A critical analysis of Supply Chain Management in a post pandemic environment – using the example of semiconductor sector in U.S.

Module: International Strategic Management
Course: MBA International Trade

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January 28, 2022

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Abstract

The COVID-19 pandemic accelerated the digitization process at least a decade ahead. From attending lectures to office meetings, everything is online. Technology is penetrating the traditional way and people rely on it for ordering food, shopping groceries etc. Semiconductors plays a vital role in enabling the world's technological shift, making our life hassle free. Thus, high demand are leading towards shortage of semiconductors during the pandemic, especially to the tech companies. The U.S., who holds flagship in tech is currently facing a huge turmoil and recent loss of $6 billion to Apple due to failed supply chain of semiconductors is an example for the same. This report is an attempt to highlight the current strategies that the Managers, the Organizations & The US government are adapting for ensuring stable, resilient supply chains for these vital products.

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1 Introduction

The COVID-19 pandemic has accelerated the digitization process at least by a decade ahead. From attending lectures to office meetings, everything is online. Technology is penetrating the traditional way, and people are relying on it for working remotely, ordering food, shopping groceries, treating illness, staying connected etc. Semiconductors are the foundation of modern life and plays a vital role in enabling the world's technological shift, making our life hassle free. During the COVID-19 hit pandemic period, the semiconductors-based technologies has played a significant role in helping the global economy, healthcare, and society withstand the effects. In response to the pandemic, there has been a global shortage of semiconductors, and the semiconductor sector is facing an unanticipated rise in demands along with significant fluctuations in the demand for semiconductors in different products such as cars, consumer electronics etc. This has led to a rippling imbalance in the supply and demand of the semiconductors.[1]

The pandemic has had a huge impact worldwide, affecting everyone and almost all industries and companies. It has decimated many global supply chains and the tech industry has undergone some significant changes since the onset of the pandemic. Since the stay-at-home legislative, there has been a boost in the telecommunications demand. And as the semiconductors are an integral part of the technology, and considering the globalization in its supply chain, the semiconductor industry has been significantly affected worldwide and within the United States (Rumbaugh et al.). Furthermore, since the U.S. semiconductor companies outsourced most of the semiconductor manufacturing overseas, as a result of it they had to cope with increased costs, rise in lead times and shortage of supplies in order to keep up with the rising consumer demands.[2]

The semiconductor industry largely contributes the economic growth of U.S. and is one of the major sources for job creation. Nearly 50% of the global semiconductor revenue is accounted by the U.S. semiconductor industry sector, but the U.S. semiconductor manufacturing capacity is only 12% of the global production(House 2021). The U.S. semiconductor companies depends largely on Asia for semiconductors which creates a supply chain risk. The materials, tools and equipment required for manufacturing the semiconductor can be found at limited sources. The semiconductor industry before the pandemic was focused on reducing inventory and outsourcing, but even though it was financially successful, it led to supply chain prone to risk. Furthermore, shortage of semiconductors during the past pandemic years has showed why it is so important to build a resilient supply chain and ensure that it is stable.[3]

[1] Semiconductor Industry Association, SIA, State of the U.S. Semiconductor Industry, accessed on 12.01.2021 at 16:37

[2] Rumbaugh, Corey, Jacob Hrbek, Malia Hickey, Natali Markowitz, Trevor Howell, and Mohamed Awwad. "Review of the Effect of COVID-19 on the American Semiconductor Industry Supply Chain."

[3] House, White. "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-based Growth: 100-Day Reviews under Executive Order 14017." A Report by The White House (2021).

The U.S., who holds flagship in technology sector and is currently facing a huge turmoil due to the disruptions in the supply chain. Recently the CEO of Apple stated that the primary supply chain related shortage is due to the shortage of semiconductors. A recent loss of 6 billion USD to Apple due to the shortage of semiconductors is an example . This report will highlight the current strategies that the U.S government, and organizations are adapting for ensuring stable, resilient supply chains for these vital products.

2 Literature Review

The half trillion-dollar valued semiconductor supply chain is one of the most complex and geographically dispersed supply chains in the world. Often the production of one computer chip requires more than 1000 steps. Companies are usually specialized in different aspects of the production process and thus the chip needs to pass through multiple countries, and the product crosses international borders around 70 times, including 3 full trips around the world, before it can be finally incorporated into the consumer electronic and reach the end user(Khan et al. 2021). The process takes around 100 days, with 12 days required for transit in between the supply chain steps.[4]

Figure 1: Semiconductor Supply Chain
(Ezell 2020)

The figure above represents a stylized semiconductor supply chain. As shown above, for example, first the silicon ingots can be produced and then cut into wafers in Japan. Then these bare wafers are shipped to the U.S where they are further processed into fab wafer and then cut into die. The functional IC (integrated circuits) are etched on these dies to prepare the semiconductors. The semiconductor chips are then shipped to one of the countries such as Malaysia, or Vietnam for assembling, packaging, and testing (ATP process).

After the ATP process, the semiconductor chips are exported to China, South Korea, or the U.S. for inventory wherein they are integrated into the end-product such as smartphones, tablets, automobile parts etc. These end products can

[4]Khan, S., Alexander Mann, and Dahlia Peterson. "The semiconductor supply chain: Assessing national competitiveness." Center for Security and Emerging Technology (2021).

then be distributed across the globe for the final consumers. Various modes of transport are used throughout the supply chain such as airfreight, ocean freight and trucks depending upon the nature of the product and the distance to be travelled. The transportation costs of the semiconductors are very less as compared to the value provided by them. And furthermore, its small size and light weight characteristics makes such geographically and logistically complex supply chains feasible.[3]

2.1 Assess the Supply Chain

The semiconductor supply chain can be accessed based on these five essential segments: Design, Fabrication, ATP and advanced packaging, Materials and Manufacturing equipment as per the report published by the White House, 100-Day Reviews under Executive Order 14017(House 2021). Considering the scope of this report, we will provide the overview, resilience and risks associated to these segments.

Design: The initial phase in semiconductor supply chain is the design phase. The U.S. based integrated device manufacturers (IDMs) such as Intel and Texas instruments historically carried out the design along with the complete production process. Now, the design phase is undertaken by more specialized fabless semiconductor design companies, and the manufacturing is then carried out by other companies. The design process steps basically are specification, architecture design, logic design, physical design, and then verification and validation. The reuse of part designs obtained from within the design organization or licensed from other design firm, which is known as Intellectual Property (IP), and Electronic Design Automation (EDA) providers has accelerated the development of semiconductor chips.

The U.S. is world leader in semiconductor design with most of the essential IP and EDA providers being headquartered in the country. Many of these companies such as Synopsys and Cadence, outsource their manufacturing or locate their workforce outside the U.S. For example, more than two-third of the Synopsys employees were located outside the U.S. in 2020. Some of the major risks associated to the semiconductor design are the need for high R&D expenditure, access to foundries and skilled workforce. As most of the foundries are concentrated in East Asia, the cooperation between the design companies and foundries, and access through the supply chain is of utmost importance. Furthermore, highly skilled workers are crucial for sustaining the semiconductor supply chain in the U.S. The country's ability to retain and attract these highly skilled workers and engineers marks the long-lasting competitiveness of the U.S. semiconductor industry.[3]

Fabrication: The next stage in the semiconductor supply chain is the fabrication of the design into component part. During this process, the fabrication facilities (fabs) or foundries cut the silicon ingots into disc shaped wafers. Once this process is done, the design is transferred onto the wafer; followed by testing, polishing, and dicing into individual chips. This entire process usually takes up to 15 weeks. Wafer fabrication requires subatomic level of precision and

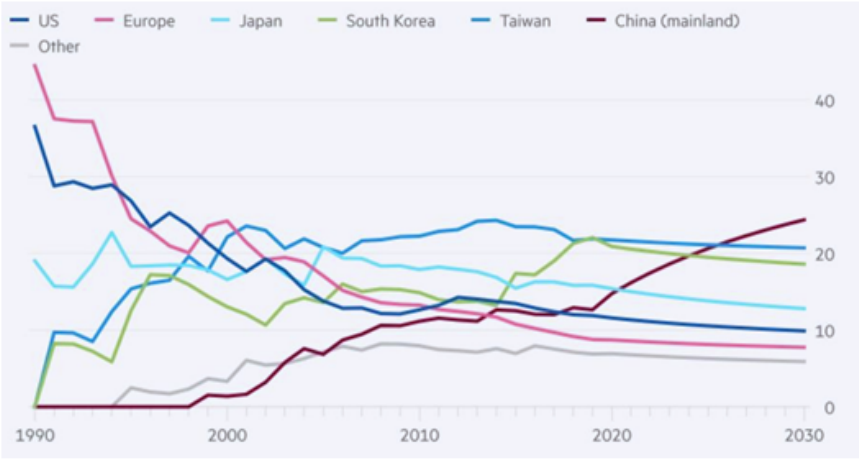

Figure 2: Share of Global Semiconductor Manufacturing Capacity
(Varas et al. 2021)

to obtain this the plants are equipped with advanced cutting-edge technology such as numerous process machines, lasers, ultra-precision optics and robotics. Similar to the design phase, specialized companies fabricate the chips or IDMs carry out all the steps from design to final testing. Many leading companies in the U.S. such as NVIDIA, Qualcomm, AMD operate on a business model such that they provide their designs to third-party foundries which act as contract manufacturers for these fabless semiconductor firms. On the other hand, many leading companies though headquartered in the U.S., outsource the manufacturing globally.[3]

For example, Intel outsources its manufacturing to Israel, Ireland, and China. The fabless model is currently more prevalent as the investment required for state-of-the-art fabrication plant is very high ($ 12-20 billion). The U.S. based semiconductor manufacturing has dropped from 37% of the global total in 1990 to 12% in 2021.[5] The capacity and production of semiconductors has been on the rise in the Asian countries such as Taiwan, South Korea, Japan, and China.[3]

As shown above, even as per the Semiconductor Industry Association and Boston Consulting Groups forecast, by 2030, the share of the U.S. production capacity will be 10% whereas that of Asian countries will be 80%. And this explains why even though the production has been relatively stable in U.S., they still lack the capacity and rely heavily on these geographically concentrated Asian countries for production. Thus, the workforce challenges, high fab costs, lack of production capability compared to Asian countries, and reliance on geographically concentrated Asian countries makes the supply chain very fragile and prone to disruption.

[5]Varas, Antonio, Raj Varadarajan, Jimmy Goodrich, and Falan Yinug. "Strengthening the global semiconductor supply chain in an uncertain era." Semiconductor Industry Association and Boston Consulting Group, March (2021).

