Global Economic Policy Lab

COVID-19 Pandemic Recovery: 2022

Briefing Note: Semiconductor Chip Shortages

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Background
Global Semiconductor Landscape

Semiconductor production is dominated by the Taiwan Semiconductor and Manufacturing Company (TSMC) which accounts for 52.9% of the semi-conductor market share. More broadly, Asia produces 80% of the world's supply of semi-conductors, with TMSC (Taiwan) and Samsung (South Korea) as the two main competitors in the production of semi-conductor chips used globally. Prior to the COVID-19 pandemic, the semi-conductor industry began to experience a heightened demand due to consumerism - consumers over the years have developed an increased desire to purchase new products more consistently than the past leading to greater demand for semi-conductor chips.

In addition to consumer trends, geopolitical challenges created strain in the semiconductor supply chain. For instance, former United States President Donald Trump placed strict regulations on semiconductor sales to Chinese firms like Huawei (who in-turn stockpiled semiconductor chips) and blacklisted major Chinese semi-conductor manufacturing firms. These challenges created a strain on the global supply chain of semi-conductors as the industry struggled to adapt to changing regulations and meet demand. The COVID-19 pandemic drastically exacerbated these trends and the global supply chain for semi-conductor chips, creating a severe backlog in the production of products that require semi-conductor chips to function. This policy brief provides an overview of the current state of the semi-conductor industry, where the semi-conductor industry is heading, and a prediction of when the industry will be fully recovered from the COVID-19 pandemic.

Section 1:
Analysis of the Challenge

The supply chain crisis can be attributed to several factors resulting from the pandemic. The first main impact involves the production shortages and logistical strains posed by lockdowns. The implementation of various forms of restrictions to halt the spread of COVID-19 reduced the production of semiconductor chips. From a supply perspective, as levels of shipping supply decreased, the costs of shipping containers increased. In fact, the cost of shipping containers increased 10-fold between 2020 and 2021. The shortage of shipping containers even prevented freight ships from transporting goods, as over 7% of freight trips were cancelled due to a lack of containers in Q1 2021.

The lack of supply has been coupled with a surge in demand, as consumers spend more time at home and have more exposable income to spend on electronic goods. The work from home model which was adopted by countries around the world also contributed to a rise in the need for personal applications that were previously used at work. In fact, the sales of computers increased by over 13% in 2020 compared to 2019, because of remote working. Additionally, the Purchasing Manager's Index (PMI) for electronics increased from a low of 35 in 2020 to 62 in June 2021. The sudden spike in demand impacted all electronics producers but was especially detrimental to the auto industry. In fact, it is estimated that the industry lost over $210 billion in 2021 due to semiconductor shortages.

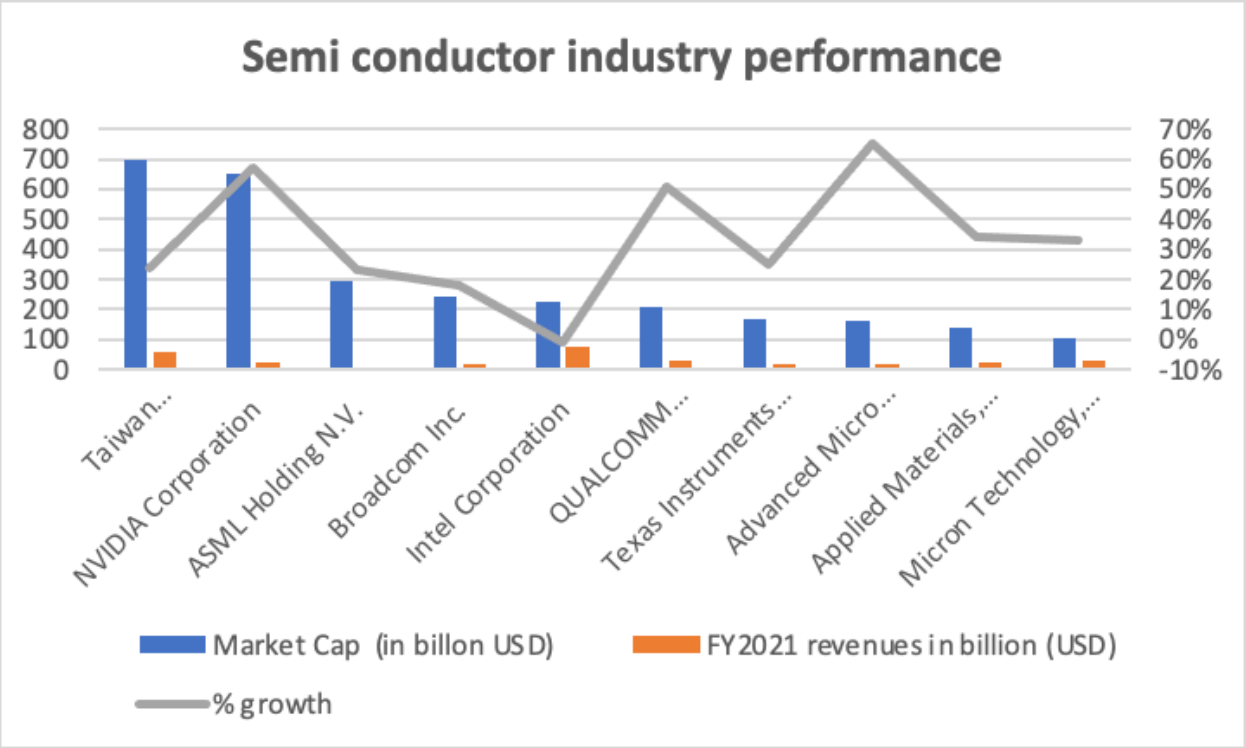
Another critical factor driving the surge in demand for electronics containing semiconductor chips were COVID-related government supports. For example, in the United States, it is estimated that 29% of the $1,200 stimulus payments were consumed on various forms of goods and services. These factors collectively caused an unexpected rise in demand for electronics.

