



NOTE FOR NATIONAL DEFENCE:

Semiconductor Supply Chains

Vincent Zottola, Bachelors Student, Department of Political Science, Concordia University, Montreal, Canada

Summary



The purpose of this report is to examine the semiconductor supply chains and identify strengths and vulnerabilities throughout the supply chain. The strategic ramifications of which is highlighted by the dependence on a small number of companies throughout the supply chain. As well as to propose solutions to this vulnerability.

CONTEXT AND BACKGROUND:

Semiconductors/microchips/microprocessors/integrated circuits are the foundation of modern technology. They are the backbone of the transportation, computers and computer equipment, telecommunications, industrial electronics, defense, and space industries. Militaries rely on semiconductors production for research and development of the latest cutting-edge technology and advanced weapons systems. Semiconductors are dual use underpinning both civilian and military technology. The dependence on only a handful of firms is increasingly causing states such as China and the USA to re-evaluate their position and attempt to alter the supply chain in their favor.

THE ISSUE:

The COVID-19 pandemic has demonstrated the vulnerability of supply chains, the semiconductor supply chain has appeared to be one of if not the most vulnerable due to the immense capital and time constraints required for building new foundries to meet demand. The leading foundries today are Taiwan Semiconductor Manufacturing Company (TSMC), Intel, and Samsung, they are respectively based in Taiwan, USA, and South Korea. Currently South Korea and Taiwan have managed to avoid armed conflict with their respective civil war adversaries North Korea and China allowing TSMC and Samsung to continue holding dominant market positions in semiconductor production. The continuity of production for the top 3 foundries/fabs are of paramount importance for the semiconductor industry and all industries dependent on semiconductors because the foundries themselves are strategic targets that if shut down will disrupt the supply chain.

Intel CEO and Semiconductor Industry Association (SIA) board member Pat Gelsinger has argued for the US government to provide tax breaks to support Intel during a 60 Minutes interview with Lesley Stahl. Essentially Gelsinger is arguing for economic nationalist policies and against dependence on Asian semiconductor foundries. Stahl then proceeded to ask Pat Gelsinger the tough question, 'How can Intel justify asking for tax breaks when they are paying out exorbitant salaries to their executives and conducting stock buybacks?'. Also worth mentioning is that Intel squandered an opportunity to produce chips for

Apple's iPhone which is partly responsible for the rise of TSMC as they seized the opportunity to work with Apple. Morningstar analyst reports have confirmed that the capital allocation score for Intel, standard, is in fact lower than the TSMC capital allocation score of exemplary demonstrating that TSMC deploys their capital more effectively to secure and grow their market share through R&D and infrastructure expenditures rather than the short-sighted shareholder mentality of Intel to buyback stock to keep their stock price up.

The issue is whether the US government would be better off having Asian companies such as TSMC and Samsung set up foundries in the USA or whether they should support Intel despite them having demonstrated poor decision making in the past resulting in their market share having declined in the past decades. The situation for the USA is a case study for the much broader question of what the trade-offs are for supporting domestic semiconductor fabs and outsourcing to the most efficient fabs.

RAMPED UP PRODUCTION IN THE USA:

Foxconn, a Taiwanese electronics manufacturer has recently bought the Lordstown Motors electric vehicle facility in Lordstown, Ohio demonstrating that Taiwanese companies seize opportunities to set up production in the USA. TSMC's plans to set up operations in Arizona and invest more money in building fabs than Intel demonstrates that TSMC is doing more to improve its prospects. Not only does setting up production facilities in the USA take market share away from Intel, but it also hedges the risk of a Chinese invasion of Taiwan shutting down TSMC facilities. With 75% of semiconductor manufacturing currently happening in Asia and manufacturing in the United States having declined from 37% to 12% over 25 years, the concentration of production in Asia presents a risk to supply chains that firms such as Samsung and TSMC will hedge by setting up operations abroad.

Intel announced recently plans to set up two new fabs in Arizona at a cost of \$20 billion with plans to upgrade an existing facility in New Mexico at a cost of \$3.5 billion. Shortly after the Intel announcement, TSMC announced plans to deploy \$100 billion in capital for R&D, upgrades and a fab in Arizona over 3 years. As stated earlier TSMC deploys their capital much more effectively than Intel, TSMC's focus on the producing the highest quality chips on the market has resulted in a product 30% more powerful and faster than Intel chips.

