

Forum: *Economic and Social Council (ECOSOC)*

Issue: *Addressing the global shortage in semiconductors*

Student Officer: Weiwei Chao

Position: *Deputy Chair*

Introduction

Semiconductors are one of the most important products and components of technology. Its presence influences the world through improving communication, transportation, computing, health care systems, and other countless applications. Starting from 2020, global semiconductor supply chains have been disrupted in various ways, causing a tremendous shortage of semiconductors, and there haven't been any signs of improvement to being prone to resolve in any time soon. The semiconductor shortage has affected hundreds of different industries, some of which are consumer electronic devices and the automotive industry. Not only that, the ripple effect of the semiconductor shortage is massive, ranging from steel production to electronic technology systems. It is worth noting that millions of products nowadays incorporate the use of semiconductors; the shortage of chips would eventually paralyze the whole supply chain, which then might cause some serious economic issues or consequences. One of the issues is the disproportionality of the chip supply chain, which puts pressure on specific countries. Global semiconductor production has always been leaning and relying on East Asian countries like Taiwan and South Korea. Supply chains are mostly packed in Asia, with Western countries contributing only about 20% of the global production. The shortage of semiconductors will be a burden for these countries.

The COVID-19 pandemic was the most important and evident cause of the shortage. The pandemic that started in late 2019 not only changed people's way of living, but the whole modification of scale of demand and production. Due to the lockdown, factories and enterprises' operations were terminated, temporarily closing the supply chain of semiconductors and many other technologies like automobiles. Thus, semiconductor companies have constantly been rejecting orders. On the other hand, the increase in demand for consumer technologies and the development of the auto industry have put pressure on those semiconductor companies, pressing them to forcibly open up the supply chain to accommodate the large consumer demand. Opening up factories without enough raw material resources and personnel is ineffective. With the strong demand of the quantity and quality of technology in times of

the COVID-19 pandemic, semiconductor manufacturers sales went way more than the time of the start of the pandemic. The growth continued in 2021. According to the Semiconductor Industry Association, semiconductor sales have increased 26% compared to last year. However, demands from the market are still too high for the manufacturers to achieve. In addition, the US-China trade war since 2018 was also one of the causes of the global shortage in semiconductors. Government and private semiconductor companies like the TSMC have to take actions to cope with the loss and imbalance of demands and outputs.

Definition of Key Terms

Semiconductors

Semiconductors, or microchips and integrated circuits (ICs), are usually made of electrical conductivity value and silicons or other “metalloid staircase” chemical elements that can have various functions in relation to powering displays and transferring data. It refers to any class of crystalline solid that is intermediate in electric conductivity. Semiconductors are designed with properties similar to conductors and insulators. With these different properties, semiconductors are used to power multifarious devices such as cars, phones, laptops, game consoles, and other technical uses. Chips are made of properties that can handle extreme temperatures, vibrations, and external shocks. However, the global semiconductor supply chain is unstable and fragile, which would be easily disrupted by changes in the economy and society. If there is a shortage of semiconductors, the sale of various devices would be affected significantly.

Automotive Industry

The automotive industry started in the 1860s when gasoline engines were invented. This industry covers up all the companies and activities related to automobiles and their manufacturing process. Some common products of this industry are passenger automobiles, light trucks, commercial vehicles, buses, and other automobiles. The automotive industry has emerged vastly in the technology sector since the introduction of mass production. In modern days, the automotive industry grew to become one of the largest industries. It is the largest manufacturing industry in the United States in terms of revenue.

Wafer Fabrication Capacity

Wafer fabrication is the repeated and sequential process of producing a complete electrical or photonic circuit on semiconductor wafers. Fabrication or wafer capacity refers to the number of wafers the blank disk of silicon can process. Raw silicon wafers are being turned into ICs, or semiconductor fab.

These fabs are also being measured as the diameter of the wafers. Adding new fabrication capacity can take a significant amount of time, which slows down the production. Companies started to create innovations like disks with higher wafer fabrication capacity as an alternative.