Assembly, Test and Packaging: In this stage the chips are assembled into the semiconductor components, tested to verify that they function as intended and then packed for further integration into the end product, e.g., smartphones, tablets etc. ATP basically functions on two business models, one being in-house assembly, packaging and testing done by IDMs and foundries, and two by outsourced semiconductor assembly and test firms (OSAT) which provide ATP services on contractual basis(Platzer et al. 2020). ATP is very labor intensive, requires floor space, is automated and provides very less value in the semiconductor supply chain. Thus, most of the companies develop their facilities in developing countries or outsource it to mostly southeast Asia. Firms based in Taiwan (29% and 52%), U.S. (28% and 15%), and China (14% and 21%) are world leaders for providing ATP and OSAT services respectively.[6],[4]

Lately packaging is becoming more advanced, and the substrates required for advanced packaging is primarily based in Asia. Advanced packaging solutions are crucial for defense needs, and very limited number of U.S. companies provide it. Other than that, even though U.S. has packaging capability, Chinese government has already invested significantly in advanced packaging and threaten to upend the packaging market in coming years. Furthermore, the U.S. is relied on the Asian countries for advanced packaging services which makes the semiconductor supply chain vulnerable and susceptible to disruption risks.[3]

Materials : The semiconductor supply chain as we have seen above is extremely complex, and manufacturing of the semiconductors requires hundreds of materials at various different stages. The electronic materials, gasses and chemicals required for fabricating semiconductors was valued at $18.3 billion in 2020. Considering the scope of the report, we would overview some of the crucial materials required for fabricating the semiconductors. Silicon is the most fundamental material required to produce semiconductors. U.S. currently has production capability for polysilicon, but China is heavily investing in order to increase their dominance in this sector. The silicon ingots are sliced to obtain wafers, and Japanese companies are at the forefront in this sector with 56% market share, followed by Taiwan 16%, Germany 14% and South Korea 10%. Other than this, photomasks are plates which are necessary to produce the Integrated Circuits. These are usually customized as per the end user requirements, and this aspect of semiconductor supply chain is very susceptible to malicious tampering. Again, this sector is dominated by Japanese companies, with 90% market share, while the remaining 10% is held by the U.S. and South Korea. The raw materials silicon and gallium which are essential for fabricating the wafers are densely concentrated in China, whereas the U.S. is one of the key sources of Helium gas. Furthermore, the U.S. is one of the leading providers for wet chemicals and semiconductor gases which are critical for fabricating semiconductor. In summary, various materials are required to produce semiconductors, and the U.S. has to rely on foreign countries, particularly concentrated in East Asia. Furthermore, the transportation of chemicals, gases etc. poses safety threats. Any disruption in any of these materials can cause production problems.[3]

[6]Platzer, Michaela D., John F. Sargent, and Karen M. Sutter. "Semiconductors: US Industry, Global Competition, and Federal Policy." In R46581. Congressional Research Service. https://crsreports. congress. gov/product/details. 2020.

Manufacturing Equipment: The U.S., Netherlands, Japan are at the forefront of semiconductor manufacturing equipment (SME). There are numerous categories in SME such as wafer manufacturing, lithography, mask manufacturing, assembly, packaging, testing, services etc. Services comprises of setup, troubleshooting and repair services provided by the SME companies. The U.S. are market leaders in production of almost every segment of SME other than Lithography, which is dominated by Netherlands and Japan, and back-end process of particularly packaging. As compared to the front-end SME, the U.S. has relatively very small market share of 4.9% in back-end packaging SME but has 33.5% market share in back-end testing SME.[4]

One of the major risks for the U.S. associated with the SME is the dependence of foreign sales. For example, U.S. company Applied materials and Lam Research generated around 90% of their total revenue via non-U.S. sales. China, Taiwan, and South Korea are currently the largest markets for SME. The possible chokepoint for U.S. in the semiconductor supply chain could be due to the reliance on Netherland and Japan for Lithography equipment, and lack of in-house packaging. Another risk for the U.S. SME producers in the supply chain can arise due to the trade restrictions between U.S. and China.[3]

The following figure shows the position of the U.S. in the critical layers of the global semiconductor supply chain. It provides an overview of the position of U.S. in the global semiconductor supply chain considering the major segments discussed above. U.S. are global leaders in design and equipment, but relies on foreign countries for certain materials, manufacturing, assembling, and testing. Also, no one single country has the technical capability required to run the entire semiconductor supply chain.[5]

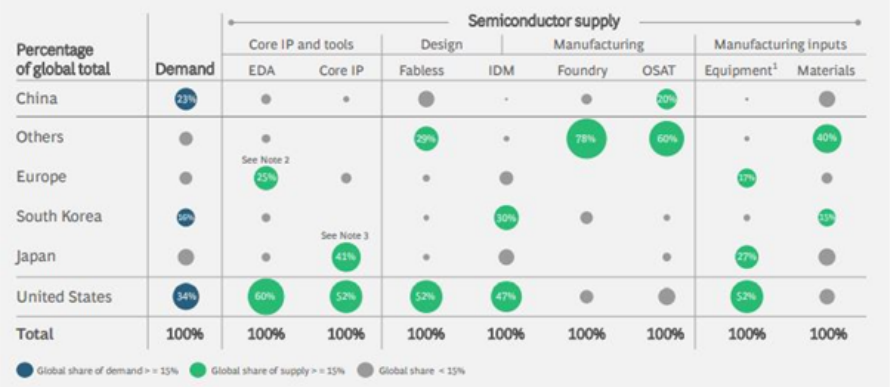

Figure 3: U.S. positioning in critical areas of Global Semiconductor Value Chain (Varas et al. 2021)

Impact of Covid 19 : The world faced a severe health emergency due to the Covid-19, and the World Health Organization (WHO) declared it to be global pandemic in the beginning of 2020. The pandemic has gravely affected both, the human life, and the economy, globally. It has had a massive impact on the

semiconductor supply chain, disrupting the supply and demand, globally and in the U.S. as well. In particular, the semiconductor industry is being largely affected by the pandemic since as we have already seen, the sector is largely relied on the Asian countries, and the suppliers are geographically concentrated in those regions.[7]

Since the pandemic initiated in China, and China being one of the major semiconductor chip manufacturers, the semiconductor supply chain was disrupted. The production of the chips declined in the early 2020 and as the virus spread across other countries, and with lockdowns being implemented and some plants being shut, the production of electronics was halted. During this period, some of the factories also had to switch lines considering the requirements, such as ventilators, medical device manufacturers, public testing, and tracing, work-at-home and virtual learning etc. which were necessary during the covid pandemic.[8]

The semiconductor chips are at the heart of modern life, since they are essential in communication, automobiles and electric vehicles, connectivity, consumer electronics, transportation, industries and robotics, and its application is expected to grow. But a major consequence of the pandemic has been the shortage of chips throughout 2020, due to the unanticipated and substantial imbalance in demand. The shortage of chips has affected all the associated sectors, and the semiconductor sector had worked to classify its operations as essential in order to continue operating to mitigate this. The chip shortage has highlighted how susceptible the supply chain is, and it has forced the companies in this sector to reconsider and transform its global supply chain model.[1]

Shortage of chips : The sectors associated to semiconductor segment has been affected differently. For example, the automobile sector was negatively impacted due to the chip shortage causing loss of billions of dollars.(Marinova & Bitri 2021) Tesla stated that during this period they faced some of the most difficult supply challenges. As the demand for consumer electronics rose, and a result of trade war between the U.S. and China, had led to shortage of semiconductor chips.[9]

The pandemic has spurred the demand for PC and consumer electronics. As per the American Trade Group Consumer Tech Association, 2020 was the biggest year on record with nearly $442 billion in retail sales revenue for game console, smart home products, TVs, and headphones. The PC sales rose by 4.8% to 275 million units in 2020. Apple reported record sales during this period, with $111 billion quarter, and CEO Tim Cook said they could have been better if they had enough supply of chips to meet the demand. The founder of Moor Insights, a firm studying semiconductor industry, Patrick Moorhard stated that the demand for such products was a result of the work-from-home and virtual

[7]Hade, Aniket. n.d. Meticulous Research Viewpoint. Meticulous Research, accessed on 12.01.2022 at 17:29

[8]How will Covid-19 affect the semiconductor industry?, MRL Consulting, May 2020, accessed on 17.12.2021 at 14:23

[9]Marinova, Galia I., and Aida K. Bitri. "Challenges and opportunities for semiconductor and electronic design automation industry in post-Covid-19 years." In IOP Conference Series: Materials Science and Engineering, vol. 1208, no. 1, p. 012036. IOP Publishing, 2021.

learning culture across the globe.[10]

As per the Goldman Sachs report, the shortage might last until end of 2021, and as per Acer it may last until 2022/2023. The touch screens, GPS and smart technology used in automobile needs semiconductor chips, and due to its shortage, the car production globally dropped by 2-6% this year. Also, in particular for the U.S., the car production dropped by 14% in first quarter (Q1) of 2020 relative to Q4. The chip shortage has affected other sectors as well, such as Smartphone component leaders Foxconn has projected 10% drop in supply. Also, Apple has lowered its production of tablets and laptops. Considering the long lead times, Intel's supply response will take 6-9 months before they can provide additional chips that are required by the automobile industry[11]

The imbalance between the semiconductor supply and demand is around 50%, and it is expected to persist as stated above. This is mainly due to the proprietary technologies, machineries and equipment, and economies of scale required for fabricating the chips, and since many of the manufacturing companies are operating at almost full capacity. This shows why the $50bn subsidies for semiconductor production facilities provided by the Biden administration won't be able to substantially boost the short-term chip availability in near future. Therefore, the imbalance in supply and demand is bound to persist in 2022. Furthermore, the shortage of chips has also led to the inflation of the core goods such as automobiles and it is expected to remain so until the end of 2021.[11]

Semiconductor Demand Drivers U.S. Industry Market Share: The innovation in semiconductors in the coming years will revolutionize the transformation in technology in different sectors such as artificial intelligence (AI), 5G, autonomous electric vehicles, Industry 4.0 systems, smart cities and Internet of things (IoT). Some unexpected shifts in the end-use demand drivers for semiconductors was observed in throughout 2020 as an effect of the pandemic. During the pandemic the society also identified its reliance on the semiconductor-based technologies to sustain through this period. The figure below shows the total global semiconductor demand by end-use categories in 2020. Strong sale is being observed across these categories in first half of 2021.[1]

The U.S. semiconductor industry has approximately 48% market share in 2020 and are the global sales market share leaders. U.S. leads in various product categories such as PCs, IT infrastructure, consumer electronics etc. The U.S. semiconductor industry is way bigger as compared to other countries, as we can see above, its more than twice as big as Korea, and almost four times that of Japan and Europe, and around 15 times that of China. The U.S semiconductor industry being global sales market leaders is a result of the virtuous cycle on innovation. High sales enable them to invest intensively in Research and Development (RD) which in result help them develop innovative products. These products in return provide high revenue and profits. And since semiconductors are such highly complex products, investing in RD ensures continuous sales

[10]Kif Leswing, Why there's a chip shortage that's hurting everything from the PlayStation 5 to the Chevy Malibu, CNBC News, 10 Feb 2021, accessed on 12.01.2022 at 17:36

