Data Center Group revenue grew 50 percent year over year. Cloud is also directly affecting every industry around the world, one being the healthcare industry. To increase efficiency within hospitals and to increase the quality that medical professionals offer to patients, Cloud is being used to help cut costs for patients to help medical professionals keep track of records as well. According to the article written by Nick Ismail, "Today, the use of cloud technology — namely its ability to efficiently process and deliver data in a collaborative fashion plus

[22] Ranger, Steve. "Cloud Computing Will Virtually Replace Traditional Data Centers within Three Years."

[23] Ranger, Steve. "Cloud Computing Will Virtually Replace Traditional Data Centers within Three Years."

[24] Dignan, Larry. "Micron Says Memory Demand Strong Thanks to Cloud, Mobile, IoT."

analyzing data into meaningful information — has the ability to relieve the challenges. By using cloud services, healthcare organizations only need to pay for what they use, such as storage, applications, and infrastructure service."[25] Overall, once Cloud is adapted in more industries along with the wider integration of IoT, this will change the way businesses are run and will increase the quality of products, services, and technologies as well as directly helping the semiconductor sector due to large increase in demand for semiconductor chips from these emerging technologies.

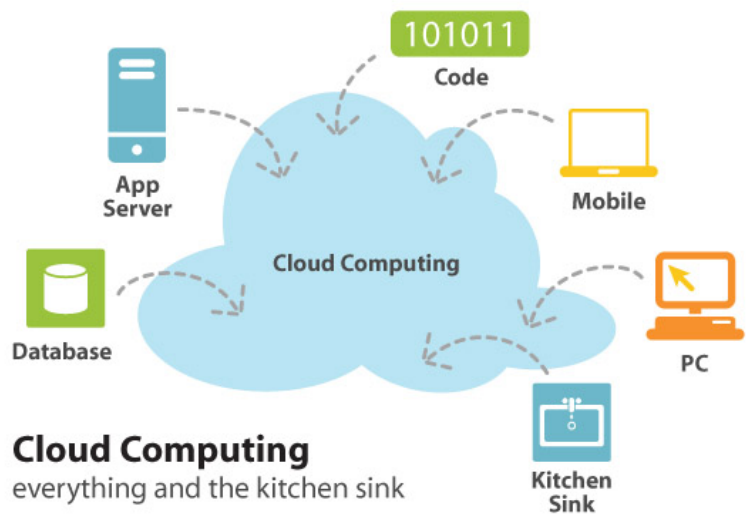

Figure 5 [26]

Cloud Computing; The Endless Types of Devices that Can be Connected to the Cloud

[25] Ismail, Nick. "How Cloud Technology Is Transforming the Healthcare Industry."

[26] Capital, TrueBridge. "Software Revolution, Part II: The Shift to Cloud Computing." Forbes. June 11, 2014.

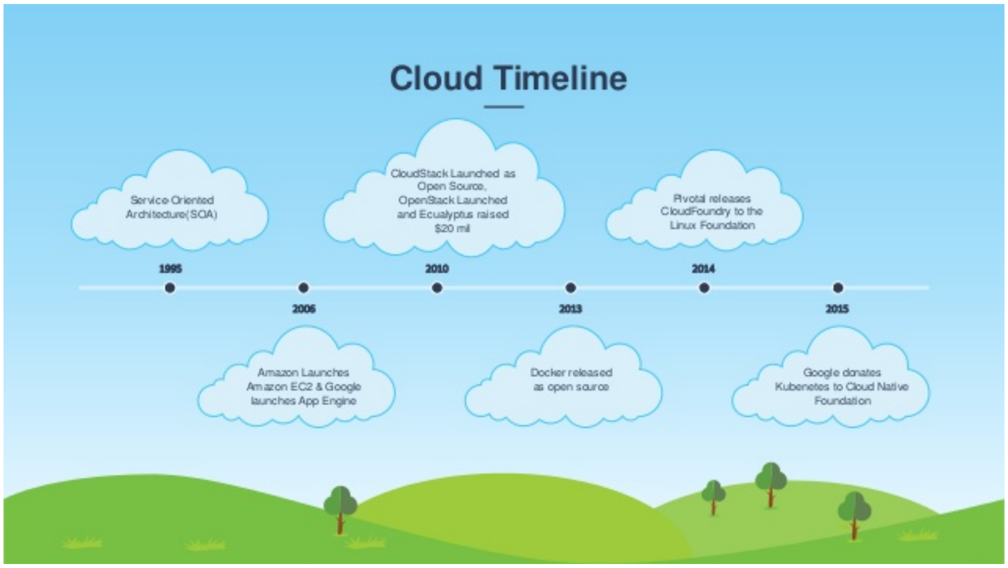

Figure 6 [27]

Cloud Timeline; How Cloud Evolved Since 1995

The final emerging technology that will be discussed in this paper that is expected to provide a huge growth driver for the semiconductor sector are Autonomous vehicles. Autonomous vehicles have come a long way within the past few years and their advances will provide a new revenue source to many companies in the semiconductor sector as they progress toward full autonomy. Many well-known technology and auto companies such as Apple, Google, Tesla, GM, BMW, Ford, Lyft, Uber and hundreds of start-ups from all around the world have been investing billions of dollars in R&D in order to pass safety tests and implement fully autonomous technology in vehicles. Once autonomous vehicles are fully developed and ready to be on the road safely, they will completely change the auto industry as well as the way the economy works in terms of manufacturing jobs, the potential loss of trucks and taxi driving jobs, how people will travel to work, how often consumers will purchase new vehicle, etc. If we look in terms of

[27] Hinkle, Mark. "Cloud 2.0 - How Containers, Microservices and Open Source Software Ar." October 19, 2015.

safety measures, it is reported that about 80% of car accidents occur due to human error. If this could be prevented, then thousands of lives can be saved. According to one article, “This 21st-century gold rush is motivated by the intertwined forces of opportunity and survival instinct. By one account, driverless cars will add $7 trillion to the global economy and save hundreds of thousands of lives in the next few decades”[28]. Semiconductor companies are playing an important part due to the success of the development of autonomous vehicles with many highly advanced semiconductors chips that allow cars to communicate with one another on the road. For example, the semiconductor company Qualcomm which will be discussed later in the paper in greater detail, released a new 9150C-V2X chipset. These new chips introduced in September 2017 will let cars communicate with other cars as well as infrastructure like traffic lights. This technology could work alongside chips dedicated to autonomy by improving safety. Qualcomm has begun field trials of Ford vehicles containing the chipsets in San Diego County, where the company is based. Similar tests of the technology will take place in Michigan, China, Germany, Italy and Japan[29]. Micron Technology has already invested about $3 Billion on autonomous vehicles as well as expanding into Virginia, demonstrating to investors that they’re committed to developing these new technologies that will be in the market in the near future. Micron’s main business are memory chips including chips known as NAND’s and DRAM’s. Both of these chips have been used in the past for PC’s, mobile phones, and servers. Now however, these chips will soon be used to further develop autonomous vehicles as well. According to an article, “more widespread adoption of level 5 automotive vehicles could accelerate the need for memory even further. Although today's "regular" vehicles have quite a bit of electronic content in them, a fully

[28] Davies, Alex. "How Self-Driving Supergroup Aurora Plans to Make Robocars Real."