Trade war

A trade war is a war between two countries on the matters of the tariffs imposed on imported goods. It occurs when a country raises tariffs on imported goods to retaliate against the other country. Placing restrictions on the importation of goods from a specific country can lead to a trade war. One of the examples of a trade war is the most recent conflict between the United States and China in 2018.

Background Information

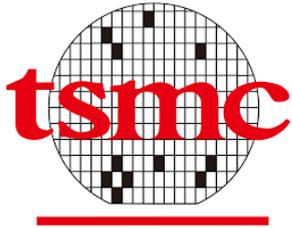
Semiconductor chips supply chains

Millions of products in the world rely on the production of semiconductors, which includes cars, machines, electronic devices, and other important technologies. The semiconductor supply chain includes various procedures, any change in one of the processes would possibly slow down or knock down the whole supply chain. These processes include System Companies, travels through EMS, IC Design, IC Manufacturing, IC Assembly & Test, End Consumers, and circles back to System Companies. In order to keep the supply chain efficient, companies need to ensure code compliance, risk assessment, audit participation, and continuous improvement of their production process. The chip supply chain has gradually decreased in the west; however, East Asian countries have increased their chip supply chain. Countries like Taiwan, South Korea, Japan, and China have become some dominant semiconductor manufacturing hubs. Pressure is exerted as those important semiconductor suppliers toil to meet demand of the global consumers.

Asia's Semiconductor Industry

The "Big 4" semiconductor players are the four most advanced countries in East Asia -- Taiwan, South Korea, Japan, and China. The two most important semiconductor foundries in East Asia are Taiwan Semiconductor Manufacturing Company (TSMC) and Samsung Electronics in South Korea. According to data from Trendforce, TSMC has 55% foundry market share and Samsung has 18%, which accounts for 81% of the global market in foundries. They are responsible for 70% of the world's semiconductor demands, with China itself accounting for 30% of the production. With TSMC being the world's largest semiconductor contract company, its

cooperation with Sony in Japan to build another semiconductor factory will provide even more production to meet the large demands of semiconductors.



Caption #1: TSMC logo

America's semiconductor industry

The United States' semiconductor industry or company only stands for 10% of the global semiconductor production. Thus, the US is currently trying to regain its sovereignty and dominance over the global semiconductor supply chain. The current US president, Joe Biden, is carrying out attempts to increase their manufacturing abilities in order to lessen the reliance of chip manufacturers in Asia. Nonetheless, East Asia semiconductor companies still rely on the US and other European countries on equipment and specialized machinery.

Consumer demands

Consumer electronics

Consumer electronics have a substantial role in the global economy and the overall development of technology. The consumer electronic market is estimated to have a value of USD \$1 trillion in 2020, and would grow 8% from 2021 to 2027. It is categorized as electronic equipment for daily usage, especially in private homes, which includes devices used for entertainment, recreation, and communications. This market requires an intensive amount of chips. With only personal electronics, the sector accounts for a total of 50% of the global chip production.

Automobile industry

The automobile industry was totally being shut down due to the ongoing COVID-19 pandemic. Carmakers like Ford Motor and General Motor closed their production line completely, with a momentary reopen of the production. Carmakers and factories were refusing orders. Thus, sales in the automobile industry have decreased significantly during the pandemic. Although car

maker companies started to ramp up its production again in late 2020, time is still needed for the supply chain to return to its effectiveness again. Semiconductor companies and factories are still in low production, therefore are not able to keep up with the surge of demands. Furthermore, as market pressure increases the expansion of the auto industry, semiconductor demands have increased even more. The auto industry's demand for chips becomes more as companies start to create new assistance systems and autonomous driving systems. A typical new vehicle costs about 1400 chips. Total input costs for new premium cars will also increase as the global chip supply chain faces inevitable pressure from demand.

Changes in the chip industry/current situation

Technologies have been improving continuously, and markets need to meet the rapidly growing demand for goods regardless of the situation present. With the emergence of 5G and other inventions, the semiconductor industry needs to burst out more products for the supply chain to keep on operating. Adding on to this new demand in the industry, the COVID-19 pandemic was one of the most pivotal reasons that caused the global chip shortage. Overall, the situation globally has altered the semiconductor supply chains.