[11]Goldman Sachs - A Semi-Troubling Shortage, 21 April 2021, accessed on 24.12.2021 at 17:13

End Use Category	Computer	Communication	Consumer	Industrial	Automotive	Government
Annual Growth	21.2	1.2	-3.0	8.2	-0.3	-11.8
Total Value ($B)	142.2	137.6	53.0	52.9	50.1	4.6

Figure 4: Semiconductor Demand Drivers for 2020
(SIA 2021)

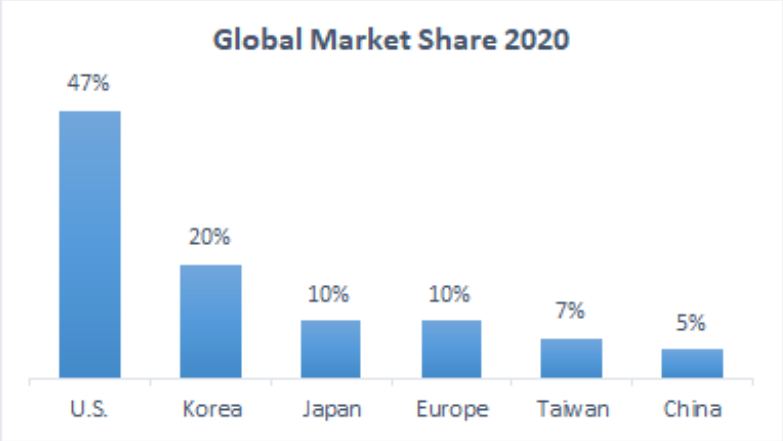

Figure 5: Global Semiconductor Market Share
(SIA 2021)

and subsequent profits. The U.S. semiconductor industry has already invested around $312 billion in RD over the past decade. This amount is nearly double the amount invested by the semiconductor industry in rest of the world combined. But on the other hand, the U.S. semiconductor industry rely on Asian countries for fabrication, raw materials, advanced packaging, testing and assembly. Furthermore, the U.S. government's investment has declined in the past few years as compared to other countries. This imbalance has highlighted the necessity to strategically improve the domestic manufacturing in U.S.[5]

3 Research Objectives

The aim of the research is to analyze the semiconductor supply chain in the U.S. in post-pandemic environment. The report provides an overview of the semiconductor supply chain globally, and how it has been disrupted due the covid-19 pandemic. Based on the literature review, we would provide insightful details into what measures the U.S. government is undertaking to make the semiconductor supply chain more resilient. Furthermore, what strategic investments could be implemented to make the supply chain less vulnerable and mitigate the risks in case of such unanticipated scenarios. Therefore, the main research objectives can be summarized as follow:

- How has the pandemic disrupted the semiconductor supply chain in U.S?
- To identify how the supply chain in U.S. can be more resilient to cope with such disruptions. (Opportunities and Challenges)
- What measures should the U.S. government undertake to make the supply chain more resilient?

4 Research Methodology

To analyze the effect of covid-19 on the U.S. semiconductor supply chain, we have mainly conducted secondary research wherein we have reviewed the literature and critically summarized the information from government reports, company reports and forecasts, scientific research papers, journals, articles, related websites, case studies and news articles. Furthermore, we have also gathered data based on some primary research wherein we acquire data based on surveys and come interviews with the people working in the semiconductor sector in U.S. The survey questions were distributed to people working in the semiconductor sector, but the companies are diverse in terms of size and product base..

The research methodology is developed into three parts. In the first part, how pandemic disrupted the semiconductor Supply Chain in the US is discussed.What were the pre and post Pandemic scenario were, whats the role of Global Production Networks and how Company's fall into Bullwhip effect as soon the shortage start occurring. In second part, we conducted a survey with Supply Chain market leaders and Analyze the data collected. In third part, we analyze market reports by Big 4 which helps us to understand the Measures proposed to overcome this Supply Chain disaster.

5 How has the pandemic disrupted the semiconductor supply chain in U.S?

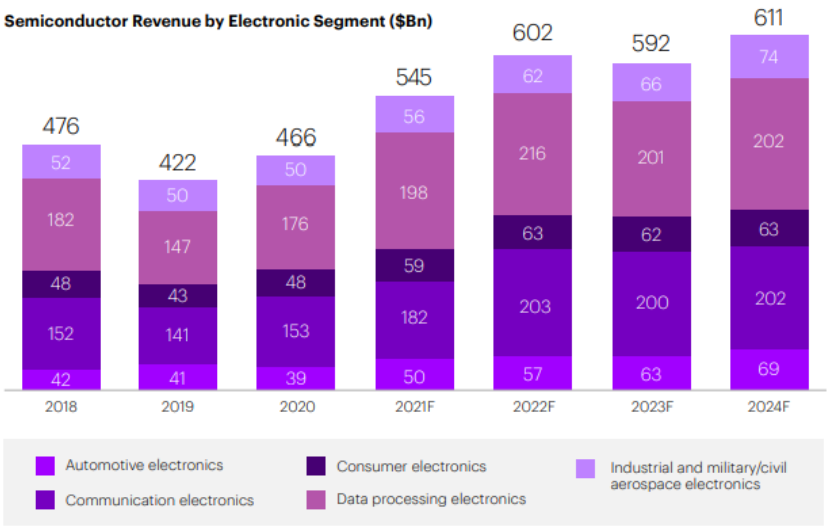

Figure 6: Semiconductor Revenue by Electronic Segment (Gartner 2021)

Many of the Business Supply Chains has Semiconductors as an integral part of it. Today, chips power everything from Tesla, Nissan cars to Apple smartphones to industrial equipment. Many upcoming technologies like 5G/6G, AI, Quantam Computing, Block-chain(Web 3) etc., will heavily depend on semiconductors. Gartner categorized 6 end use categories for semiconductors - automotive, industrial, consumer, data processing, military/civil aerospace and communication. A 7.0% CAGR forcats from year 2020 to 2024F is predicted in global semiconductor Market. Where The automotive and industrial electronics segments are front runner and will witness the fastest growth.[12]

On April 30th 2021, Goldman Sachs put forward a report which estimated that 169 U.S. industries were being directly affected by the semiconductor chip shortage.This Shortage also contribute in rising product costs, both for Consumers and Industries.[13]

Figure 6 shows that, More and more business are relying on semiconductor and thus a resilient semiconductor supply chain is necessary for these business to deliver products in time, stay in competitions and fulfill demand of consumers.

[12]Gartner (Semiconductor Forecast Database, Worldwide, 1Q20 Update and 1Q21 Update), accessed on 11.01.2022 at 15:54

[13]1 Ziady, Hanna, "The global chip shortage is going from bad to worse. Here's why you should care." (CNN, May 4, 2021)

5.1 Pre vs Post-pandemic Supply Chain Management

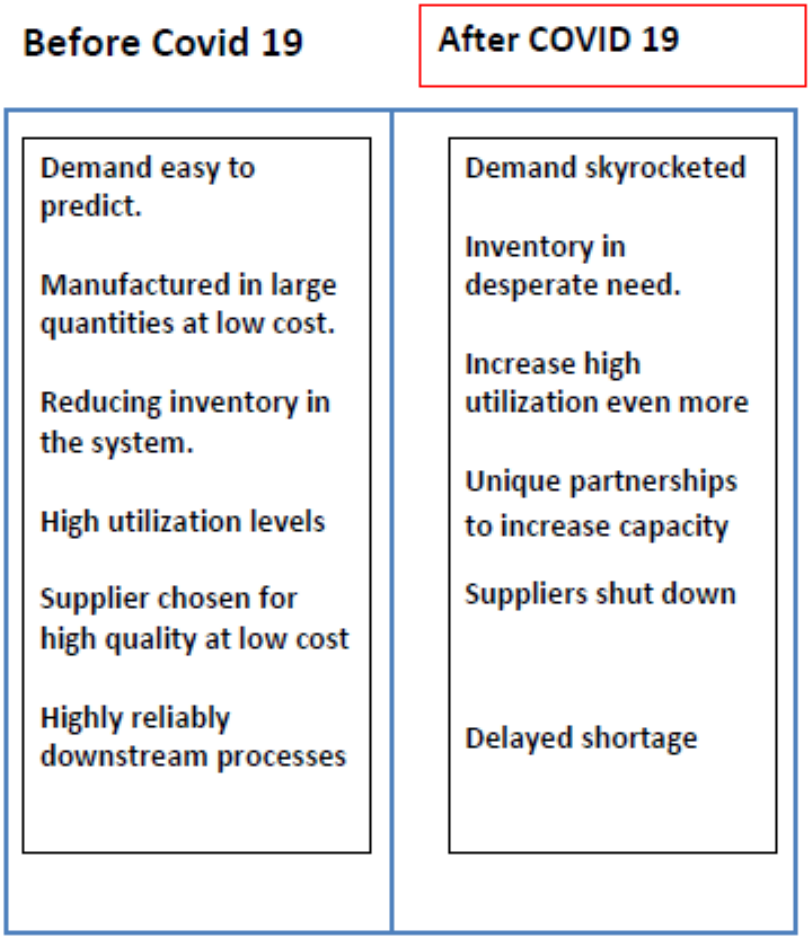

Figure 7: Pre Covid vs Post Covid
(Scott 2021)

Figure 7 from Gies Business School, UIUC, shows the difference between Pre Covid and post Covid demand side of Chips supply chains. Before COVID-19, the demand for chips was relatively easy to predict. Based on past sales, new launches, market trends etc., it was way easier to observe the trend and thus the cost, quantity and suppliers were in control. This also helps the suppliers to not manage a very high inventory and utilization levels were also high, which means that their machines were operating for a majority of the business day. It's not only about the machines, but also the talents which were skilled enough to operate them. It's also worth noticing The higher the utilization of the manufacturing resources depicts that company's are using there resources full fledged, and thus the company will be less able to respond to a sudden rise

in demand.(Scott 2021)

With Covid, With high raising demands, the Semiconductors supply chain had to switch its way of operations to tackle the rising demands. Inventory could no longer be minimized, manufacturers who were already operating at high utilization needs to increase that utilization even more. Many manufacturers even pushing there limits to enhance production for 24/7, by seeking extra capacity or enhancing partnerships. Also, Suppliers shutdown and delayed supply of materials also a challenging problem.(Scott 2021)

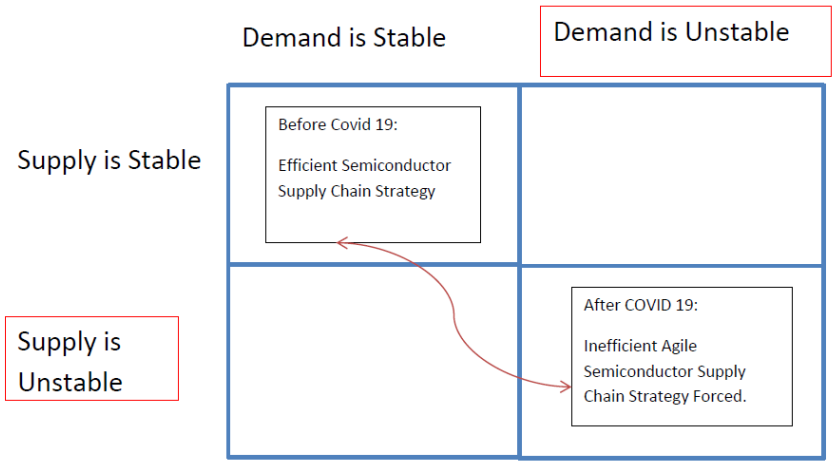

Figure 8: Demand vs Supply
(Scott 2021)