Although arguments can be made that it is unacceptable to risk having Taiwan be one of the most important locations in the supply chain because war can critically disrupt the industry, it is also this risk that protects Taiwan from war for two reasons; (1) China still needs to import chips to satisfy its demand so they are one of the most vulnerable countries if they attack Taiwan because the ROC government may have contingency plans to destroy and scorch the earth of their semiconductor industry before it falls under PRC control, (2) the business relationships between TSMC and American companies such as Apple, Qualcomm, AMD, NVIDIA, Amazon, among many others heavily reinforce the existing military partnership between ROC and the USA affording Taiwan a big brother that will ensure China does not act aggressively in the future. According to a congressional research report from January 2021, China outlines plans to foster peaceful relations with Taiwan in their 14th 5 year plan.

The risk of Chinese attack on Taiwan seems overblown due to Intel wanting to push their agenda and attempt to disrupt TSMC from becoming the dominant producer of high quality chips. Currently Intel is the largest semiconductor company by revenue but in terms of production TSMC is far ahead and with their smart investments in R&D and expanding production capacity it is only a matter of time before TSMC succeeds Intel as the industry sales leader

INDUSTRY STATISTICS:

USA and allies (Japan, UK, Netherlands, Germany, Taiwan, and South Korea) are global semiconductor supply chain leaders (in what positions in the supply chain are they leaders? Producers?). USA accounts for 39% total value of global semiconductor supply chain and their allies in Europe and Asia account for another 53% value of the supply chain. China only has 6% total value in the global supply chain putting them in an unfavorable and also explaining the economic nationalist policies the PRC has adopted recently in an effort to put them in a better position long term. The dependence on state support for semiconductor design and manufacturing sectors

Samsung is among the world's largest technology company by revenue with market capitalization over \$500 billion USD. Samsung has been the world's largest television manufacturer since 2006 and largest smart phone manufacturer between 2011 and 2021. Samsung semiconductor division specializes in the manufacture of semiconductor nodes, MOSFET transistors, integrated circuits, and memory chips. Samsung has a dominant market position in the dynamic random access memory market (DRAM), the European Commission brought a lawsuit against Samsung for price-fixing between 1998-2002 which ended in €145.73 million in fines paid to the EU. The Ontario provincial government had agreed to a multibillion-dollar clean energy deal which later saw reductions in the scale of the deal due to a change of provincial government. IC Insights has recorded over a 10-year period between 1999-2009 compounded annual revenue growth of 13.5% for Samsung compared to only 3.4% for Intel, Samsung briefly surpassed Intel as the largest chip company in the world in 2017. As of 2020 Samsung plans to become a leader in the extreme ultraviolet (EUV) lithography process to mass produce 5nm (nanometer) chips. The EUV equipment is supplied by ASML who supplies semiconductor foundries/fabs all over the world including Taiwan, China, South Korea, USA, etc. Despite the strong business relationship with Dutch company ASML this has not stopped the Dutch competition watchdog ACM from recently fining Samsung €40 million for price-fixing television sets.

ASML, a Dutch company specializing in equipment sales in the semiconductor supply chain has 80% or higher market share selling extreme ultra-violet photolithography machines which high quality fabs purchase to produce their chips. Nikon, a Japanese company that once had 40% market share in the photolithography market share for the semiconductor industry decades ago has now seen their market share plummet below 20% and has had to cut 1000 jobs in that business segment reflecting the dominance ASML enjoys in the photolithography market. Japan itself is lagging in innovation to their position in the semiconductor market being specialization in manufacturing equipment and producing mostly older generation semiconductors increasing the innovation gap between them and the big 3 (TSMC, Samsung, Intel).

Semiconductors are a \$500 billion industry (the market cap of TSMC alone is above that figure), production of single computer chip often requires more than 1000 steps to complete and passes through international borders 70 or more times before reaching the consumer. China lags behind other developed semiconductor producing nations, they have potential to reconfigure the supply chains in their favor if they can develop a formidable domestic industry. Although it appears the USA and allies have already taken steps to make it more difficult for China to reconfigure supply chains in their favor due to the USA beginning to welcome semiconductor factories to set up fabs within their borders.

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