COVID-19 Pandemic

Starting from December of 2019, the COVID-19 pandemic has been causing immense changes to the international community in economic, social, and political aspects. Lockdown has been imposed due to the continuous widespread of the disease in 2020 until now. The pandemic has devastated the global economy as companies and restricted other smaller enterprises. The pandemic has two significant impacts on the semiconductor industry that cause the global shortage. As the pandemic worsens, factories are being forced to close, terminating the production of materials, which obviously includes the production of chips and other technologies. With employees and students being locked in their houses, the demand for consumer electronics and technologies increases. At the end of 2020, most people already purchased all electronic devices needed. Computer sales have increased 26.1% compared to the previous years.

5G

5G is a new advancement in mobile networks following 4G. This new global wireless standard guarantees delivery of higher multi-Gbps peak data speeds, latency, reliability, and capacity. The introduction of 5G into the industry improves the overall efficiency and performance of the connecting experience between users. The usage of the 5G mobile network is estimated to

be responsible for \$13.1 Trillion dollars of global economic output. However, this also indicates that global chip shortage would most definitely have some substantial impact on the economy.

Key Issues

Immoderated Market Demand

Semiconductors have been a vital production for most of the products on the market. However, the production of the semiconductor wasn't able to meet the rapidly growing market demand from 2019 to 2021. Market demand has gone wild during the pandemic, suddenly causing a large demand of production. During the pandemic, electronic devices, video games, and other consumer electronics have become more popular as people started to rely more on internet connections. With inadequate supplies and preparation of those big chip and technology manufacturers, the increase of demand became a serious problem in the technology industry. Semiconductor companies were not able to function effectively at first due to temporary terminations of production. Hence, their production wasn't able to sustain the needs of people. Furthermore, this sudden shortage of chips led to a phenomenon of panic-buying. People started to store supplies and dried resources like toilet papers early on, which exacerbated the issue even more. Although people started to get vaccines, and began slowly recovering and reopening society, the consumption of chips was still continuously growing.

COVID-19 pandemic

One of the major problems that goes along with the shortage of semiconductors is the COVID-19 pandemic. This problem should be highlighted because not only did the pandemic increase the demand overall, it completely revolutionized the mode of society. Society tends to become more lenient toward electronic device use. Even if society started to get back to the norm, development in new technologies and functions were already surging since 2020. This development will not stop after the pandemic, and instead, would remain to be what society relies on. This indicates that without the pandemic ending, the shortage of semiconductors will still be a major issue concerned by tech companies all over the world. For now, the pandemic has not yet ended, but semiconductor companies now need to find ways to cope with any possible disadvantages caused by the lockdown and change in demands. In the future, companies also need to find ways to deal with the long-term and ever-changing role of semiconductors in society and market.



Caption #2: graph of semiconductor unit growth from year 1978 → future

Effects on industries and their supply chains

There have been issues in the process of production and the overall supply chain of semiconductor products due to various causes, either environmental or man-made problems. As the supply chain becomes strained and restricted by external factors mentioned above, semiconductor industries or companies need to adopt changes to improve their efficiency and effectiveness. These companies that manufacture chips and other technologies that are connected to the supply chain were all being devastated by insufficiency of supplies but increment of demands. They were not able to produce more chips for manufacturing companies to create more automotive, personal, or public use of technologies. Especially during the pandemic, companies or their factories were not able to meet up and react to the surge of demands. Prices of their products would definitely increase. Products were being delayed for shipping. However, these companies still underwent strugglings; the loss of revenue and the amount of production during the pandemic indeed hit hard on the economy.

Automotive industry

The automotive industry is one of the industries that were significantly affected by the shortage of semiconductors. On the other hand, it is also an important factor in the shortage because of how it increases the demand for chips. The pandemic and the soaring improvement in the car-making process will most definitely have a negative impact on production and output. Some people in the US estimated that the US manufacturers will make at least 1.5 to 5 million less cars in the year 2021. Large car companies have also been undercutting their production, and rejecting offers that might have overloads. Companies like Ford and General Motors have been limiting their amount of production. Almost all of the automotive companies have been

facing temporary shutdowns due to the shortage of chips they need on the assembly line. Toyota, one of the largest manufacturers in the world, said it is going to build 60,000 to 80,000 fewer vehicles in October. This means fewer cars or other products are going to be available on the market, and fewer revenue is gained by the companies. In return, the creation of new kinds of automobiles also increased the demand for semiconductor chips, which was an issue of the balance between the speed of innovation and the semiconductor supply chain. However, the most important issue in the automotive industry is the delay in car production caused by the semiconductor supply chain shortage.