Figure 8 highlights the research findings. The first column shows the Demand is Stable and the second column shows labelled Demand is Unstable.On the other hand, the first row is labelled as Supply is Stable and the second row is labelled as Supply is Unstable. In the box where the first row and column intersect, it shows the before Covid Time when Supply Chain Strategy was efficient. So when a disruption event like COVID-19 disruption event forces supply chains to change the operations more quickly and thus not only making operations of supply chain extremely inefficient but also cause many problems for the supply chain.(**?**)

5.2 Global Production Networks

Global production networks (GPNs) is an economic model that is used for better coordination & interconnection of stakeholders in any of the particular industry, and is gaining popularity among other industries too[14]. In the semiconductor

[14]Gereffi, Gary, and Miguel Korzeniewicz, eds. Commodity chains and global capitalism. No. 149. ABC-CLIO, 1994.

industry, During 1980, the business model of semiconductor design moves towards the outsourcing model which is heavily based on GPN. This model is called as fabless model where "a company designs and sells the hardware and semiconductor chips but relies on chip-making factories known as foundries to manufacture the chips" (Gereffi & Korzeniewicz 1994).

East Asia emerged as a potential for this model & Smasung, TSMC emerged as major players.But they rely heavily on equipment and machinery supplied by semiconductor capital equipment vendors (semicap). It's worth to notify the three out of five of them are in The US. It's not necessary to stick wih the GPN but it's not easy to undo existing chip GPNs and the current fabless model too.[15] An upfront $1 trillion investment is required to build a local self sufficient supply chain for every region. This will also increase the cost of chips ranging between 35% to 65%.(Voas et al. 2021)

The U.S. government has realized that" the global semiconductor shortage has significant national security implications.household appliances, computers, phones, and cars, semiconductors are also embedded in military equipment.If Taiwanese foundries were ever fully shut down, replacing their production would take three years and a $350 billion investment in other economies to build back a sufficient.The U.S. is taking legislative and policy measures for strengthening domestic semiconductor manufacturing. In February 2021, an executive order was signed, which involves assessing potential risks in semiconductor supply chains. A bill known as the Creating Helpful Incentives to Produce Semiconductors for America Act (CHIPS Act) (H.R.7178), introduced in 2020, aims to provide incentives to enable advanced RD in the semiconductor industry and securer supply chains."[23](Voas et al. 2021)

The U.S. government is providing subsidies & incentives to support and promote domestic manufacturing of semiconductors through subsidies and other incentives. President Biden has approved $ 50 Billion to support semiconductor industry. Even corporate are using this favourable trade environment provided by the USA gov and building new factories. Recently Intel announced a plan to build two chip factories of worth $20 billion. Similarly big foreign players likes Samsung, TSMC also want to get along with this opportunity of favourable trade environment. In 2020, TSMC announced a "plan to spend $12 billion to build a semiconductor plant in Arizona. Samsung was reported to be considering Texas and Arizona for a new logic-chip facility; this facility would likely be the most advanced in this category in the U.S. TSMC alone is planning to spend $100 billion over the next three years in the US Market."(Voas et al. 2021)

5.3 Bullwhip Effect on Semiconductor Supply Chain in The US

Figure 9 demonstrate the bullwhip effect which makes it easier to understand the Demand challenges that a Semiconductor Supply Chain has encountered.[16]

[15]Voas, Jeffrey, Nir Kshetri, and Joanna F. DeFranco. "Scarcity and Global Insecurity: The Semiconductor Shortage." IT Professional 23, no. 5 (2021): 78-82.

[16]Scott, Nehemiah: Managing Supply Chain Disruption During COVID-19 2021 accessed on 12/01/2022 at 19:20

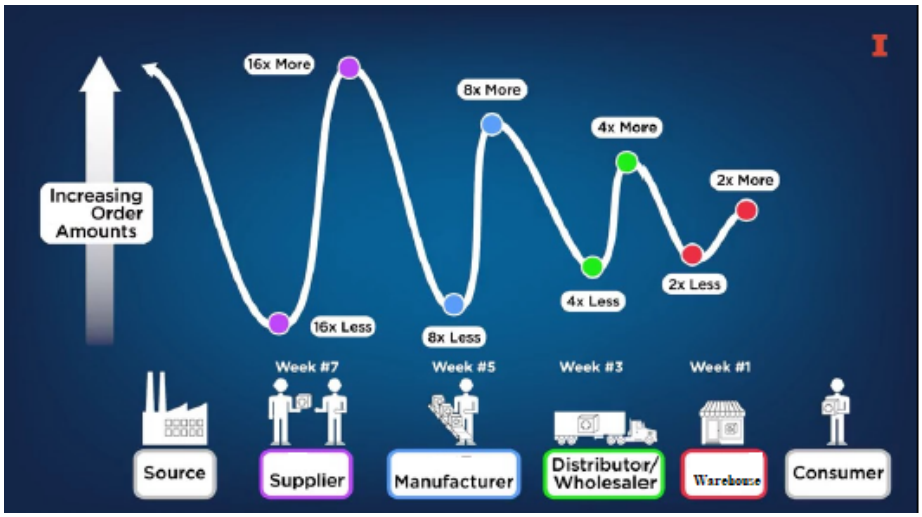

Figure 9: Bullwhip effect on Semiconductor industry -I
(Scott 2021)

Understanding the bullwhip effect will help us to get a more clear picture about how the chip shortage started and why it's affecting today's economics. It will also provides insights that how semiconductor industry can paved it's way out from this crisis.[17]The Figure focused on both, manufacturing side and delivery side of the semiconductor supply chain network. The arrow pointing upwards shows the increasing orders for semiconductors. Whereas, in bottom side, the stages of supply chains are highlighted. It start with Source, followed by, Suppliers, Manufacturers, Distributors, Warehouse and Consumers

To Understand the effect, Let us assume now that in week number one, the manufacturer sees a sudden increase in the need for products made with semiconductors(Can be any) compared to last week. As a result, a revised order is issued compared to regular order. This demand will be fulfilled by the warehouse as initially they is some stock. Lets say after A couple of weeks later in week number 3, the wholesaler gets the order amount from the warehouse and notices the amount by which the store increased its order. Just like the warehouse did, the wholesaler will now increase their demand by as much as twice the amount of the increase in demand they see from the store. Which is also equal to 4 times more than the original increase in demand the warehouse experienced. The distributor will then send this order to its supplier, which is the manufacturer.(Scott 2021)

A couple of weeks later in week number 5, the semiconductor manufacturer will notice that the distributor has increased its order significantly. Just as the warehouse and the distributor did, the manufacturer and will now increase their demand by as much as twice the amount of the increase in the demand they see from the distributor, which is now equal to 8 times more than the original in-

[17]https://finance.yahoo.com/news/global-semiconductor-shortage-explained-bullwhip, May 2021, accessed on 08.01.2022 at 14:13

crease in demand the store experienced.Lastly, the raw materials supplier in this case, will end up increasing their demand in order by as much as sixteen times more than the original increase in demand that the warehouse experienced.It's worth noticing that a exactly reversed process will be followed if demand start decreasing which at the end leads to as much as sixteen times less than the original decrease in demand.(Scott 2021)

In order to enhance production, Manufacturers of automobiles,electronics & Mobile phones ordered in for more semiconductors. This unexpected rise in demand puts a sudden pressure on major players like Huawei, Qualcomm, and NVIDIA, which design and sell the chips. This further leads the demand pressures on suppliers & manufacturers (TSMC, Samsung, and Intel) that assemble advanced semiconductors. The demand pressure further circulated overwhelming crush of orders for the basic parts supplier companies. With time, many industries which do not operate in electronics domain start facing the heat as chip foundries fielded far more orders than any supplier could fulfill. Which further leads to huge backlog and long delivery time.

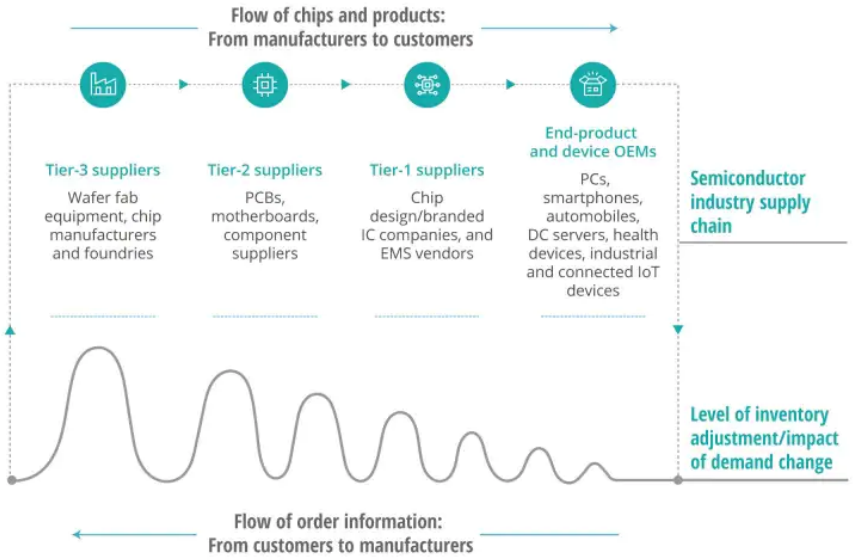

Figure 10: Bullwhip effect on Semiconductor industry -II
(Ramachandran 2021)

Figure 10 shows how the supply chain of semiconductors works with tier 3 suppliers to reach towards tier 1 suppliers and final product is delivered to the customers, but as demand of products increased from the customers side,the pressure directly transferred from tier 1 suppliers to tier 3 suppliers. The demand here is based on signals of demands, but as actual communications based on real time is missing, the effect is Bullwhip Effect.[18]

[18]Dan Hamling Chris Richard Duncan Stewart Karthik Ramachandran, Five fixes for the semiconductor chip shortage, Deloitte Insights, 6 Dec 2021, accessed on 13.01.2022 at 15:24,