It is important to consider that some of the semiconductor-related market disruptions can be attributed to the current structure of the supply chain system. In particular, the lean and efficient structure of supply

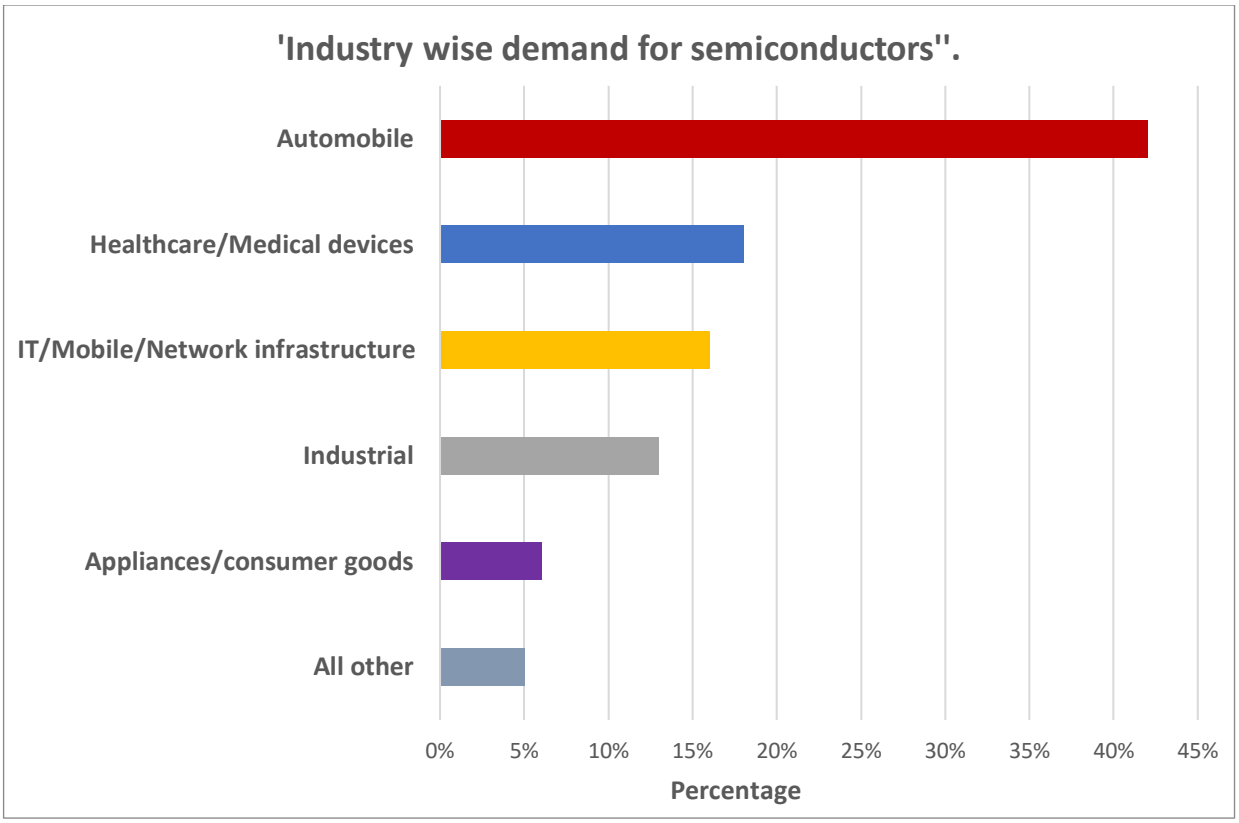
chains means there is little room for error or disruptions to the production and/or transportation of goods. Since systems operate close to full capacity during periods of steady state (without market disruptions) any variations will greatly disrupt the system. This model, referred to as the "just in time" model, was initially developed by Toyota in the 1950s and has come to dominate the operating landscape of global production facilities.