[29] Novet, Jordan. "Qualcomm Gets a Permit to Test Self-driving Cars in California."

autonomous Level 5 vehicle, which can drive with no human behind the wheel will need more than nine times the amount of DRAM and a stunning 100 times the amount of NAND flash".[30] As more companies need this advanced technology to help them reach a level 5 fully autonomous vehicle, the demand for semiconductor chips will only rise leading me to believe that their revenues, profits, and business will blow past investor's expectations in the stock market. Another company that has really been focused on revolutionizing the autonomous vehicle market is Intel. This started when Intel decided to buy an Israeli company called Mobileye for $15 billion in 2017. Mobileye has a very special technology that has been used to keep vehicles from drifting out of their lanes in case the driver isn't paying attention. This technology in addition to their already innovative IoT and processor technology, has already given them a head start toward building and developing the first fully autonomous vehicles to be released to the market in the near future. Since Mobileye is based in Jerusalem, Intel has been test driving its self-driving cars on the roads in that city. According to Mobileye CEO Amnon Shashua, "Jerusalem has a reputation for aggressive driving and testing in the challenging Jerusalem conditions according to the CEO demonstrates the car's ability to make quick decisions and they must react to other drivers and pedestrians who don't use crosswalks without causing slowdown or accidents."[31] According to one article, "The initial test cars are using camera data alone to process their surroundings, and Mobileye will soon complement that with radar and lidar. The goal is to eventually have several viable systems, each of which Mobileye says "can support fully autonomous driving on its own," interweaved to create "true redundancy" -- if one system fails, the others simply pick up the

[30] Duberstein, Billy. "Micron Bets $3 Billion on Autonomous Vehicles."

[31] Holt, Kris. "Intel Is Testing Self-driving Cars in 'challenging' Jerusalem Conditions."

slack"[32](Kris Holt, 2018). Mobileye also plans to have these vehicles tested in other countries overseas such as the U.S., in order to pass safety tests which would allow the company to bring these vehicles to the market by 2021. Mobileye has already made a deal with European automakers to provide them with approximately 8 million vehicles over the next few years.

Although, as discussed, many companies are racing to be the ones to bring a fully autonomous vehicles to the market such as Waymo, the autonomous vehicle division of Google, that has been the first to reach many important milestones. According to Forbes "Key Milestones of Waymo Google's Self-Driving Cars" (Bernard Marr, 2018) Waymo team announced in November 2017 "Starting now, Waymo's fully self-driving vehicles-our safest, most advanced vehicles on the road today -are test-driving on public roads, without anyone in the driver's seat."[33] These vehicles have been on the roads of Chandler, AZ a suburb of Phoenix, since mid-October 2017 without a safety driver behind the wheel, although there is a Waymo employee in the back seat. Waymo vehicles are equipped with powerful sensors that provide them with 360-degree view. According to the article some predict that we will see Waymo's autonomous vehicles on the road by 2020. It's anticipated that just like Uber or Lyft people will be able to order rides from Waymo via an app to take them home, run errands or commute to work. Fully autonomous vehicles are clearly on the horizon, it just depends on which company will win the race to release the first one ever to enter the market.[34]

[32] Holt, Kris. "Intel Is Testing Self driving Cars in 'challenging' Jerusalem Conditions."

[33] Marr, Bernard. "Key Milestones Of Waymo - Google's Self-Driving Cars."

[34] Marr, Bernard. "Key Milestones Of Waymo - Google's Self-Driving Cars.".

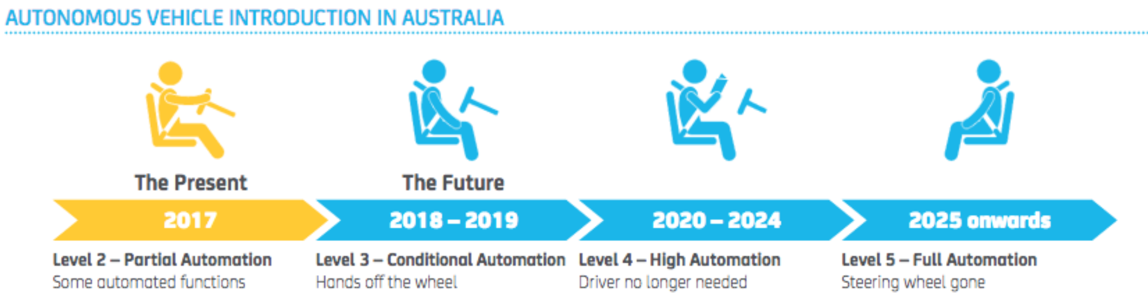

Figure 7 [35]

Autonomous Vehicle Timeline; The Future of Autonomous Vehicles in 2025

After discussing the five major emerging technologies that are expected to provide revenue growth to the semiconductor sector for next several years, I will now discuss in much greater detail five major semiconductor companies; these companies operate in different segments within the semiconductor industry. To analyze these companies, I reviewed their most recent and past year earnings reports, as well as their financial performance over the past several years. Additionally, I reviewed earnings call transcripts with analysts, financial publications and analysts' recommendations as well as comments and guidance that I received during my conversation with a Wall Street semiconductor analyst as part of my research for this paper. Finally, I have utilized my own personal knowledge of the industry as an investor in the sector for past several years and as such I have been following the industry daily as I currently own shares of Micron Technology and I have previously owned shares in other semiconductor stocks.

Disclaimer: This paper is primarily a student report for academic purposes and I do not offer specific recommendations to buy or sell any stock covered in this paper. Potential investors should consult a qualified investment advisor before making any investment.

[35] Bennett, Tess, and Tess Bennett. "Fully Autonomous Vehicles Will Arrive in Oz from 2025: NRMA - Which-50." Which. August 10, 2017.

The first company to be reviewed is Micron Technology.