5.3.1 Solution tp Bullwhip Effect on Semiconductor Supply Chain

The initial response to any shortage is to increase the production of short product. Same goes with case of Chips, Manufacturers already started working on the same, but the main issue is the completion time to create a foundry or factories can't be completed before end of 2022. Prof Shih from Stanford states that by the time New factories will build up, there is high chances that the demand might fall. He stated "Just when the new factories come online, there's all this excess supply and then prices collapse and no one wants to build another factory for a while." This will create a cycle, "When suppliers stop building new factories, demand gradually grows until it falls in line with supply. At that point, small shifts in consumer demand can once again create big shocks to the supply chain thanks to the bullwhip effect. Shortages beget supply gluts, which eventually lead to shortages again. All this means that chip suppliers need to carefully plan their expansion, or else they risk producing a semiconductor glut in the next few years, which could be followed by another shortage. "[19]

Professor Shih also coined that "The problem right now is there's a lot of panic buying going on," said Shih. Worried about the chip shortage, every company is trying to stockpile chips to last them through the crisis. But hoarding further distorts the demand signals that are rippling through the supply chain, making it seem like companies need far more chips than are truly necessary to meet consumer demand."[19]. He also added "It's hard to convince any individual company not to do it, even though it harms everyone."[19]

5.4 User Survey

Data collection was performed by offering a survey using social networking site, LinkedIn[20]. The questionnaire is made up of a 2 minutes survey with total of 14 questions, mainly focus on a major aspect of semiconductor supply chain activities in the USA.The survey is focused on demand, measures and features. A total response of 22 people were collected when the survey was left open for 72 hours.

source: https://www2.deloitte.com/xe/en/insights/industry/technology/semiconductor-supply-chain-solutions.html

[19]https://finance.yahoo.com/news/global-semiconductor-shortage-explained-bullwhip, May 2021, accessed on 08.01.2022 at 14:13

[20]Survey Link: https://forms.gle/ynBEKtLEkGmPLzUeA

6 Data analysis of survey results

22 responses were collected in 72 hours where the participants were reached out at LinkedIn. The survey was focused on users categories, connections, punctuality of supply chain, extra costs, profit/ loss due to chip shortage, measures taken at low supply, vision for futuristic supply chain.

6.1 Users as per categories

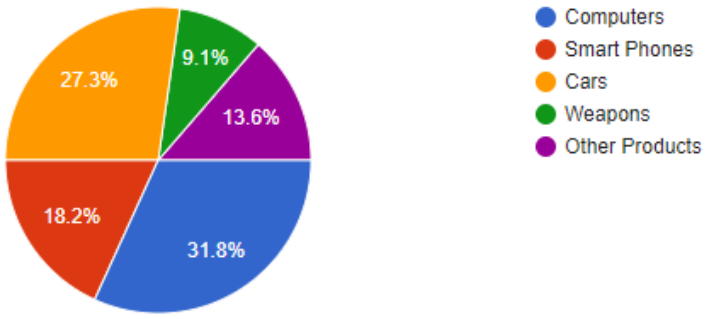

Figure 11: Categorical division of users as per companies association

Figure 11 illustrates the survey results for the products, which were affected by the Supply Chain. 31.8% people voted that they are associated with Business of Computers. These computers are not only limited to laptops, but also other components like devices for 5G, Raspberry pi etc. The second highest affected industries are automobile with 27.3%. Thirdly is Smartphones industries with 18.2%, followed by weapons and other products who were directly/ indirectly affected by shortage of semiconductors.

6.2 Users affected

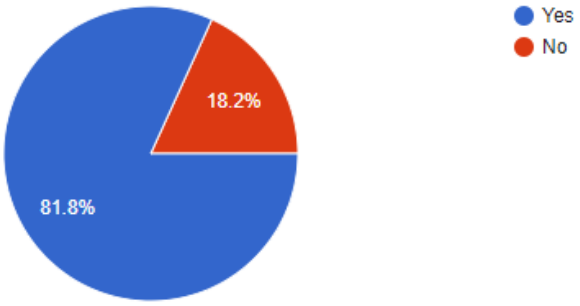

Figure 12: Users affected due to semiconductor shortage

Figure 12 describes people's opinions on the problems faced due to chip shortage. With 81.8% people agree they have faced problems due to shortage of chips, 18.2% doesn't face any problems. We follow up there responses and found out that they have either multiple partners and good inventory which help them to sustain during supply chain crash.We also witnessed that 91% agree that they observed a spike in sales.

6.3 Business sectors affected

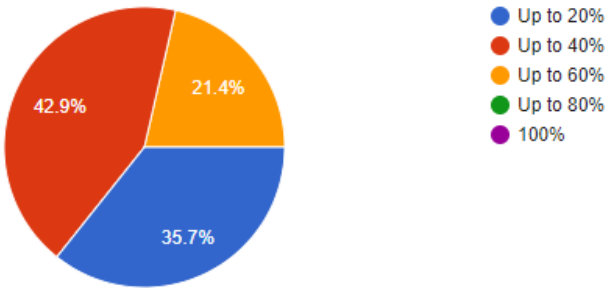

Figure 13: Business sectors affected due to semiconductor shortage

Figure 13 describes the Business sectors affected by the Supply Chain Disruption. 43% of Businesses have claimed to be affected up to 60% due to disruption which a very huge loss. Another 36% people claimed that there business were affected between 20%. Whereas 21% were on the higher end of loose and claimed there Business were affected by 80%.

6.4 Country Wise Measures

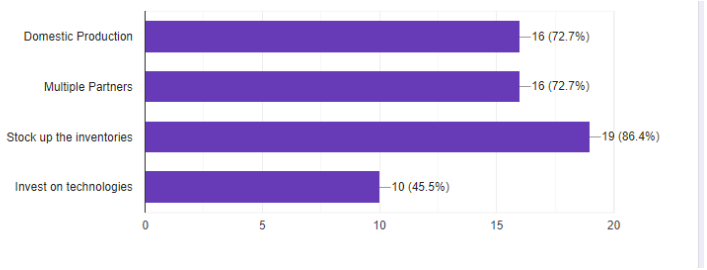

Figure 14: country wise measures adaption

Figure 14 describes people's opinions on the measures that they think as a country, United States need to work on to reduce future effects on semiconductor industry. 72 % people said that Domestic production with local partners , or having multiple partners can reduce this bottleneck of reliability. 86% percent users think that having a big inventory can save them from this type of problem in future.While, only 45% people think that they need to invest more on latest

technologies.

6.5 Desired features in future supply chains

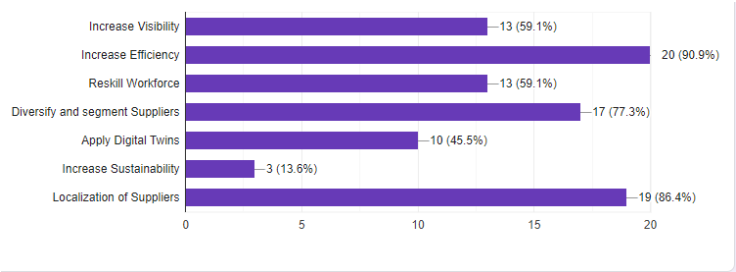

Figure 15: Desired features in future supply chains

Figure 15 clearly shows that 91% users stated that supply chain must become more efficient and we all must focus to increase supply chain efficiency. 86% users said that focus must be localization of suppliers and domestic supply chain will be more resilient.77% Users say its important to diversify suppliers and get in contact with multiple suppliers instead of putting all your eggs in one basket. They also mean to promote and support other suppliers who are already present in the market or who are willing to incest and join in. Increasing visibility and training/enhancing skill set are also an important factors to enhance the supply chain which is supported by 60% participants. Lastly, 46% participants said that adopting latest technologies like Digital Twins will help to create simulations of the chain and help to figure out disruption and effect of disruption more clearly and thus important decisions can be taken in due time. It's also interesting to see that only 13% participants supports increasing sustainability and focus on reducing carbon footprints.

6.6 Impact of Supply Chain issue on Business

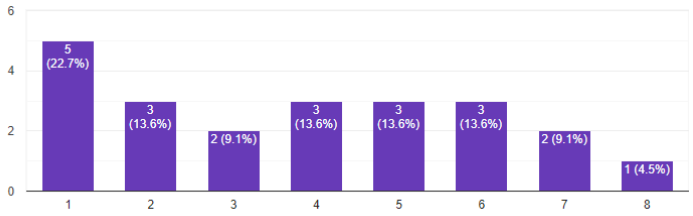

Figure 16: Chip shortage & it's impact

Figure 16 describes impact of chip shortage on their business. 40% users said they they company had medium affect ranging between 3-6. 15% users said they they have major impact and 35% small users said they don't feel that much affect.

7 Building Resilient Supply Chain

7.1 Bain & C0. Strategy to improve semiconductor supply chain

Bain & Co.(Peter Hanbury 2021) has put forward some strategies to cope up with ongoing Semiconductor shortage. They mentioned that as Supply Chain Management is a top priority for the management at the moment, following steps must be taken to improve it .

Developing a segmented strategy: Majority of Companies who need Semiconductors in their products must take some advanced steps and rank/prioritize components based on the probability of disruption.This Ranking will help company to understand the area they need to work hard to get the components, inventory management and not stocking up the unnecessary available components mostly at high prices too.[21]

Risk Assessment & Smart Resilience: "lead time to add capacity; concentration of the supply base; geographic concentration (considering weather risk and geopolitical tensions); and multiple industries competing for supplies from the same producers."[21] Companies must make more strategic investments to embed more resilience in their supply chains. Scenario based pressure testing helps to identify the weakness beforehand and also expose the ares which need to be invested to make more resilience. While Making Supply Chains resilience, 3 areas need to be improved which are Adaptability, Redundancy & Real-time feedback. In Adaptability, focus is to make product flexible in terms of components. For Example, Tesla uses standard Hardware is making its software running on in-house chips and thus making things flexible in terms of components. This adaptability to revise component qualification for hardware will reduce pressure on supply chains. The second area which need improvement is Redundancy, where company need to maintain inventory and purchase from multiple vendors. Lastly, Real-time feedback helps to monitor possible failure points in a supply chain via heat maps. A recent example is BMW. The German car manufacturer is working on latest technologies like Blockchain, Machine Learning on Cloud Computing(AWS) to improve visibility in there supply chains. Figure below highlights that chip shortage have not only long lead times, but based on excess orders it's taking a longer times based to fulfill nay orders. Therefor Applying the mentioned suggestions can be very helpful.[21]

Deploying a cross-functional operating model: Maintaining Supply Chain resilience is not possible by Supply Chain experts alone.The best approach is to make involve all the stakeholders, including sales, procurement, engineering and supply chain experts. This not only remove head off disruptions or help to change customer demands to the products which have inventory within the company. In fact Product design phases have supply chain teams in their meetings so that risks and trade-offs can be highlighted before hand by the experts. For Example: Continental, a Germany-based automotive parts maker has established an advanced buying process. This advanced buying process increase

[21]Peter Hanbury and Anne Hoecker, "Two Lessons the Chip Shortage Taught Us about Supply Chains", Bain & Company, 20 September 2021, accessed on 09.01.2022 at 17:16