Consumer electronic companies

The advance in technology and gradual digitalization during the pandemic became some crucial issues that affect those companies. Consumer electronic companies need to deal with the large demand during the pandemic. Similar to the automotive industry, consumer electronic companies have been taking steps toward some more convenient and advanced technologies, causing more demands from the companies. For example, Samsung introduced a touch tab and increased its sensitivity. In September 2020, Samsung released its new Galaxy tab Activity 3, which demanded a new kind of chip. Within all different kinds of consumer electronic companies, video-game consoles or other gaming companies are the ones that were being affected the most. The production of games like the Playstation 5 and Xbox series X, the last generation of consoles from Sony and Microsoft, was constrained by the short supply of semiconductors. Consumers were expecting to get the game soon, but the shortage caused disappointments toward the extensive delay of production. Furthermore, these consumer electronic companies faced constant internal and external competition in the industry. Electronic device companies need to compete for semiconductor supplies due to inadequate supply. They also need to compete with other industries such as the automotive industry. The inevitability of this shortage in semiconductors became an issue for consumer electronic companies. Thus, companies need to implement new methods or components in order to increase sufficiency, decrease reliance on semiconductor companies.

Medical industry

Aside from automotive and consumer electronic companies, the medical industry has also been affected by the pandemic and weather-related supply chain. With the shortage of semiconductors, not only did it affect the production line of cars and daily-used technologies, medical technology (MedTech) was also in the ripple effect. A shortage in medical supplies and technologies means putting millions of patients at risk in countries like the US. Most patients

require at least one or more medical chip-powered technologies, which includes ventilators, defibrillators, blood pressure monitors, implantable pacemakers, ultrasound machines, and many other essential machines. Hospitals were experiencing delays as the shortage continued. Nevertheless, chip shortage has been exacerbating due to the new kind of Delta variant. Semiconductor shortage should be addressed to prevent a delay in supplies of these vital Medtech devices.

Major Parties Involved and Their Views

The United States

Semiconductor production in the United States only accounts for less than 10% of the global semiconductor production. Its contribution to the supply chain is fairly low compared to countries in East Asia. As the major world power, the US would definitely want to increase their semiconductor companies' dominance over the global supply chain. President Joe Biden started to implement policies and take actions to support the global supply chain. Biden sought to improve America's own semiconductor industry by providing funds to semiconductor companies. In June, the White House report stated that the semiconductor industry will be included in the four major categories of industry that are in need of an expansion in domestic capacity. In addition, the semiconductor companies urged for a \$50 billion federal subsidy to improve its ability to compete with overseas semiconductor companies. The government agreed to this and will provide subsidies through 2027 for the production of chips. The US is also prone to provide funds for further research in high-tech fabs to solve the shortage of semiconductor.

The US-China trade war

The US-China trade war started when the US attempted to decrease China's semiconductor imports in America. President Donald Trump had imposed 25% tariffs on China's semiconductor imports, making those chips from China exclusively expensive compared to the domestically produced chips in the US. As a result, China's semiconductors only stand for 5% of the overall demand in the US. The US is trying to make China's manufacturing unavailable. This was also one of the reasons why semiconductor shortage in the US exacerbated in 2020. Even though Joe Biden became the incumbent president, semiconductor shortage still exists as a crucial issue to solve.

China

China has also been subsidizing its semiconductor industry to boost its self-sufficiency in order to compete with nearby rivals such as the TSMC. The increasing demand was hard for manufacturers to keep up. China implemented several policies in an attempt to create additional capacity. China has been improving significantly ever since the shortage of raw materials, but still has a long way to go. It is estimated that it would become one of the world's greatest exporting countries. However, China also relied heavily on supplies of sophisticated ICs from other countries. It has been importing more and more US supplies like consumer electronics machines. This made their domestic semiconductor vulnerable to foreign dominance.