Definitions:

1. Earnings per share, or **EPS** is the portion of a company's profit allocated to each share of common stock. Earnings per share serve as an indicator of a company's profitability.
2. The price-to-earnings ratio, or **P/E** is the ratio of the market price of a company's stock to its earnings per share (EPS): Market Value Per Share/EPS
3. The return on equity ratio or **ROE** is a profitability ratio that measures the ability of a firm to generate profits from its shareholders investments in the company. In other words, the return on equity ratio shows how much profit each dollar of common stockholders' equity generates.
4. Free cash flow (**FCF**) is a measure of how much cash a business generates after accounting for capital expenditures such a buildings or equipment. This cash can be used for expansion, dividends, reducing debt, shares buyback, or other purposes.

Micron Technology Timeline:

- 1978- Micron Founded
- 1984- Micron Breaks Ground on first fabrication in Boise Idaho
- 1998- Micron Becomes one of the largest memory producers in world after purchasing Texas Instruments
- 2002- Micron acquires Toshiba's commodity DRAM operations at Dominion semiconductors.
- 2010-2015- Micron acquires Numonyx B.V., STMicrolectrics, Francisco Partners, Elpida Memory, Rexchip Electronics Corp. Pico Computing, etc.
- 2017– Micron establishes R&D center of excellence in Boise
- 2018- Micron expands fabrication facility in Hiroshima, Japan.

https://www.micron.com/about/our-company/timeline

Micron Technology, Inc. (Nasdaq: MU) is a producer of semiconductors based out of Boise, Idaho, incorporated on April 6, 1984. The company is one of only three companies that is still making DRAM, the chips that provides short-term memory in personal computers, servers, smartphones, tablets, and other devices. Micron is the smallest of the three with market share around 21 percent, but it's the only one based in the U.S. Micron also makes another kind of memory, called flash, where it faces more competitions and holds about 13 percent of the market. The two other larger competitors located in Korea are SK Hynix and Samsung. The company's portfolio of memory and storage technologies include DRAM, NAND, NOR flash, and 3D XPoint memory. The company has four business units: Computer and Networking Business (CNBU) which includes memory products sold into computers, networking, graphics and cloud server market; Mobile Business Unit (MBU), which includes memory products sold into smartphones, tablets and other mobile-device markets ; Storage business Unit (SBU) which includes products for Enterprise and Client storage, cloud storage, and removable storage and Embedded Business Unit (EBU) which sales products for automotive, industrial, connected home and consumer electronic.[36] Micron generated $30 billion in revenue in 2018 making it among the world's five largest semiconductor companies.[37] For many years memory chips have been considered commodities with small differences in the products made by different companies, making competition brutal resulting in boom and bust cycles. Over the past decade Micron has experienced many cyclical activities in the stock market since its business relied mostly on the health of the PC's market, when demand for PCs was down it caused buildup of inventory by the computer makers that forced Micron and its competitors to lower their prices to bring inventory

[36] "Independent Fundamental & Forensic Investment Research." CFRA.

[37] "Independent Fundamental & Forensic Investment Research." CFRA.

down which resulted in lower revenue and profit and sharp decline in Micron stock. The cycle begins its way up again when the inventory correction is up causing the prices of chips to go up along with revenue, profit and stock price. Within the past few years however, the company has expanded its business into many different areas such as AI, Cloud, Autonomous vehicles, IoT, etc. These new technologies provided the company many sources of revenue they didn't have before easing the cyclical trend and making a case to investors that the semiconductor market is becoming more secular growth industry that will enjoy steady growth for a long period of time as opposed to being purely cyclical. Although it is expected that from time to time there will still be a buildup of inventory due to economic slowdown or other factors which will impact revenue and stock price, but the cycle will not be as severe as it used to be in the past. To compete effectively Micron's key strategy is developing new technologies that can distinguish them from rivals according to Micron's CEO Sanjay Mehrotra. For example, according to the article, "Micron Technology, Inc., the leading supplier of innovative memory and storage solutions for the automotive industry, today announced that it is working with Qualcomm Technologies, Inc., a subsidiary of Qualcomm Incorporated, to develop highly advanced solutions for next-generation in-vehicle cockpit compute systems. The increased level of technology needed to enhance in-cabin experiences requires system-level design expertise and innovation to efficiently accelerate technology integration"[38] (Micron, 2019). Micron is utilizing its new automotive memory chip LPPDR4X combined with Qualcomm's 3rd generation Snapdragon Automotive cockpit in order to enhance the autonomous vehicle experience. According to the article, "Tomorrow's feature-rich automotive cockpits incorporate multiple displays with higher resolutions, in addition to advanced human-machine interfaces (HMIs) and applications — all of which continue to demand

[38] "Micron Works with Qualcomm to Drive Innovation in Infotainment Systems for Next-Generation Vehicles."

higher performance"[39](Micron, 2019). In addition to this, Micron has also developed a new type of technology called 3D XPoint, which is considered a "nonvolatile" memory that can take in a lot of data and transform it into valuable real time information. It is also meant to improve storage performance and reduce server costs and provide 1000 times lower latency speeds and greater endurance in comparison to NAND's technology. According to the article, "Its ability to enable high-speed, high-capacity data storage close to the processor creates new possibilities for system architects and promises to enable entirely new applications."[40] (Micron, 2019) Back in 2015, Micron and Intel had originally partnered up to develop its 3D XPoint technology together, however in July 2018, Micron announced it would buy out Intel's share of their joint venture together for $1.5 Billion making Micron the prime owners of this technology giving them 100% control of the product, the technology, and its distribution.[41]

According to MarketWatch, Micron rallied 2.9% after KeyBanc Capital Markets analyst Weston Twigg reiterated its bullish rating on the company, citing expectations of NAND shortages by the end of 2019.[42] The analyst also said DRAM supply remains 'rational" and despite significant recent price declines, DRAM remains highly profitable. Micron's CEOspoke at Goldman Sachs technology conference and said that he continues to see healthy end market demand and still expects a strong second half in 2019.

[39] "Micron Works with Qualcomm to Drive Innovation in Infotainment Systems for Next-Generation Vehicles."

[40] "3D XPoint™ Technology." 3D XPoint Technology.

[41] Witkowski, Wallace. "Micron to Buy out Intel's Share of Flash Joint Venture for $1.5 Billion."

[42] Kilgore, Tomi. "Micron's Stock Surges after KeyBanc Projects NAND Shortages, DRAM Tailwinds."