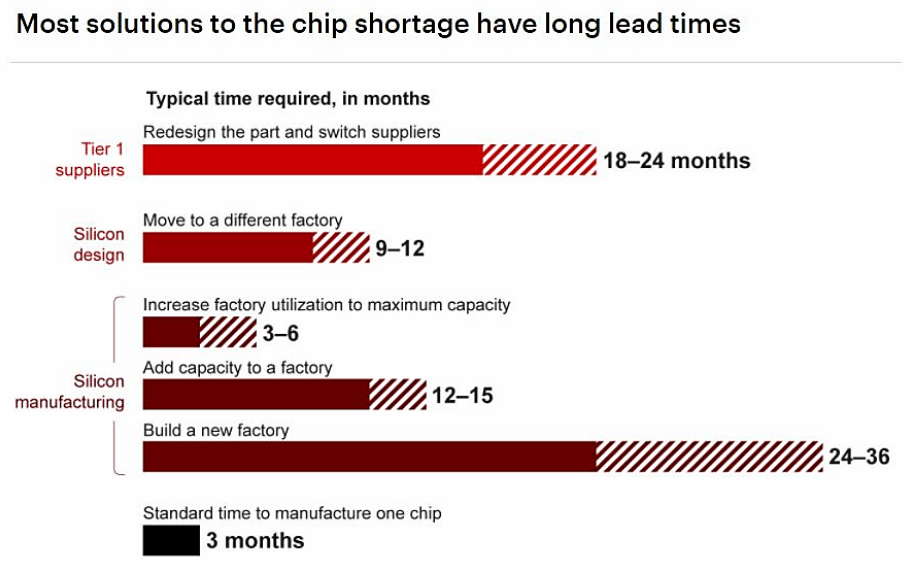

Figure 17: Supply chain tiers and Risk Management
(Peter Hanbury 2021)

purchasing department's role in the engineering of parts. This approach helps to streamline the component use and also help Continental in reducing the number of parts in Continental's end products. This approach is not only help full in cost cutting but also gives a clear picture about the Supply Chain to the engineering team and thus decisions made more quickly then later facing supply chain issues.[21]

Collaborating up and down the supply chain. A strong collaboration is required between customers and suppliers. A more transparent data sharing among industries and negotiation can help to avoid the bullwhip effect we saw with the chip shortage. Collaboration and support can only help industries to come out from this circle of semiconductor shortage. A constant accessing of markets situation, developing strategies must be done by planning team to support.[21]

7.2 Mckinsy strategy to improve semiconductor supply chain

Mckinsy states that in case of Risk management the supply chain is again on a wring track which is focused more on breadth but not enough depth. Mckinsy states that actions taken for risk management of supply chain for any company is directly proportional to the maturity of their supply-chain risk-management capabilities. Mature organizations focused on new practices and their implementations whereas Companies with less experience on risk-management experience are more likely to invest in new software tools.[22]

[22]Knut Alicke, Ed Barriball, and Vera Trautwein, "How COVID-19 is reshaping supply chains", November 2021, accessed on 10.12.2021 at 18:00

They also highlighted that even after all these efforts,Blind spots lefts in the Ecosystem of supply chain management of the companies. In a survey conducted by Mckinsy, several companies, in fact majority of them states that they understand the risk & location of their tier-one suppliers. It's surprising to see that only two percent companies are concerned about the third tier suppliers and know about the risks associated with them. This Risk management is more important because supply shortage, such as semiconductors occurs in this area.[22]

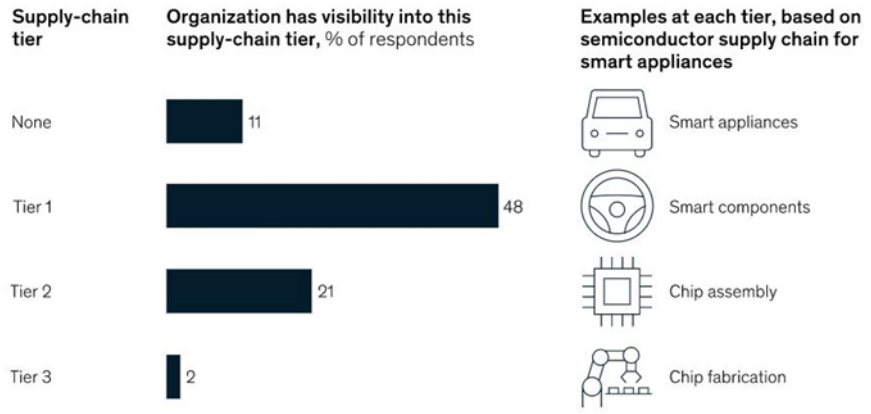

Figure 18: Chip Shortage& long lead times
(Peter Hanbury 2021)

7.3 Deloitte strategy to improve semiconductor supply chain

Digital Twins: Supply chain resilience stress test can be performed by creating digital twin of the supply chain. This Digital twins will help to assess risks associated with Operations and Finances with respect to disruptions in the market.Various Scenarios are then modeled and their impacts were realised, monitored and strategies o deal with particular scenario needs to be formulated.The outcomes from these models helps to predict the time needed by supply chain to recover, maximum performance that a supply chain provides to match with demand (time to survive) in case of disruptions.

Time's up for just-in-time: Semiconductors supply chains previously always built on just-in-time principle for many components. The assumptions that lies behind the things will always run in sync. Recent result of this approach have already shown severe effects.An entire production line of an expensive car can be stopped by a missing 20 cent chip and thus may be just in time can save some money, but can be very costly at time.

In Figure 19,With connected customer mindset, customers demands can be figured out or forecasts beforehand and thus the bullwhip effect can be reduced

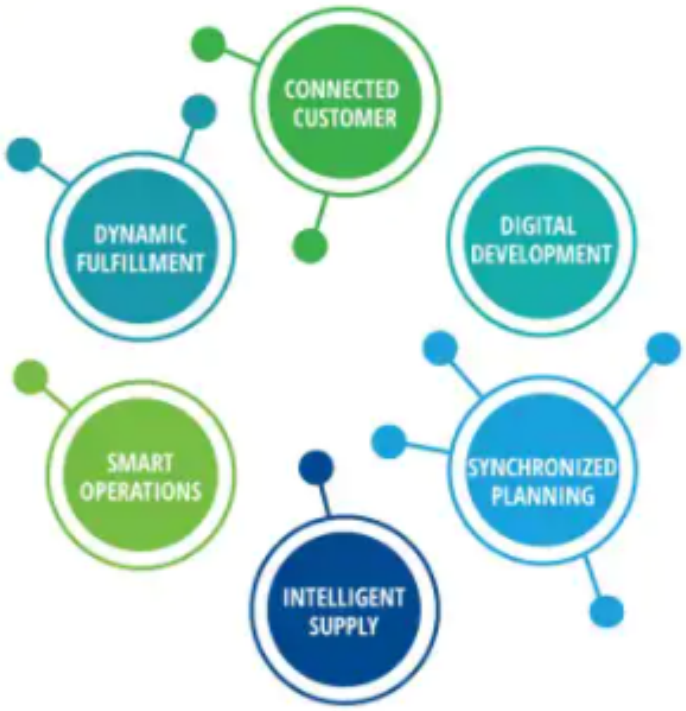

Figure 19: Digital Development
(Ramachandran 2021)

which results from demand swings. Secondly, Digital Development help companies to build and access prototypes in more efficient manner. "The efficiencies and agility of digital development address the semiconductor industry expectations related to fast-moving innovation and product"

Digital Supply Chains: Digital capabilities model can help us redesign the traditional supply chains into a integrated and connected supply chain by focusing in all tiers of suppliers.

Synchronized planning capabilities helps to challenges that arsis due to complex value network. These challenges are "long-range manufacturing capacity planning and near real-time demand and supply alignment, across a complex mix of internal and external suppliers. Intelligent supply capabilities support the continued expansion of outsourced manufacturing through enhanced supplier collaboration, development, and monitoring. They can mitigate the risks inherent in the global semiconductor supply network when integrated with synchronized planning systems."(Ramachandran 2021)

Smart operations capabilities such as digital twins, AI, Block-Chain are vital to semiconductor industry. Operations monitoring, factory operations such

as availability of materials, scheduling adjustments & high asset utilization. Lastly, Dynamic fulfillment capabilities support the "multiple sales channels, production paths, and fulfillment service points in the semiconductor industry. Products ordered through various sales channels can be adaptively manufactured by multi-sourced supplier networks, and delivered through internal and third-party logistics warehouses, distributors, managed consignment hubs, and more."(Ramachandran 2021)

Action	Chipmakers	Distributors	Customers	Governments
Build overall capacity	✓			✓
Build local capacity	✓			✓
Become strategically lean		✓	✓	
Break the bullwhip	✓	✓	✓	✓
Digital transformation	✓	✓	✓	

Figure 20: Key Consideration for major players
(Ramachandran 2021)

Figure 20 highlights the actions need to be taken by Chip-makers, Distributors, Customers & Government. All the steps are not needed to be completed by all of the players involved. But the most important factor here is to break the Bullwhip effect, for which all of the players need to coordinate and work in close cooperation to come out of this semiconductors shortage circle.

8 U.S. Semiconductor Innovation Policy Landscape

With the ongoing pandemic, disturbed supply chains, loss in Business, and rising competition in the area where USA was once a pioneer and world leader in semiconductor supply chain is now restricted with shrinking market. Figure 21 shows that the forecast of Chine being a world leader in semiconductor industry with not only becoming self sufficient, but also capturing the world market.BCG highlighted in their report, that only "6% of the new global capacity in development in semiconductor sector will be in U.S. On the other hand, China is projected to add about 40% of new global capacity to become the largest semiconductor location in the world in the next decade" (Varas et al. 2021)

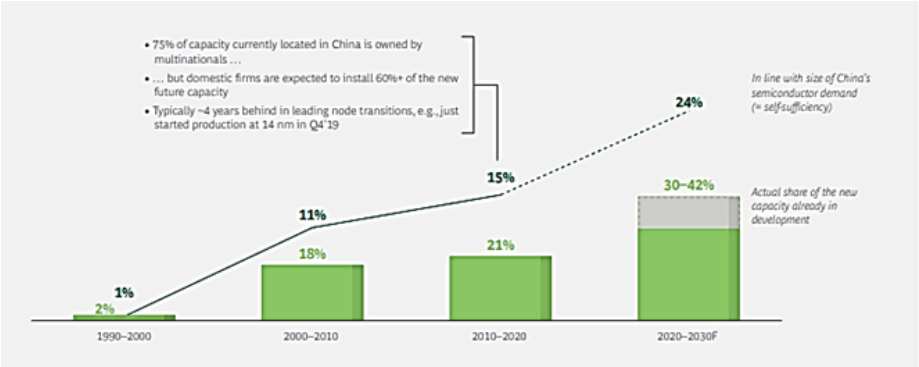

Figure 21: China's rapid growth in semiconductor industry (Varas et al. 2021)