Republic of Korea

The South Korean government has strengthened its semiconductor industry by maintaining the semiconductor supply chain partnership with the United States. South Korea based chipmakers have tried to maintain a close connection with the US counterpart. As the US Department of Commerce has demanded global semiconductor companies to voluntarily submit their internal data to Washington, most South Korean chipmakers are preparing their internal data. The gathering of data aims to increase transparency; identify the bottleneck in the global supply; and predict challenges set forth by the global semiconductor shortage. However, the two largest memory chipmakers in Korea, Samsung and SK Hynix, claimed that they won't provide any sensitive information about trade. Furthermore, the government implemented the so-called "K-Semiconductor Strategy" to strengthen its semiconductor industry. The government aims to spend \$451 billion on domestic semiconductor production over the next decade. Government supported packages, tax incentives, corporate investment, tax breaks, lower interest rate, and funds for infrastructure are provided by the government to support its own chipmakers. Thus, South Korea has a fast-growing semiconductor industry with 20,000 semiconductor companies, aiming to compete with nearby countries such as Taiwan.

Semiconductor manufacturers

Semiconductor manufacturers are the ones that were being affected the most by the shortage of raw materials and a rise in demands. They are anxious in finding alternatives or improvements to tackle the issue of short supplies during the pandemic. Prior to being able to restore the effectiveness of factories, these semiconductor manufacturers need to implement ways to deal with the lockdown measure in each county. Some important and large semiconductor companies or manufacturers are TSMC from Taiwan, Intel, Samsung, and many others. All of the companies need to decrease their amount of offers because systems require time to return to the normal production level, which causes a

loss of revenue. Companies are eager to decrease the impact of the shortage crisis and keep the production level with the demands. Many would use tactics such as cooperation, funding, addition of factories, or even development of a new alternative product. Overall, the semiconductor manufacturers and large companies are struggling to alleviate the damage caused by the shortage through taking actions to improve their own systems.

Timeline of Relevant Resolutions, Treaties and Events

Date	Description of event
July, 2018	<p data-bbox="432 719 703 745">US-China trade war</p> <p data-bbox="432 786 1476 913">The US-China trade war started. President Donald imposed tariffs on US\$550 billion of Chinese goods. In return China imposed tariffs on US\$185 billion of US goods.</p>
April 3, 2019	<p data-bbox="432 987 600 1014">5G emerged</p> <p data-bbox="432 1055 1394 1137">5G mobile service is implemented in states like Chicago, allowing users to connect faster through the internet.</p>
January 30, 2020	<p data-bbox="432 1234 852 1261">COVID-19 Pandemic Outbreak</p> <p data-bbox="432 1301 1418 1384">WHO declared COVID-19 outbreak a global health emergency. The disease started to spread around countries from around the world, not only in China.</p>
February 14, 2020	<p data-bbox="432 1451 1102 1478">Treaty about the US-China trade war was signed</p> <p data-bbox="432 1518 1469 1646">The Economic and Trade Agreement between the United States of America and the People's Republic of China was signed. China agreed to import and purchase certain US goods.</p>
June, 2021	<p data-bbox="432 1749 683 1776">Drought in Taiwan</p> <p data-bbox="432 1816 1453 2000">The worst drought in Taiwan since 56 years ago. It affected and caused the power-supply shortage, and other dysfunctions of manufacturing systems. The repercussions caused by this drought and the pandemic definitely devastated the whole supply chain.</p>

The Innovation and Competition Act

June 8, 2021

Biden brought up the Innovation and Competition Act, which distributed \$52 billion for the semiconductor sector. The fund was intended to support the chip production system, research, and designs. He would also want to create the National Semiconductor Technology Center.