The next semiconductor company I am going to analyze is Advanced Micro Devices (AMD):

Advanced Micro Devices Timeline:

- 1969- Advanced Micro Devices (AMD) was founded
- 1970- AMD introduces its first proprietary device
- 1972- AMD Goes Public
- 1975- AMD enters the chip business
- 1979- AMD enters the NYSE
- 1987- AMD Acquires Monolithic Memories and enters the programmable logic business.
- 1993- AMD Launches Intel 486 processor clone Am486.
- 2004- AMD Demonstrated its first x86 dual processor.
- 2008- AMD introduces triple-core processors and launches its 4800 graphic cards.
- 2011: AMD Launches the AMD Fusion Family of APU's
- 2018//2019- AMD is set to release its new technology called GPU Navi.

https://www.scribd.com/doc/101336886/Timeline-AMD

The company was founded in 1969 and is headquartered in Santa Clara, California and is a global semiconductor company. AMD operates in two different segments; Computing and Graphics which includes x 86 desktop and notebook microprocessors and chipsets, graphics processing units (GPUs) and professional GPU; and Enterprise, Embedded and Semi-Custom, which includes server and embedded processors, semi-custom System-on-Chip (SoC) and technology for game consoles. These microprocessors are an integrated circuit that serves as the central processing unit or brain of the computer. GPU's are used in computers to increase the speed of images, improve image resolution and color. Accelerated processing units (APU's) combine CPU's and GPU's increasing user experience since they combine them onto a single piece of silicon. The company sells x86 microprocessors for desktop PCs under Ryzen and microprocessor for servers under EPYC brands.[43] Its semi-custom SoC products are used in Sony PlayStation and Microsoft Xbox game consoles. The microprocessor market is dominated by two companies, Intel and AMD. AMD accounts for about 20% of the market however it has been growing its business and advancing its technology in order to compete and take away some market share from Intel. Also, in its GPU business it competes with Nvidia, which has a large percentage of the GPU market as well. AMD however, is set to release its new technology called GPU Navi, which is set to close the gap between the two semiconductor firms in terms of technology and market share just like its doing with Intel.[44] These improvements in its technology have reflected directly on its financials and stock price. The company has reported $6.4 billion in revenue for 2018 an increase of 23% from the prior year, a net income of $514 million compared to $103 million in the prior year and a gross margin of 38 percent an increase of 4 percentage points over

[43] "Stock Reports." TheStreet. Accessed April 10, 2019.

[44] "Independent Fundamental & Forensic Investment Research." CFRA.

the same period. According to a report by CFRA, “Computing and Graphics annual revenue grew 39% in 2018, while Enterprise, Embedded, and Semi – custom annual revenue rose 3%. Both segments posted operating profits for the year.”[45] EPS for 2018 was of $0.46 compared to $0.10 in the prior year. AMD is scheduled to release newer and more sophisticated technology to the GPU and CPU market, which their competitors aren’t scheduled to release until a year after. According to an article by Seeking Alpha, “AMD is scheduled to aggressively roll out new products with industry-leading 7nm node this year across its GPU and CPU product families. Meanwhile, channel reports suggest that Nvidia would move to 7nm only in 2020 while Intel would transition to its own 10nm node by 2019-end. This timeline suggests that AMD would have competitive silicon starting with 2019.”[46] According to the article, this is a big deal for the company. In the past the company relied on dated fabrication processes and therefore wasn’t able to compete effectively with Intel and Nvidia. With the release of the new products the company will potentially benefit from achieving higher average selling price (ASP) and market share gains against its main competitors.[47] During the second half of 2018, prices for GPU’s and CPU’s have declined due to inventory build ups and decreasing demand. Other companies in the sector experienced the same problem that resulted in lower stock prices for these companies. In 2019, analysts are estimating stronger demand for GPU’s which will help improve AMD’s revenue, margins and profit.

[45] Independent Fundamental & Forensic Investment Research." CFRA.
[46] Equity, Business Quant Long/short. "AMD: The Big Guys Just Love It." Seeking Alpha. February 21, 2019. Accessed April 10, 2019.

[47] Equity, Business Quant Long/short. "AMD: The Big Guys Just Love It." Seeking Alpha. February 21, 2019. Accessed April 10, 2019.

The next semiconductor company that will be analyzed below is Intel Corporation (Nasdaq: INTC).

https://www.intel.com/content/www/us/en/history/historic-timeline.html

Intel Corporation Timeline:

- 1968- Intel is founded
- 1969- Intel purchases its first piece of property in Santa Clara California
- 1971- Intel Goes Public
- 1972- Intel opens its first international manufacturing facility in Malaysia
- 1975- Intel launches ICE-80 the world's first emulator
- 1982: Intel Launches the high performance 16-bit microprocessor, built in numerous PC's
- 1992- Intel becomes the largest semiconductor supplier in the world
- 1995- Intel Chips power 85% of all desktop computers
- 1999- Intel enters the Dow Jones Industrial Average
- 2005- Apple announces they will transition to only using intel's chips in their MA computers.

- 2011- Intel records six consecutive quarters of record earnings

- 2017- Intel bought Israeli based company Mobileye for $15.4 Billion.

Intel is the world's largest chipmaker based on revenue and unit shipments and is well known for its dominant market share in microprocessors for PCs. The microprocessor is the central processing unit (CPU) of the computer system, and acts like the brain of the computer. The company also sells other chips products for other areas such as networking, data storage, and communication services. The company is based in Santa Clara California and was founded in 1968 by its co-founders, Gordon Moore and Robert Noyce. Intel reports its businesses in the following operating segments: Client Computing Group, Data Center Group, Internet of things, Non-Volatile Memory solutions group, and Programmable solutions Group.[48] Most of these groups focus on microprocessors, chipsets for desktops, notebook laptops, servers, wireless connectivity products, smartphones, navigation systems, etc. The Internet of Things (IoT) unit develops embedded chips for retail, transportation, industrials and video surveillance market segments, along with other embedded applications. Although the unit made up only 5% of the company's sales in 2018, it is fast growing and profitable. During the second quarter of 2018, Intel reported that its IoT group delivered $880 million in revenue up 22.2 % year over year. According to the company's quarterly filling, the growth in this group came from "strength across the retail, industrial, and other market segments. "The microprocessor market accounts for about 20% of the total semiconductor industry's revenue mostly sold by two companies Intel and Advanced Micro Devices (AMD)."[49] Intel which overwhelmingly dominated this market for many years has been

[48] "Stock Reports." TheStreet. Accessed April 10, 2019..
[49] "Independent Fundamental & Forensic Investment Research." CFRA.