The U.S. government has realized that "the global semiconductor shortage has significant national security implications.household appliances, computers, phones, and cars, semiconductors are also embedded in military equipment.If Taiwanese foundries were ever fully shut down, replacing their production would take three years and a $350 billion investment in other economies to build back a sufficient.The U.S. is taking legislative and policy measures for strengthening domestic semiconductor manufacturing. In February 2021, an executive order was signed, which involves assessing potential risks in semiconductor supply chains. A bill known as the Creating Helpful Incentives to Produce Semiconductors for America Act (CHIPS Act) (H.R.7178), introduced in 2020, aims to provide incentives to enable advanced RD in the semiconductor industry and securer supply chains."[23]

The U.S. government is providing subsidies & incentives to support and promote domestic manufacturing of semiconductors through subsidies and other incentives. President Biden has approved $ 50 Billion to support semiconductor industry. Even corporate are using this favourable trade environment provided by the USA gov and building new factories. Recently Intel announced a plan to build two chip factories of worth $20 billion. Similarly big foreign players likes Samsung, TSMC also want to get along with this opportunity of favourable

trade environment. In 2020, TSMC announced a "plan to spend $12 billion to build a semiconductor plant in Arizona. Samsung was reported to be considering Texas and Arizona for a new logic-chip facility; this facility would likely be the most advanced in this category in the U.S. TSMC alone is planning to spend $100 billion over the next three years in the US Market."[23]

The semiconductor industry opens up opportunities for lots of workers at many levels. From Research Scientists, Engineers, Supply chain managers, Accountants, Industry workers, etc. When production & maintenance start locally, a huge workforce need to get trained up with some training through apprenticeships, workforce development programs and by other methods.(House 2021)

Collaboration, Transparency & Investments with public private partnership are major factors to setup a successful domestic supply chain for semiconductor industry to deal with the semiconductor shortage. U.S. government can assist in redoubling partnerships with industry and develop a fair channel of communication and information flow between semiconductor producers and suppliers and end users. Fair engagements must be established between companies can help to crack the Bullwhip effect successfully.(House 2021)

		2020–2030 FORECAST		
			Scenarios of new government incentives[3]	
Trend vs. 2010–2020: ↓ = ↑	2010–2020 ACTUALS	Status quo	$20B program	$50B program
Share of new addressable capacity[2] captured by the US	10%	6% ↓	14% ↑	24% ↑
Excluding China	*12%*	*12%*	*24%*	*41%*
US global ranking by share of new capacity[2] (out of 7 regions)	#5	#5 =	#3 ↑	#2 ↑
Excluding China	*#4*	*#4*	*#2*	*#1*
No. of new fabs built in the US[3]	9	9 =	14 ↑	19 ↑

Figure 22: Potential impacts of new government incentives (Varas et al. 2021)

The US government has passed National Defense Authorization Act (NDAA) with seven purpose. The first one is to provide federal financial assistance to either construct,modernize or expand facilities for different phases of semiconductor design. The second purpose is to provide assistance in enhancing the Research and Development via a new National Semiconductor Technology Center (NSTC).(House 2021)

The third one is to provide continuous support for investing the USA. Many programs are initiated like Select USA, started by department of commerce. Another such program is offered by newly established department NIST(National Institute of Standards and Technology) which primarily supports in manufacturing. The fourth one is besides NIST, the Biden government is also vowed to

[23]Voas, Jeffrey, Nir Kshetri, and Joanna F. DeFranco. "Scarcity and Global Insecurity: The Semiconductor Shortage." IT Professional 23, no. 5 (2021): 78-82.

Small and Medium size businesses. The supports comes in the form of either financial help to support growth and by proving R& D resources with emerging technologies. The fifth purpose is to Develop a talent base in semiconductors.

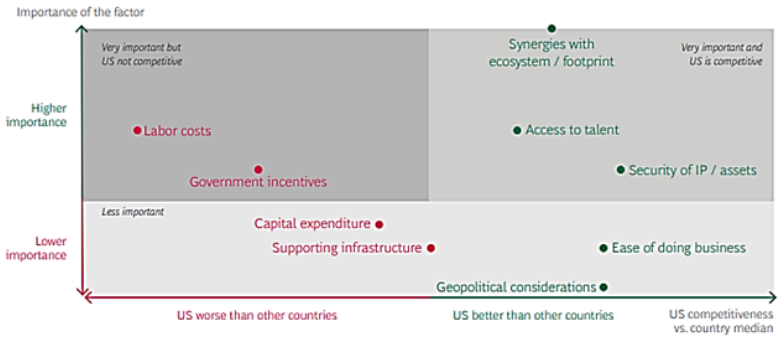

Figure 23: Strength sectors for selecting FAB location
(Varas et al. 2021)

From STEM graduates to skilled labours, all can be trained and integrated in the market. The government is ready to fund workforce development programs, ready to offer changed & attractive immigration policies to the talented and motivated workforce around the globe.(House 2021)

The sixth one is to promote and attract foreign companies to come and invest in the USA. Also forming allies, investing together in research and development, eradicate market imbalance and market actors, etc., are some of the prime motives. Lastly, addressing National security by strict foreign policy on semiconductor manufacturing and Advance packaging and thus keeping exports under control and thus protecting US advantage in semiconductor manufacturing.(House 2021)

Figure 22 shows that the $20 billion program and $50 billion program initiative by USA government holds the potential to uplift the semiconductor share to 14% and 24% respectively.

9 Recommendations

Supply chain resilience is not about adding capacity in terms of material, manpower etc., when needed and scale it. Specially, at times of pandemic, stocking up the unnecessary inventory, non- analytical decisions, unnecessary expenditure will make the situation worse and initiate the bullwhip effect.Instead, resilience comes with continuous monitoring of the supply chain via simulations, analysis of data, visualization of supply chain and not getting limited to only Tier1 suppliers, scenario planning, adapting latest technologies like digital twins, AI, etc., agile mindset, trained workforce with high-performance culture, moving in market with agile mindset, and last but not the least, being futuristic and supporting sustainability.

Government must develop policies which are not inclined towards next year profit, but instead focus on long term market leadership.[24]Some of the suggestions for the US government are:

Invest in U.S. Semiconductor Leadership: The Government keep continuing to support the domestic semiconductor manufacturing, R&D, in the CHIPS for America Act.The government must also provide an investment tax credit for both, manufacturing and design to support the advanced semiconductor R&d, increasing manufacturing facilities, support and promote innovations in domestic chip.(SIA 2021)

Workforce Development Programs: Implementing a national strategy by public-private partnership model which is backed by appropriate funding and support.The partnership can be extended to education sectors too, where the focus is to produce more Americans graduating in the STEM fields. Also, as America attract talent from all over the globe, so American government must adapt linear, supportive and liberal policies towards skilled students graduating from American Universities. Currently, Limited work Visa, Strict policies are making America loose many bright minds who either have to return back to home country, or even doesn't go to the USA, for studies , due to strange and non supportive visa policies of the American government.(SIA 2021)

Promote Free Trade and Protect IP: Free trade not only remove market barriers but also bring in fair competition. By approving Free Trade agreements, US also must implement towards expanding the most successful free trade agreement of the WTO, which is "Information Technology Agreement".(SIA 2021). Protecting Intellectual Property rights is also one of the area where Government must bring in strict laws to make sure it is maintained.

Cooperate Closely with Like-Minded Economies: Expending collaboration with like- minded allies will help in future to develop a trustworthy environment which will be not only easy to regulate but also legalize. The focus of these corporations must be inclined towards growth, support and making supply chain more resilience.(SIA 2021)

[24]FERRY, JEFF, ROSLYN LAYTON, and CHINA TECH THREAT CO-FOUNDER. "MAINTAINING US LEADERSHIP IN SEMICONDUCTORS AND COUNTERING CHINA'S THREATS." (2021).

10 Conclusion

Semiconductors supply chains are not only complex, but also globalized. The growth in semiconductors market was always driven by Moore's Law. Today, the United States is the global leader in semiconductor technologies is scattered to only 12% market share.

China is not only quickly expending it's market in semiconductors, both design & manufacturing. If successful, China will not only lead the global supply chain of semiconductors, but also reconfigure it.This will put critical impacts on U.S. national and international security. Therefor a timely, effective action is needed from US side.

The report highlights the current scenario of supply chain management in semiconductors and the US stand on it, It's very clear that both the Organization and The government are looking forward towards a resilient Supply chain Network.The government is supporting the Business with financial helps, easing norms and supporting R&D. Whereas the Business/Organization are taking various steps to enhance itself and develop a more resilience supply chain network.

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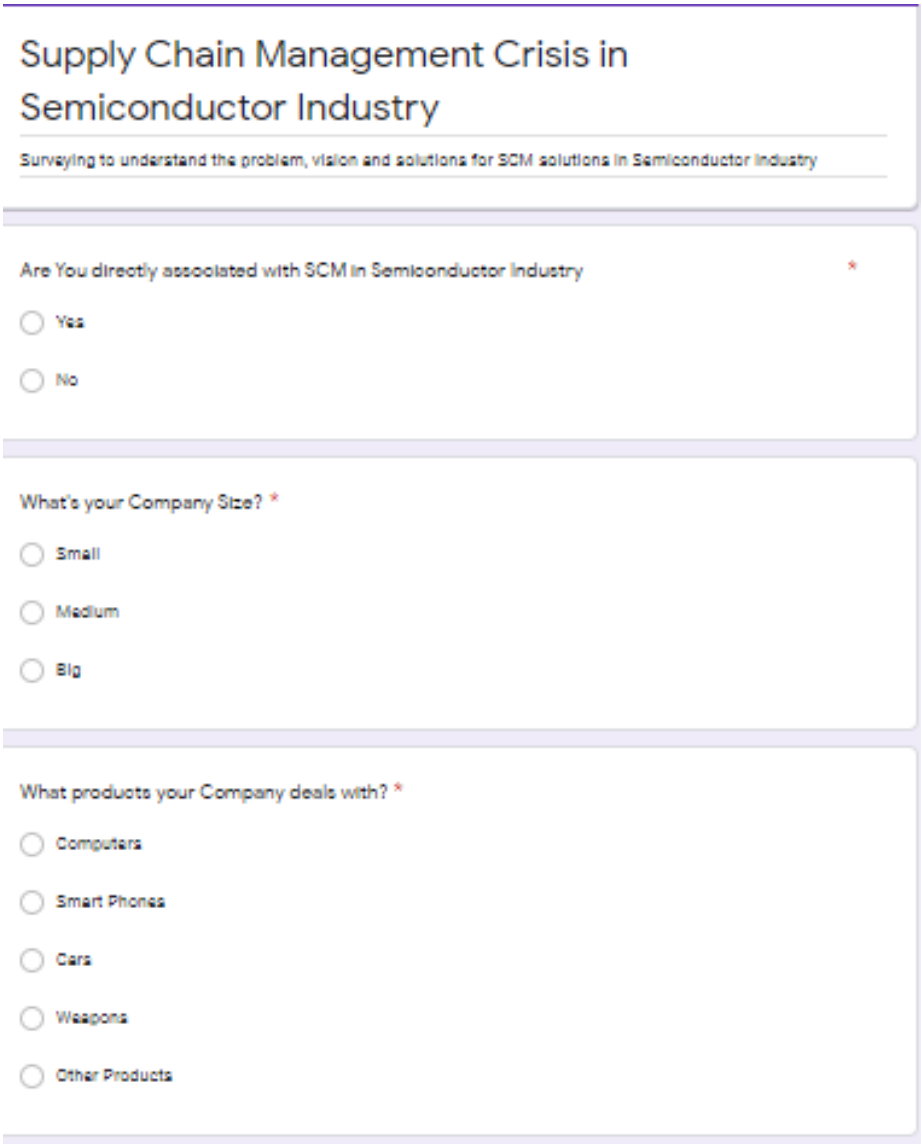
A Surveys