Relevant UN Treaties and Events

- Strengthening the links between all modes of transport to achieve stable and reliable international transport for sustainable development during and after the coronavirus disease (COVID-19) pandemic, 29 July 2021 **(A/RES/75/313)**
- Global solidarity to fight the coronavirus disease 2019 (COVID-19), 2 April 2020 **(A/RES/74/270)**
- Information and communications technologies for sustainable development, 19 December 2019 **(A/RES/74/197)**
- Science, technology and innovation for development, 22 July 2021 **(E/RES/2021/29)**

Evaluation of Previous Attempts to Resolve the Issue

Partnership between Semiconductor Companies

Some previous attempts to resolve and prevent the issue of shortage in semiconductor were made by large semiconductor companies like TSMC, Sony, Intel, and Samsung. They have been changing their capacity and effectiveness to cope with the problem of large demand. For example, TSMC and Sony came to an agreement to cooperate and establish another new factory in Kumamoto, Japan. Their chip-making partnership is one of the strategies to lessen the effects of the shortage and prevent the same problems in future. This improvement will decrease the cost and increase reliability of products. However, short-term positive effects are not expected. Creating new factories will benefit those companies in the long run by preventing the crisis if this kind of shortage happens again. There won't be a direct impact or solution to the situation present. Thus, problems that exist today will still not be solved, and might have already been solved before companies create new factories.

Government Assistance: Research and Fund

The US President Joe Biden has implemented policies to solve problems caused by global semiconductor shortage. He signed an executive order to strengthen the supply chain, which contains a 100-day review of key products that are related to the semiconductor supply chain. This review evaluates 6 different kinds of industries or sectors of the economy that have been affected by the shortage lately, ranging from medical supplies and electronic devices. This policy of a 1000 day review is helpful and effective in decreasing supply chain vulnerabilities. Resiliency has also been effectively addressed through stress tests, loans, research, and many other kinds of help. The Department of Defense awarded more than \$197 million to strengthen the American semiconductor industry. Furthermore, the Semiconductor Industry Association (SIA) also introduced some policies that could possibly solve the shortage problem. SIA, which includes AMD, IBM, Intel, Nvidia and Qualcomm, proposed to the president of the US that there should be substantial funds given in forms of tax credit and grants to improve semiconductor manufacturing and further research on incentives.

Possible Solutions

The semiconductor shortage caused by the pandemic and the increase in demand can be tackled through cooperation between semiconductor companies and government agencies. **Government agencies can help to decrease the effect of the shortage of chips on the economy through providing funds, aid, or other necessary financial support for semiconductor manufacturers.** IGOs should evaluate the amount of funds for higher end chips, and distribute them according to the amount of demand they each have. The UN organizations could distribute funds to countries that have a higher shortage in semiconductors. Some positive effects would be carried out through government spending. By providing funds to semiconductor manufacturers, companies could design innovative products that might require less chips, presenting an alternative to the present chip shortage. Companies could also use the spending to improve their manufacturing system, increasing the effectiveness and the quantity of production. Government agencies could also use public spending on further research of innovative semiconductor projects and give companies some advice they find. Furthermore, government agencies should be taking actions in creating a reliable and resilient domestic source of consumer electronics, 5G communication, automotive industry, medical technology, and other semiconductor-related sectors. These industries that have been negatively and financially affected by the shortage of semiconductor should be assisted to continue the production of fine products.

In order to maintain resilience and agility of the semiconductor supply chain, and to continue to function during a disruption, there should be a **rapid detection of crisis, an end-to-end supply chain**

control system, and planning process. Companies can implement **risk-mitigation techniques** to alleviate problems caused by shortage through increasing inventory of raw materials, personnel, machines, in order to increase inventory of semiconductors. Ensuring that there is enough storage of materials and workforce, manufacturing companies can directly solve problems caused by sudden changes in demand. This also further increases the capability of the suppliers, so that companies won't need to face a crisis in revenue or to limit their production. During lockdown, most companies didn't have any work-in-progress products, instead, they faced sudden termination. However, by maintaining a certain amount of work-in-progress products, these manufacturing companies can mitigate potential disruptions or economic crises. On the other hand, there should also be a supply chain control system to ensure the quality and reliability of semiconductor industries. These companies need to use data from their own supply chain to detect potential flaws, and regulate the balance of raw materials, work-in-progress products, and final output. Overall, by creating a resilient, reliable, agile supply chain system and network, semiconductor companies can quickly observe, respond, and deal with the disruption or any kinds of shortages afterward.