losing some market share to its main competitor in this space. As discussed in the previous segment, in the past several years AMD introduced new advanced chips at lower prices and is able to compete more effectively against Intel. According to an article in March 2019 at Seeking Alpha by Khaveen Jeyaratnam, in 2018, Intel announced the delay in volume release of 10 nm CPUs which was scheduled to be released in late 2018; supply issues have pushed it back by a year to late 2019. Additionally, the company couldn't manufacture enough 14 nm chips to cope with demand. Due to this shortage, Intel dramatically increased the prices of its CPUs. Although raising prices helped the company to boost its profit. AMD was able to gain market share and in 2018 AMD gained 2.8% share in desktop to reach 15 %. [50] Still however according to a report by CFRA, "Intel ships more than 85% of the world's microprocessors and is still the clear leader in this space."[51] The company for many years has focused on supplying CPUs to companies such as Apple, Lenovo, HP and Dell. Over the past several years however, it has expanded its businesses into other industries and new emerging technologies such as autonomous vehicles, IoT and 5G. According to a report by The Street discussing Intel's autonomous business "Intel/Mobileye has landed a big deal with a European automaker, although what automaker is involved wasn't disclosed. Financial terms also weren't disclosed. We do know however that the deal includes 8 million vehicles and will begin in 2021 involving Intel's EyeQ5 chips. The company says the EyeQ5 chips will be capable of level 4 autonomous driving. Given that level 4 is oh-so-close to level 5 fully autonomous driving, consumers have reason to be excited."[52] (Kenwell, 2018) As mentioned earlier in the paper, Intel bought the Israeli based company Mobileye in August 2017 for

[50] Jeyaratnam, Khaveen. "Intel Vs. AMD: Battle For Market Share." Seeking Alpha.

[51] "Independent Fundamental & Forensic Investment Research." CFRA.

[52] Kenwell, Bret. "Intel Is Making Waves in the Autonomous Driving Race With Mobileye."

$15.4 Billion. The company focuses on machine learning, mapping and driving policy technology. Since the acquisition of Mobileye, the company have made great strides in their advancements being that they have almost reach a level 4 out of 5 in autonomous vehicles technology. From recent reports the company has already partnered with BMW and another European auto company and has planned to potentially ship 6 to 8 million vehicles within the next few years. This will certainly put Intel as one of the leaders in this space. According to Reuter's business news article in February 2019, "Intel aims to push beyond phones with 5G infrastructure deals".[53]

The company announced new chips and partnerships for 5G networks. Bob Swan, Intel's CEO, said Intel's future is in 5G networks, which are expected to roll out this year and next and be much faster than the current 4G networks. The CEO said at a press event in Palo Alto, California "Now we are at a stage where we believe we have products that are as good as anybody in the industry as we move into 5G".[54] Financial information is discussed in the Financial analysis section below.

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[53] Nellis, Stephen. "Intel Aims to Push beyond Phones with 5G Infrastructure Deals." Reuters. February 25, 2019. Accessed April 11, 2019.

[54] Nellis, Stephen. "Intel Aims to Push beyond Phones with 5G Infrastructure Deals." Reuters. February 25, 2019. Accessed April 11, 2019.

The fourth semiconductor company that I am analyzing next is Nvidia Corporation

(Nasdaq : NVIDA) Nvidia Timeline:[55]

- 1993- Nvidia Founded by Jensen Huang.
- 1995- Nvidia launches its first product, NV1.
- 1997- Nvidia launches world's first 128-bit 3D Processor, RIVA 128.
- 1999- Nvidia invents the GPU (Graphic Processing Unit).
- 2003- Nvidia acquires Media Q.
- 2008- Tegra Mobile Processor launched.
- 2011- Nvidia acquires baseband leader, Icera.
- 2017- Nvidia furthers modern AI with GPU Deep Learning, Volta.
- 2018- Nvidia reinvents computer graphics with Turing architecture
- https://www.nvidia.com/en-us/about-nvidia/corporate-timeline/

[55] "NVIDIA Company History: Innovations Over the Years." NVIDIA.

This company is also based in Santa Clara, California and was founded in 1993 by Jensen Huang, who currently serves as their Chief Executive Officer. Their two main products are GPU's (Graphic Processing Units) and Tegra Processors. Their products are known for visual computing, high performance computing and mobile computing. According to a report by CFRA, "The GPU segment includes GeForce for PC gaming; GeForce NOW for cloud-based game streaming services; Quadro for design professionals working in computer – aided design, video editing, special effects and other creative applications."[56] Their other segment of business which is Tegra Processors, focuses on automotive super computers that provide self-driving capabilities, cloud computing, AI and gaming. Nvidia, Advanced Micro Devices, and Intel are the three main competitors in the GPU market. Nvidia leads in the desktop computer market space, but AMD on the other hand controls the laptop market. In 2018 the company stock have reached all time high of $292 per share due to strong demand for their chips, however in late 2018 with a sharp correction in the stock market and particularly in the semiconductor sector its stock price fell sharply and reached low of $124 in December 2018.[57] The correction that was caused by investors' concern of the Fed possible rate hikes in 2019 as well as the trade war with China was eased substantially in early 2019 resulted in a strong rebound in the first 4 months of 2019, Nvidia stock climbed back up to $190 by April 2019. In the most recent quarterly report on March 19th, Nvidia released its most recent graphic cards used for video games, artificial intelligence and machine learning tasks which have been reported to cost thousands of dollars. According to an article written by Aaron Pressman, "CEO Jensen Huang announced a product for

[56] Independent Fundamental & Forensic Investment Research." CFRA.

[57]"Stock Reports." TheStreet. Accessed April 10, 2019.

the “maker” market of students, hobbyists, and tinkerers with a tiny $99 computer optimized for A.I and machine learning.”[58] Since they’re offering this technology for such a low price, the company hopes it could allow more people to create the next big “thing” to the market. In addition, the article also mentioned one of Nvidia’s most recent partnerships with Amazon, where they will begin offering its cloud server customers the ability to run their apps on Nvidia’s newer T4 Tensor Core graphics cards in addition to the other types of Nvidia cards it already offers. This is one of many partnerships that Nvidia has formed over the past year.[59]

On March 11th of 2019, Nvidia announced that they are acquiring Mellanox, an Israeli based company in an all cash transaction for $6.9 Billion, the company’s largest ever acquisition. Mellanox technology has applications in self-driving cars, and even in gaming computers, but its primary niche is in cloud-data centers and as such is expected to strengthen its data centers business.[60] Mellanox produces what they call interconnect chips which are used in data centers for mainly networking. According to an article in Seeking Alpha, interconnect chips is an $11 billion market that has been growing at a double digit rate every year and it is valuable for Artificial Intelligence and high - performance computing. In addition to helping Nvidia broaden its portfolio of products it will also potentially help them financially once the acquisition gets approved by its shareholders. Mellanox reported in 2018 that it earned $240 million in EBITDA and grew sales

[58] "Nvidia Has an A.I.-Focused Computer for the DIY Crowd."

