Revitalizing Domestic Semiconductor Manufacturing in the United States: Prospects of The Chips Act in Reestablishing US Semiconductor Supply

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Stephen Klem

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisors

William F. Stafford, Jr., Department of Engineering and Society

Introduction

There is currently a shortage in the supply of semiconductors to the United States. The country's consumers, businesses, military, international influence, and technological advancement have all faced adverse impacts, as a result of this shortage during recent years. This shortage stems from declines in the availability of both foreign imports, and domestic production of semiconductor materials. American importing of fabrication material, used by the U.S. as a manufacturing component of semiconductors, has spiked downward in response to the U.S.-China trade war and the COVID-19 pandemic (Mohammad et al., 2022). In the decades preceding this sharp drop, the country's domestic capacity to produce semiconductors has gradually declined. This fading in production occurred due to American firms' outsourcing and offshoring of fabrication manufacturing. By exporting fabrication manufacturing plants and labor overseas, these firms were able to cut production costs and increase profits. Consequentially, the U.S.'s domestic infrastructure has been left without the means to produce basic materials comprising the semiconductor component to its electronics (Yeung, 2022).

Now that the country is beset with an inadequate supply chain for its semiconductors, it is in danger of failing to sustain itself economically and militarily (Voas et al., 2021). For example, the U.S. could become unable to provide its civilian and military constituents with essential electronics. Secondly, the country could stagnate in its progress transitioning to emerging technologies. Thirdly, the nation could fall into a state of overreliance on foreign powers for semiconductor materials crucial to its prosperity.

In response to these looming dangers, the U.S. government instated The Chips Act in August of 2022. The Chips Act allocates $52.7 billion of federal funding to revitalize domestic semiconductor manufacturing here in the United States. This funding has been allotted for the industrial areas of manufacturing plants, research and development (R & D), vertical integration, and progress in emerging technology. Of this total funding, $39 billion is going toward the construction of manufacturing plants for fabrication materials (fabs), and $11 billion is going toward R & D (Moeller et al., 2022). The remaining money is delegated to semiconductors for military defense technology, collaboration programs, and workforce education (Sargent Jr. et al., 2023).

By investing these amounts, the U.S. government aims to bring about specific outcomes. The biggest aim, embodied within the act, is to restore the supply of fabrication material (fabs) available to the U.S.. This will regain for us a resource fundamental to manufacturing all semiconductors. The act arranges to carry through with this aim by providing loans, grants, and tax credits to domestic firms in the market for constructing fabrication plants (foundries). An Advanced Manufacturing Investment Credit was created by the act. This tax credit covers 25% of the venture expenditure made by a firm in plant facilities, and physical equipment used to manufacture semiconductors (Sargent Jr. et al., 2023). The credit will reduce cost barriers to market entry for U.S. manufacturing firms in producing fabs.

Another important aim of the act is to secure the stability and integrity of America's vertical supply chain for semiconductors, which includes the manufacturing equipment used in foundries to make the fabs comprising the semiconductors. This vertical supply chain is important to semiconductors because without a stable vertical supply chain, critical military technology will be vulnerable to sabotage and tampering. Also, events such as a Chinese invasion of Taiwan pose threats to our access to our primary supplier of fabs. By having all parts of the vertical supply chain in the United States, we are protected from these kinds of risks.

A third prominent aim for the act is to elevate R & D so that American chip designers resurge to the forefront of advanced design. Emerging technologies such as Artificial Intelligence (A.I.), 6G Networks, and Internet of Things (IoT) require advanced designs, an area in which the U.S. is lacking.

While predictions have been made about the act's effects, its true outcomes lie yet to be seen. Accordingly, the question that this research project determines to answer is: how will The Chips Act prospectively impact the U.S. semiconductor industry in supply recovery, in stability and integrity of vertical supply chains, and in R & D to take advantage of emerging technologies?

In order to answer this question about government intervention in the semiconductor industry, it is useful to examine a past example of a similar intervention: The SEMATECH consortium.