Next is **cooperation. Semiconductor companies all over the world should be cooperating with each other either through private or international cooperation to deal with the current issue at hand.** For example, TSMC has been cooperating with Sony to create more factories in Japan. Private enterprise cooperation can not only foster the revenue of a certain company but both countries' economy overall. Government organizations should also hold meetings or conferences for countries that are struggling with shortage issues to cooperate and provide support for each other. Even though countries like China and the US have been having conflicts over global trade, imposing tariffs and preventing each other's products from coming in. However, by signing agreements and establishing global industry connections, both countries' import of technologies wouldn't be affected by politics. By maintaining a mild relationship and decreasing tensions between countries in the past, international peace over economy and industries might also be restored after nations started to cooperate and support each other.

Bibliography

Rae, John Bell and Binder, Alan K.. "automotive industry". Encyclopedia Britannica, 12 Nov. 2020, <https://www.britannica.com/technology/automotive-industry> . Accessed 29 November 2021.

SCMP Reporters. "Explainer | Why there is a global semiconductor shortage, how it started, who it is hurting, and how long it could last". South China Morning Post, 12 May, 2021, <https://www.scmp.com/tech/tech-war/article/3133061/why-there-global-semiconductor-shortage-how-it-started-who-it-hurting> . Accessed 29 November 2021.

Baraniuk, Chris. "Why Is There a Chip Shortage?" BBC News, BBC, 26 Aug. 2021, <https://www.bbc.com/news/business-58230388> . Accessed 29 November 2021.

Dashveenjit Kaur | 6 October, 2021. "Here's What the 2021 Global Semiconductor Shortage Is All About." Tech Wire Asia, 2 Nov. 2021, <https://techwireasia.com/2021/10/heres-what-the-2021-global-semiconductor-shortage-is-all-about/> . Accessed 29 November 2021.

Taiwan Semiconductor Manufacturing Company. "A Look at Semiconductor Supply Chains." Taiwan Semiconductor Manufacturing Company Limited, Taiwan Semiconductor Manufacturing Company, 3 Sept. 2020, https://www.tsmc.com/english/aboutTSMC/dc_infographics_supplychain . Accessed 29 November 2021.

Kharpal, Arjun. "How Asia Came to Dominate Chipmaking and What the U.S. Wants to Do about It." CNBC, CNBC, 12 Apr. 2021, <https://www.cnbc.com/2021/04/12/us-semiconductor-policy-looks-to-cut-out-china-secure-supply-chain.html> . Accessed 29 November 2021.

"Chip Shortage to Drive Consumer Electronics Retail Prices, Says GlobalData." *GlobalData*, 15, Sept. 2021, <https://www.globaldata.com/chip-shortage-drive-consumer-electronics-retail-prices-says-globaldata/> . Accessed 30 November 2021.

Manda Schweitzer - Miller. "How Automotive Manufacturers Can Prepare for Ongoing Chip Shortages." Kinaxis, 15 Nov. 2021, <https://www.kinaxis.com/en/blog/how-automotive-manufacturers-can-prepare-ongoing-chip-shortages> . Accessed 30 November 2021.

“What Is 5g: Everything You Need to Know About 5G: 5G FAQ.” Qualcomm, 13 May 2021, <https://www.qualcomm.com/5g/what-is-5g> Accessed 30 November 2021.

Howley, Daniel. “These 169 Industries Are Being Hit by the Global Chip Shortage.” Yahoo! Finance, Yahoo!, https://finance.yahoo.com/news/these-industries-are-hit-hardest-by-the-global-chip-shortage-122854251.html?guccounter=1&guce_referrer=aHR0cHM6Ly9lbi53aWtpcGVkaWEub3JnLw&guce_referrer_sig=AQAAAFBJMYLzj3b3SGovwrdWJLOMsZh0rxofDNCPPSNOWKXga263PYCMTQX4L80qBJ1YEmVlqpEzjDqnZwxHlg3w3hYldr7VPOvLzQJC9Im3wABxEcGOn4KCzPWM7VFw5XN8Oo7KFnUugF_rkRKEV-cjkyDcXH-jWWCc8ScW77ij Accessed 30 November 2021.