[59] "Nvidia Has an A.I.-Focused Computer for the DIY Crowd."

[60] The Meticulous Investor Registered Investment Advisor. "Mellanox: Long The Deal Spread."

by over 26% within the past year which will immediately boost Nvidia's earning for the following quarters.[61] According to an analyst report from CFRA, "we think Mellanox (MLNX) provides greater diversification away from the volatile gaming business as it expands Nvidia's capabilities within networking and storage to address a $60 Billion plus addressable data center market."[62]

Nvidia announced at the GPU technology conference of 2019 that it will be forming a partnership with Toyota Motor, the second largest automaker in the world. According to a Yahoo Finance article written by Beth Mckenna, "Nvidia builds on an ongoing relationship with Toyota to utilize the NVIDIA DRIVE AGX Xavier AV (autonomous vehicle) computer, according to NVIDIA's press release. The collaboration involves the development, training, and validation of self-driving vehicles."[63] Nvidia and Toyota are seeking to be one of the first companies to release a fully autonomous vehicle to the market. This will give both companies a significant advantage over both technology and auto companies who have invested billions of dollars in order to achieve the same goal. In addition to this strategic partnership, Nvidia has many other partnerships with very large automotive companies from around the world".[64] According to an article from Motley Fool, "In addition to Toyota, it's inked partnerships with many top companies, including automakers Mercedes-Benz and Volkswagen's Audi unit, and ride-hailing giant Uber".[65]

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[61] The Meticulous Investor Registered Investment Advisor. "Mellanox: Long The Deal Spread."

[62] Independent Fundamental & Forensic Investment Research." CFRA.

[63] Mckenna, Beth. "NVIDIA Expands Driverless Vehicle Partnership With Toyota."

[64] Mckenna, Beth. "NVIDIA Expands Driverless Vehicle Partnership With Toyota." Yahoo! Finance. March 26, 2019. Accessed April 11, 2019

[65] McKenna, Beth. "NVIDIA Expands Driverless Vehicle Partnership With Toyota." The Motley Fool. March 26, 2019. Accessed April 11, 2019.

The fifth and final company that I will be analyzing is Qualcomm Corporation Nasdaq (QCOM):

Qualcomm Timeline:

- 1985- Qualcomm was founded by professor Irwin Jacobs, Andrew Fiterbi, Harvey White, and a few others from MIT.
- 1992- The manufacture of CDMA cellphones began, alongside base stations and chips.
- 1999- Qualcomm sold its base station business to Ericsson, cellphone business to Kyocera, while focusing on wireless technologies instead
- 2014- Steve Mollenkopf was promoted to CEO and announced that Qualcomm would target the data centre market with sever chips based on ARM architecture. Qualcomm saw huge growth in profits during this time as its Snapdragon System-on-Chip poached market shares from competitors.
- 2017- Apple sued Qualcomm for $1 Billion in the United States and $145 million in China
- 2019- Qualcomm announced its second-generation 5G cellular modem, known as the Snapdragon X55

https://www.manufacturingglobal.com/technology/qualcomm-history[66]

The company was founded in 1985 and is located in San Diego, California. Qualcomm is one of the largest companies in the semiconductor sector, and they focus specifically on marketing, developing, and manufacturing digital communication products. They currently operate in 3 segments: Qualcomm Technologies (QCT), Qualcomm Technology Licensing (QTL) and, Qualcomm Strategic Initiatives (QSI). QCT focuses on Integrated circuits, system software, and other technologies for use in wireless voice and data. QTL focuses on licensing their technology to manufacturers that use their products in wireless devices such as mobile phones, tablets, laptops gaming devices, etc. QSI focuses on potential investments and opportunities that are available for the company as well as focusing on specific industries to invest in such as healthcare, energy, ecommerce, etc. One of Qualcomm’s main focus is to produce modem chipsets which are sold to mobile phone manufacturers such as LG, HTC, Sony, Microsoft, etc.[67] Their wide range of products include processors, software, and now they’re one of the leaders in 5G wireless services and IoT. In an event in Hannover Germany, Qualcomm showed to the public how far along they are in their 5G service technology in accordance with their upgraded IoT technology. According to an article from Business Insider, “Qualcomm is demonstrating 5G's strongest industrial applications. Qualcomm has selected the most enterprise-ready applications of the technology to show at Hannover. Several of the partnerships highlight how its technology is well suited for data transmission for robotics in large manufacturing plants, because 5G offers increased bandwidth and data transmission rates as well as lower latency.”[68] While talking about 5G, Qualcomm un-

[67] "Independent Fundamental & Forensic Investment Research." CFRA. Accessed April 10, 2019.

[68] Paul, George. "Qualcomm Is Showcasing 5G's Strongest Industrial Applications at Hannover Messe." Business Insider.

veiled in 2019 its 2nd generation 5G technology that will soon be used in mobile phones. According to an article from Nasdaq, “Wireless technology giant Qualcomm announced its second-generation 5G cellular modem, known as the Snapdragon X55, earlier this month. The modem is a significant advancement from the company's first-generation 5G modem, known as the Snapdragon X50…Although there is a market for stand-alone cellular modems, the vast majority of smartphones use applications processors that also have the main cellular baseband processors integrated inside. That integration is popular because it allows smartphone makers to build smaller logic boards as well as potentially improve power efficiency”[69]. In its most recent earning call Qualcomm management stated that “It will be the “modem supplier of choice for the majority of the first wave of 5G devices”.[70] These are all very significant upgrades for Qualcomm’s business that I believe will reflect positively on their future earnings reports as well as their stock price once 5G is fully released to the market.

Recently, Qualcomm has appeared in many headlines regarding legal battles with Apple over royalties and patent infringement. This dispute started in 2017 when Apple sued Qualcomm for $1 Billion in the United States and $145 million in China. Qualcomm countered by suing Apple in China and Germany as well. Once Apple started using Intel modems instead of one made by Qualcomm, Qualcomm filed a lawsuit stating that they aren’t using all of their technology, and that Apple needs to pay them a certain amount of royalties. Apple thought they were acting as if they were in a monopoly by charging higher royalties since Apple didn’t only use Qualcomm’s technology.[71] These resulted in many lawsuits that still haven’t yet fully concluded in

[69] Eassa, Ashraf. "Qualcomm Just Made Another Huge 5G Chip Announcement."

[70] "The 5G Economy | 5g Value Chain." Qualcomm.