Supply Chain Management Crisis in Semiconductor Industry

Surveying to understand the problem, vision and solutions for SCM solutions in Semiconductor Industry

Are You directly associated with SCM in Semiconductor Industry *

- Yes
- No

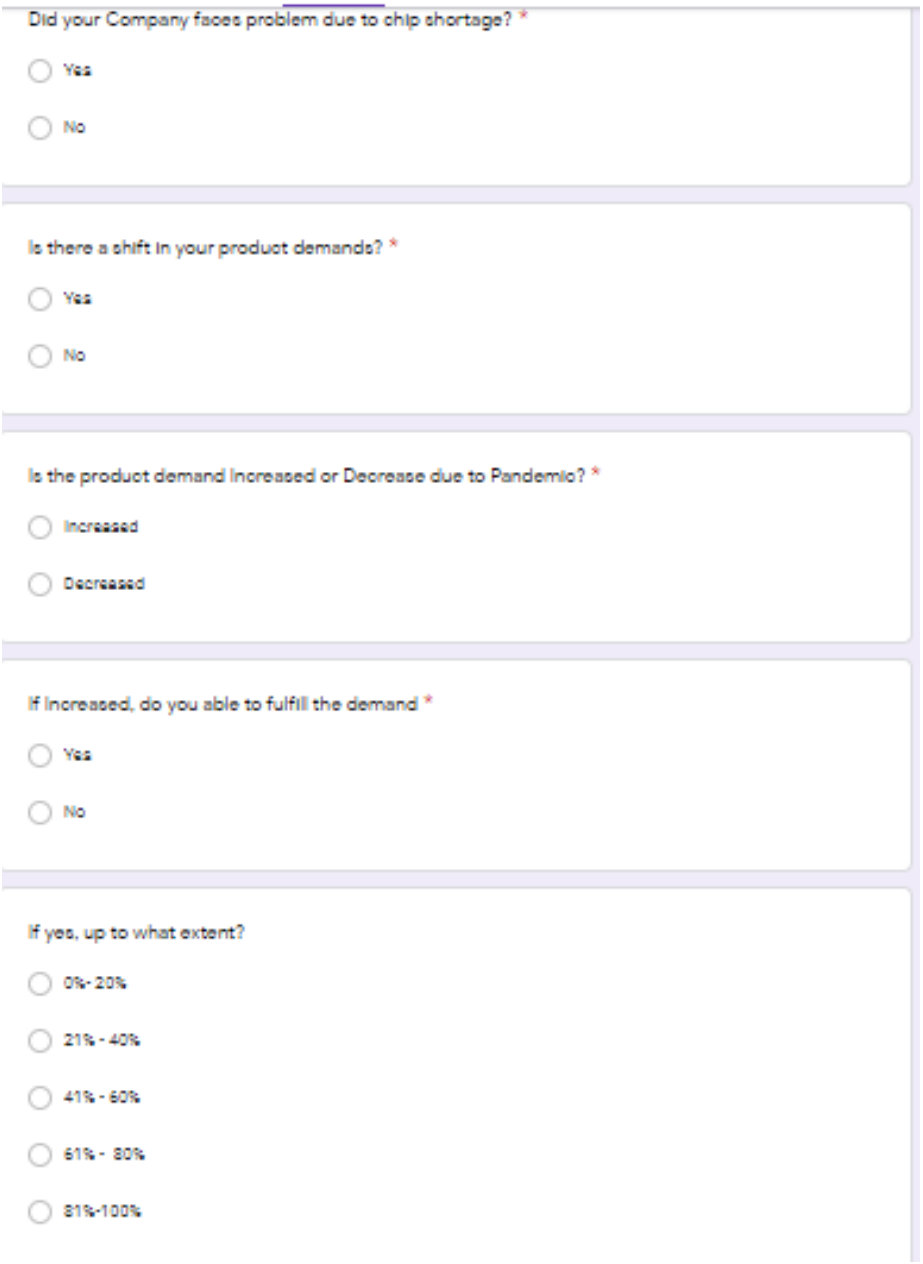
What's your Company Size? *

- Small
- Medium
- Big

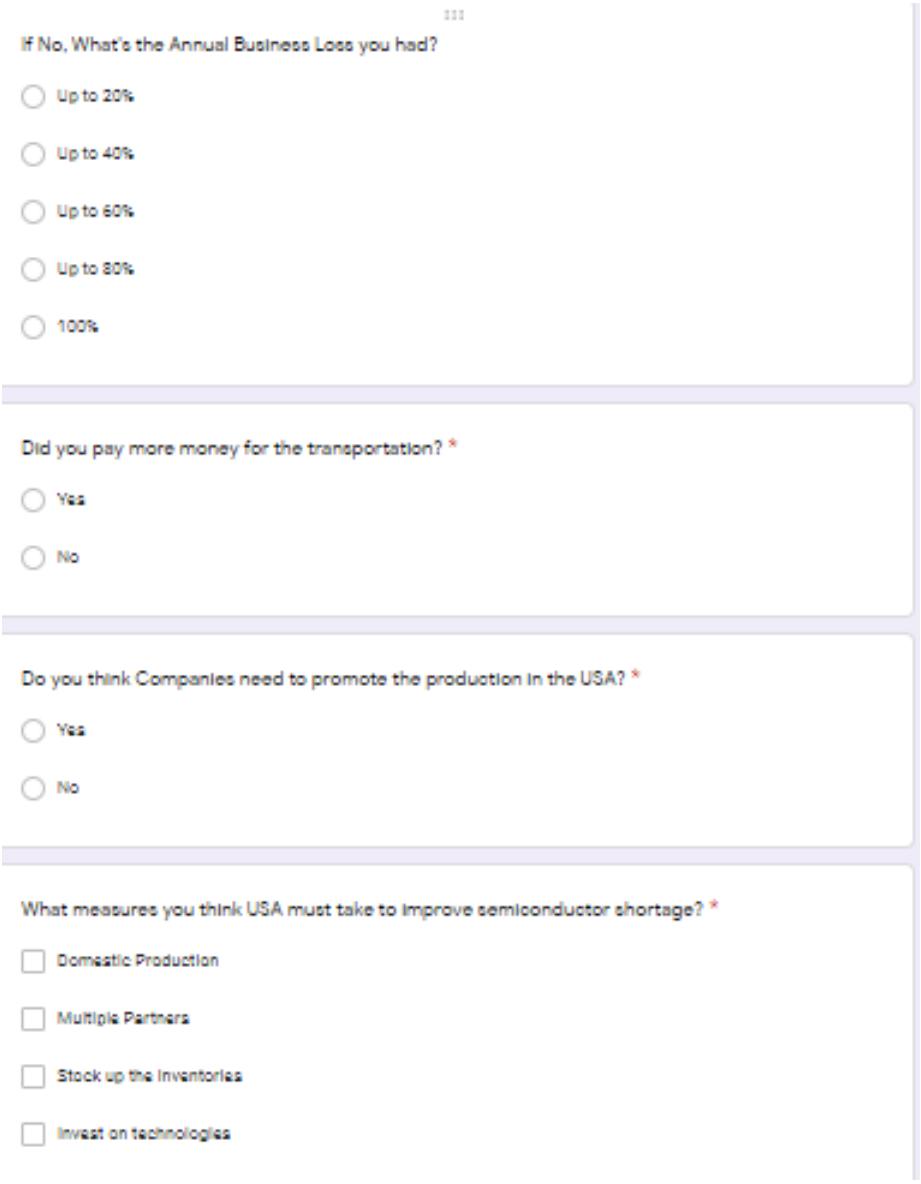
What products your Company deals with? *

- Computers
- Smart Phones
- Cars
- Weapons
- Other Products

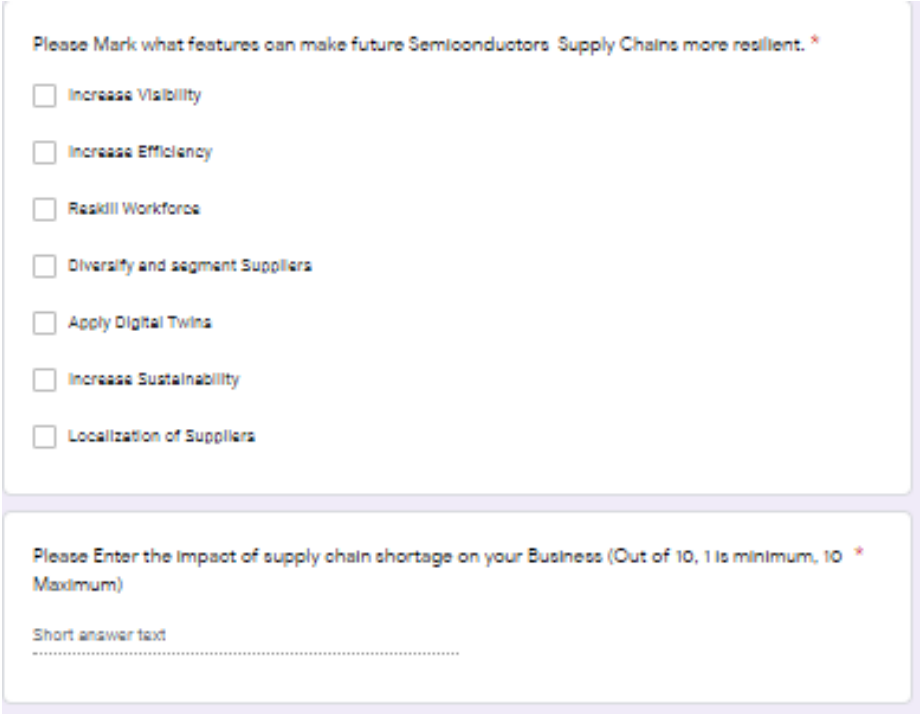
Survey: Supply Chain Management Crisis in Semiconductor Industry part 1



Survey 1: Supply Chain Management Crisis in Semiconductor Industry part 2



Survey 1: Supply Chain Management Crisis in Semiconductor Industry part 3



Survey 1: Supply Chain Management Crisis in Semiconductor Industry part 4