“US-China Phase One Tracker: China's Purchases of Us Goods.” PIIE, 24 Nov. 2021, <https://www.piie.com/research/piie-charts/us-china-phase-one-tracker-chinas-purchases-us-goods> Accessed 1 December 2021.

Joseph, |By Priya, et al. “When the Chips Are down: Governments Move to Address Shortage.” Counterpoint Research, 6 Oct. 2021, <https://www.counterpointresearch.com/chips-governments-move-address-shortage/> . Accessed 1 December 2021.

Preston, Benjamin. “Global Chip Shortage Makes It Tough to Buy Certain Cars.” Consumer Reports, <https://www.consumerreports.org/buying-a-car/global-chip-shortage-makes-it-tough-to-buy-certain-cars-a-8160576456/> . Accessed 2 December 2021.

“Consumer Electronics Market Size, Share & Covid-19 Impact Analysis, by Product Type (Electronic Devices (Television, Computer, Digital Camera & Camcorder, and Others) and Home Appliances (Refrigerator, Washing Machine, Air Conditioner, and Others)), Distribution Channel (Offline and Online), and Regional Forecast, 2020-2027.” Consumer Electronics Market Size, Trends and Forecast [2027], <https://www.fortunebusinessinsights.com/consumer-electronics-market-104693> Accessed 2 December 2021.

Mangold, Lewis. “Semiconductor Shortage Impact on Consumer Electronics.” Corintech, 16 Sep 2021. <https://www.corintech.com/news/posts/2021/september/the-chips-are-down-for-the-electronics-industry/> Accessed 2 December 2021.

“The Semiconductor Chip Shortage Hits Medtech: Strategies to Build Resilient Supply Chains.”
AdvaMed, 23 Sept. 2021,
<https://www.advamed.org/2021/09/23/the-semiconductor-chip-shortage-hits-medtech-strategies-to-build-resilient-supply-chains/>. Accessed 3 December 2021.

Weatherbed, Jess. “The End of the Semiconductor Shortage Could Be in Sight Thanks to China.”
TechRadar, TechRadar Pro, 18 Aug. 2021,
<https://www.techradar.com/news/the-end-of-the-semiconductor-shortage-could-be-in-sight-thanks-to-china> . Accessed 3 December 2021.

Fingas, Jon. “Sony and TSMC Attempt to Address Chip Shortages with a Factory in Japan.”
Engadget, 9 Nov. 2021,
<https://www.engadget.com/sony-tsmc-confirm-japan-factory-chip-shortage-153515725.html> . Accessed 3 December 2021.

Newman, Rick. “Why Biden Can’t Fix the Semiconductor Shortage.” Yahoo! Finance, Yahoo!,
<https://finance.yahoo.com/news/why-biden-cant-fix-the-semiconductor-shortage-201713716.html>.
Accessed 3 December 2021.

Iakovou, Eleftherios, and Chelsea C. White III. “How to Build More Secure, Resilient, next-Gen
U.S. Supply Chains.” Brookings, Brookings, 3 Dec. 2020,
<https://www.brookings.edu/techstream/how-to-build-more-secure-resilient-next-gen-u-s-supply-chains/>
Accessed 3 December 2021.

Moss, S. (2021, May 14). South Korea spent \$451 billion on becoming a semiconductor
manufacturing giant. All Content RSS. Retrieved January 12, 2022, from
<https://www.datacenterdynamics.com/en/news/south-korea-to-spend-451-billion-to-become-semiconductor-manufacturing-giant/>. Accessed 12 Jan 2022.

Park, K. (2021, November 8). South Korean chipmakers will submit semiconductor data to the
U.S. by Nov. 8 deadline. TechCrunch. Retrieved January 12, 2022, from
<https://techcrunch.com/2021/11/07/south-korean-chipmakers-will-submit-semiconductor-data-to-the-u-s-by-nov-8-deadline/>. Accessed 12 Jan 2022.