[71] "Apple Loses Battle to Use Intel Modems in Germany in Latest Clash with Qualcomm."

court. Some of these lawsuits resulted in a ban on older IPhone models in Germany, until they switched to Qualcomm modems on their most recent IPhone's. More recently however, Qualcomm won another legal victory against Apple in court. According to the New York Times and Reuters, "Qualcomm won a legal victory against Apple on Friday when a federal jury in San Diego found that Apple owed the mobile phone chip supplier about $31 million for infringing on three of its patents. During an eight-day trial in the United States District Court for the Southern District of California, Qualcomm asked the jury to award it unpaid patent royalties of up to $1.41 per iPhone that violated the patents"[72] (Stephen Nellis, March 2019). This two-year legal battle has certainly affected Qualcomm's business since Apple's promise to pay their royalty was broken which forced Qualcomm to lower their forecasts for their future quarterly earnings reports and their yearly projections.

In another large news headline that has been widely talked about over the past year or so, was when President Trump blocked the potential acquisition between the semiconductor company based in Singapore, Broadcom Ltd. Broadcom was planning to acquire Qualcomm for $117 billion however, Trump issued an executive order to have this blocked since Qualcomm has been known to be one of the biggest suppliers for the Pentagon. They may hold other classified contracts which is worrisome since Broadcom is a foreign company. Another possible reason the government blocked the acquisition, according to an article in Bloomberg "CFIUS warned that Broadcom, an enthusiastic cost-cutter, might slash Qualcomm's R&D spending in pursuit of short-term profits. In doing so, it could put Qualcomm at a disadvantage in the race to offer next-

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[72] Nellis, Stephen, Reuters. "Apple Violated 3 Qualcomm Patents, Jury Finds."

generation wireless and diminish its influence in setting standards and protocols. That, in turn, could give a leg up to Qualcomm's top competitor, Huawei Technologies Co. Ltd., which has ties to the Chinese government"[73] (Leonid Bershidsky, March 2018). Since the trade war has been taking place over the past year, the U.S. government still views China as a security threat in term of creating disadvantages from U.S. firms as well as intellectual property theft. Since Qualcomm is an American based company and is currently one of the leaders in 5G technology, their business in this industry could come at a disadvantage once a new management takes over the company and potentially change their orders of operation. President Trump has been all about "The U.S. first" in terms of businesses, manufacturing, and trade, so he definitely wants Qualcomm to remain in the U.S., so it could be one of the main leaders in 5G throughout North America.

The section below will discuss the financials and the financial tools that I used for each of the five companies that I discussed in great detail about in the previous paragraphs. The main tools I looked at are listed below in Graph 1 and Graph 2. I listed their current **Stock Prices** in the stock market. The next tool shown is their **52-week range** of how much their prices have fluctuated within the past year. Next, is the **Market Cap** which refers to the total value of all a company's shares of stock. Next, is their annual revenue they each earned over the past year, which makes it easy to compare how they've performing financially amongst each other. Earnings per share, or **EPS** is the portion of a company's profit allocated to each share of common stock. Earnings per share serve as an indicator of a company's profitability. The price-to-earnings ratio, or **P/E** is the ratio of the market price of a company's stock to its earnings per share (EPS): (Market Value Per Share/EPS). The return on equity ratio or **ROE** is a profitability ratio that

[73] Bloomberg.com. "Trump is right to block Broadcom-Qualcomm deal."

measures the ability of a firm to generate profits from its shareholders investments in the company. In other words, the return on equity ratio shows how much profit each dollar of common stockholders' equity generates. **Net Income** is the total revenue in an accounting period minus all expenses during the same period. A Dividend Yield is the distribution of reward from a portion of company's earnings and is paid to a class of its shareholders.

Chart 1

Companies	Stock Price	52 Week Range	Market Cap	Annual Revenue	Net Income
Micron Technology	$42	28$-$64	$47.4 Billion	$30.39 Billion	$14.1 Billion
Advanced Micro Devices	$28	$9-$34	$31.46 Billion	$6.4 Billion	$337 Million
Intel Corp.	$53	$42-$57	$251 Billion	$70.8 Billion	$21 Billion
Nvidia Corp.	$188	$124-292	$114.6 Billion	$11.72 Billion	$4.1 Billion
Qualcomm Inc.	$80	$48-$82	$70 Billion	$22 Billion	$-4.8 Billion

Chart 2

Companies	EPS	PE Ratio	Dividend Yield	Return on Equity
Micron Technology	$11.82	3.63x	N/A	40.70%
Advanced Micro Devices	$0.35	83.11x	N/A	37.84%
Intel Corp.	$4.58	12.21x	2.25%	30.08%
Nvidia Corp.	$6.07	31x	0.34%	41.78%
Qualcomm Inc.	$3.20	18.14x	4.29%	36.67%

According to Charts 1 and 2 that demonstrates each of the five company's financials, their stock prices have all fluctuated within the past year, however they are all somewhat in the middle or close to their 52-week high. Micron has a very high EPS in comparison to the other 4 companies and also has a high annual revenue of $30.39 Billion as well. Micron has a full year EPS of $11.82 or close $12 meaning this stock should be traded at a much higher stock price since it is only being traded at 3-4x PE Ratio. As the reader can see, the rest of the 4 companies are being traded at a much higher PE ratio than Micron which is shocking how Micron is only around $42 a share currently. Even if Micron had traded at 10x PE the stock price would have been at $120 per share which demonstrates that shares are traded at a discount relative to other companies in the sector. When reviewing Micron's balance sheet and how it changed over the past 5 years, it demonstrates the significant reduction in long term debt since 2017. In 2014 Micron had approximately $4 billion in debt which grew significantly to $11 Billion by 2017 due to more investment, acquisitions, and overall spending. Since 2017 however, they have cut their debt to as low as $3 billion based on its most recent quarter. Because of buildup in inventory prices of DRAM and NAND decline, Micron was forced to lower their chip prices which resulted in lower revenue and profit for Micron in Q1 2019 and lower revenue guidance for Q2. As a result, Micron stock price has suffered going from as high $64 a share to as low as $28 per share. This cyclical trend still impacts the company to a certain extent but not nearly as it used to which is why Micron's stock price has recovered back to $40 a share within just a few months.