Section 2:
Current State of Semiconductor Market

The global semiconductor shortage is expected to continue through 2022 as fundamental issues in the supply chain (from mines to shop floor) are forcing companies to rethink their sourcing and manufacturing strategies. The top ten leading semiconductor manufacturers face supply chain issues that some company executives say will change the nature of the business forever. The shift is coming in the core manufacturing of semiconductors as companies move to a strategy of manufacturing in excess (just in case Vs just in time approach) instead of sticking to the demand flow. The negative sentiments towards semiconductor stocks despite a strong Q3 performance of these companies indicate the bottle-necks that the industry is facing will persist.



Source- DOW, Company statements



Source- US Dept of Commerce

For the current quarter (Q4) threat of Omicron and China's zero covid policy are immediate concerns. Micron technology, the US based semiconductor company with a market cap of USD 106 billion recently announced closure of its Xi'an factory in China due to the new outbreak. The company has warned that such closures would be increasingly difficult for the company to mitigate these disruptions. The second issue manufacturers are facing is a silicon shortage, a key component of semi-conductor chips. Silicon commodity prices shot up by 300% in October 2021 due to production cuts by China, as the country imposed a power rationing last year in the Yunnan province which is one of the major province for silicon processing.

Section 3:
Longer-term Projections

Challenges with lead times and customer inventory persist but countries like the U.S. are making investments in production which are likely to pay off in the longer term. The semiconductor supply chain requires three months on average to make one chip, including 2-3 years to build a factory or 12-21 months to increase capacity for current factories. Prior to the pandemic, these lead times were 1-2 months compared to the 3-4 months currently. The semiconductor industry is currently running at full capacity but stifled by the long lead time it takes to increase production and run new factories. This means inelastic supply is likely to persist at the present time until these lead times are overcome.

Additionally, there are efforts in place to expand production of semiconductors. For example, In the U.S. TSMC is building a fabrication facility in Arizona for wafers alongside a facility for nanochips in Japan, both of which expect output to begin in 2024. And in Ohio, Intel has announced it plans to invest at least $20 billion to create new chip factories. In East Asia Japan approved a $338 million research project in summer of 2021 to improve their capacities in the industry. However, the dangers of overproduction would reduce the

value of semiconductors and given the massive capital expenditure and long lead time raises serious questions as to whether these grand capital expenditure plans will be followed through on once the medium-term shortage is resolved.

What are the experts saying?

- The Atlantic council writes that policymakers (in the U.S. more specifically) should ensure the supply chain for semiconductors remains uncompromised from geopolitical and natural events. They predict that as production is reallocated, chips are redesigned, inventories return to pre-pandemic levels, and the excess demand that developed in 2021 falls, the shortage of semiconductors will naturally subside.
- In the second quarter of 2021, smartphone original equipment manufacturers were reporting that they were missing 20% of their required key components as a result of the supply chain crunch. By Q3 of 2021 this increased to 30%. The biggest players in this market, Apple and Samsung, are also feeling the brunt of these challenges. Samsung is reducing its five flagship new handsets to just three and Apple is expected to produce 10 million fewer units.

Section 4: Conclusions & Recommendations

Looking at the shorter term, excess inventory seems to be the only viable option for intermediary semiconductor consumers. A White House brief discussed three strategies for addressing supply chain challenges, visibility, buffers, and agility. These respectively pertain to being able to monitor the system well, having multiple suppliers or holding more inventory, and being able to pivot to new products when needed. Because a few firms control most of the production of semiconductors and these chips are in virtually every electronic or smart product, these recommendations become difficult to action in practice.

Moreover, through purposely avoiding excessive supply with their "just in time" model, semiconductor manufacturers have experienced a twenty-fold boom in their year-over-year revenues on multiple occasions since the late 1990s. This makes it unlikely for them to oversupply or look for greater diversification of the industry in either the short term or the long term. The World Semiconductor Trade Statistics organization expects over 8.8% growth in sales of semiconductors in 2022. This is on top of the 25.6% growth experienced in 2021; this means growth is at a decreasing rate across 2021 and 2022.

This leaves holding an excess of inventory the only option for semiconductor consumers to absorb these shocks. It is uncertain how this excess inventory would impact their short-term financials. Until we start seeing output from greater investment in supplying semiconductors, we can continue to expect small-to-moderate shortfalls in the supply chain over the next 1-5 years.