Advanced Micro Devices (AMD) has been blowing investor's expectations with its EPS estimates to be between $0.60 - $0.90 in 2019, which is more than double what it is now. They are close to its 52-week high with strong revenue, meaning the stock price has a lot of room for growth. AMD's stock price has increased over 200% in 2018 climbing from 52-week low of $9 and reaching 52-week high of $34 but shares fell sharply back to $16 in December 2018 after releasing a weak 3rd quarter report. AMD's stock price has responded very well to the recent positive 4th quarter report rising 9.1% immediately after their earnings were released. In the 4th quarter the company reported revenue of 1.42 billion a 6% increase year-over year mostly driven by their Computing and Graphics segment. AMD's business has expanded rapidly over the last couple years and in the mean-time they have been paying off their debts as well as increasing their total assets, according to their most recent earnings reports. In my opinion, I believe AMD will continue to outperform investors' expectations in the upcoming year giving the projected increase in chips prices in second half of 2019 as well as the expected release of their new CPU and GPU products which will give them a competitive advantage as they will be the first company to have the newest technology out in the market for at least a year.

Intel, according to the chart, is very close to it 52-week high with a very strong annual revenue, which has been increasing a great deal year over year. As they show improvements in their autonomous vehicles with Mobileye, look for its stock price to increase in the near future since its only being traded at 12x PE, which is below the industries average. Recently, some analysts turned more bullish on the stock. According to MarketWatch's article by Emily Bary on February 2019, Intel shares gained nearly 3% immediately after Morgan Stanley turned bullish on the stock for the first time in seven years. Analyst Joseph Moore upgraded the stock and upped his price target to $64 from $55 citing his optimism about the company's new CEO and his belief that the shares are currently are too low relative to peers.[74] In terms of their stock price, they are being traded at $53, close to its 52-week high, with an EPS of around 4.50 and a and a paying dividend yield of 2.4 %. The stock is up 75% over the last three years as a result of strong

[74] Bary, Emily. "Morgan Stanley Is Bullish on Intel for the First Time in 7 Years."

revenue growth, which is why I believe that this stock is being traded at a discount and will outperform investor's expectations in the next couple of years.

Nvidia has recovered from having a weak second half of 2018 coming back from as low as $124 a share. The company released its 2018 fourth quarter results in February 2019 and although it missed revenue projection it reported $0.17 better than expected EPS of $0.80, resulted in the stock climbing 9% after the earning release. After the quarterly report was released, some analysts turned more positive on the stock. Their annual revenue is $11.72 Billion and net income of $4.1 Billion in 2018 and their market cap is $114.6 Billion. The company's current PE Ratio is around 31x which is average for the industry. Due to new GPU's coming to the market in addition to the acquisition of Mellanox, the company has a lot of growth potential and will likely climb back up to its 52-week high stock price as its financial performance improves.

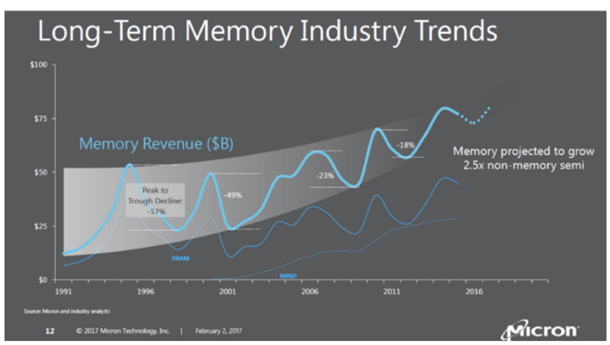
Qualcomm, according to the chart is currently being traded at around $80 climbing back from a 52-week low of $48, and has a market cap of $70 Billion, with an EPS of $3.20 for the entire year of 2018. This means that the company is being traded at around 19x PE ratio, which is below average for the semiconductor industry since its average PE ratio is around 25x.[75] In addition, its Dividend Yield payout to its shareholder is about 4.29% which is very attractive yield for investors looking for income in addition to growth. It has just made a deal with Apple to settle their long dispute in court, helping both sides get back to doing business together. Qualcomm has already reported that this will significantly help their financials and their future earnings for 2019 which has given shareholders a boost of confidence and has already helped the stock reach its 52- week high. This gives me the impression that investors were worried that these lawsuits with Apple will end up really hurting Qualcomm's business. Now that they have settled and

[75] Independent Fundamental & Forensic Investment Research." CFRA.

agreed to continue to conduct business with each other, this relief that investors have now, will then lead investors to be very bullish on the company in the years ahead.

I have researched the semiconductor sector for over a year since early 2018 and gained a much deeper understanding of the semiconductor industry as a whole and the five new emerging technologies that were discussed in detail in this paper. I also obtained an in-depth knowledge of the five companies discussed above. During this period, I have followed each of their stock's performance every day, read news articles, analysts' comments, quarterly reports and listened to post earnings conference calls. I also had the rare opportunity to discuss my research directly with a well-known semiconductor's analyst on Wall Street who provided me with encouragement, guidance, insight and outlook on the industry (his name cannot be disclosed due to his request). I watched the industry performing extremely well in the first half of 2018 and then have seen its sharp decline in stock prices and financial performance through the end of 2018, due to mostly inventory corrections and other factors such as Fed rates policy and the trade dispute with China. The industry and the market as a whole recovered sharply in the first 4 months of 2019 erasing most of its losses as the semiconductor sector gained over 30% since the beginning of the year as analysts predict a better second half of 2019. The ups and downs in stock prices in 2018 and the strong recovery in early 2019 demonstrated the typical cyclical behavior of the sector that always kept analysts and investors in semiconductors stocks on edge; this helped me gain a better understanding of investors' concerns when investing in the sector. I concluded that this sector continued to be cyclical, however in comparison to past cyclical trends, this was much shorter and less severe. I believe, based on my research, that the sector has entered a period of secular growth (secular trends are very long that could last many years as opposed to cyclical trends that are short term). As discussed in the paper, the sector has gone from relying mostly on

PCs and laptops for revenue to supplying chips for gaming, AI, Cloud, IoT, etc. These revolutionary technologies will increase demand for chips and will provide a catalyst for growth in the sector for many years as some of these technologies such as 5G and Autonomous vehicles are at the early stage of their development and implementation. In fact, most of these innovations could not have been developed without the advancement in chip designs and technology. Semiconductor companies are the heart of the technology revolution that we are seeing today. There are clear significant disagreements among analysts and investors on the business outlook of this industry as many analysts and investors still view the sector has highly cyclical; some others however, agree with my conclusion. This senior thesis will help me pursue a full-time position for an analytical position in the finance industry since I now have practical experience in this field. Overall, this was a very positive learning experience and I hope the readers will appreciate and learn from my project, just as much as I did.



<u>Graph 3</u> [76]

Long Term Memory Trends; Semiconductor Trends are Less Cyclical

[76] Forbes. Accessed May 09, 2019. https://blogs.forbes.com/tomcoughlin/micron-long-term-memory-industry-trends.

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