Case Study

There was a precedent to The Chips Act that was initialized by the U.S. federal government back in the late 1980s. During that time, Japan had gained vast market control of the semiconductor chips known as Dynamic Random Access Memory (DRAM), and Static Random Access Memory (SRAM). Both of these chips are extremely important to electronics, as they support data memory in computer hardware. Most American semiconductor firms departed the memory chip market when a global surplus drove down the profitability of those chips in 1985. Japan was then beginning to near complete control over an essential resource (DRAM), that America labeled as a "technology driver" for semiconductors (Byron, 1993). The control that

Japan had on the global market was putting American chip firms out of business. Moreover, Japan only used manufacturing equipment from their own suppliers. With so much of the market taken up by Japan, there was little option for American equipment manufacturers to sell internationally. As American chip firms disappeared from the market, American manufacturing machinery firms were left with slim options for selling to buyers. With chip and machinery forms on the brink of shutting down, the whole American semiconductor system was on the verge of collapse.

In reaction to Japan's domination of the memory market, the U.S. government determined that the Japanese economy posed a threat to American national security (Grindley et al., 1994). The government dealt with that threat by imposing trade restrictions on Japan in 1986, and later fostering collaboration between American semiconductor firms through federal action (Byron, 1993). By structuring American business such that firms could collaborate with each other, the federal government shaped the U.S. semiconductor industry to become efficient and productive in the R & D of chips.

In order to permit collaboration between private firms, the federal government first had to create an exception to laws that prohibit collusion. This exception was defined in the National Cooperative Research Act of 1984. This law permitted the creation of any consortium purposed for R & D. A consortium is a group where firms from a single industry, which are typically competitors against each other, collaborate on research. After this act was passed, the government revamped the semiconductor industry by establishing a consortium called SEMATECH.

SEMATECH consisted of fifteen American firms that pooled a total of $100 million per year into the consortium. The government matched this amount with its own $100 million per year, and structured the consortium so that employees were a distribution of members from comprising firms. Leadership for the consortium was set up as a board with each firm as a member. The Defense Advanced Research Projects Agency (DARPA) participated in board meetings for checkups on the state of semiconductor improvement, but did not directly involve itself in the consortium's R & D activities. SEMATECH's initial objective was "of demonstrating the capability to manufacture state-of-the-art semiconductors using only U.S. equipment" (Government Accountability Office, 1992).

The consortium started out with only a horizontal collaboration between American chip firms (Carayannis et al., 2004). This structure created difficulty, as firms were reluctant to collaborate for fear of "process technology expertise" in their competitive manufacturing getting leaked to other firms. Furthermore, leading firms of the consortium were worried that minor members would freely reap the benefits from the leaders' majority of work (Grindley et al., 1994). These qualms caused SEMATECH to shift its direction of firm collaboration from horizontal to vertical.

A collaborative structure that was purely vertical also did not work for the consortium. This was because a structure that was viewed as less than competitive by chip manufacturers was viewed as competitive by equipment suppliers. This difference in perspective created conflicts along the vertical collaboration chain.

This conflict was resolved by arriving at a hybrid model of collaboration that mixed horizontal and vertical together in such a way that firms at both chip and equipment levels did not have to expose their trade secrets to other firms at their level. The method of implementing this model involved forming a second consortium of solely equipment manufacturers, called SEMI.

This hybrid model drove both the advancement of equipment for semiconductor manufacturing, and technology “roadmap” schedules for the process of innovation. (Spencer et al., 1993) The result was the shortening of the development cycle of prototypes from three years down to two.

These collaborations increased the value of the semiconductor industry by over $40 billion in the first decade of the consortium’s existence, and the semiconductor industry made $41.6 billion for the U.S. economy in 1996. “Between 1987 and 1996, the industry’s contribution to the U.S. economy grew 15.7% per year, more than three times faster than the overall economy grew” (Carayannis et al., 2004). Most notably, the regrowth facilitated by SEMATECH boosted the U.S. share of the global semiconductor market past that of Japan just five years into the consortium: in 1992, the U.S.’s share was 43.7% while Japan’s share was 43.4%.

Having surpassed Japan and regained American strength in the semiconductor industry, SEMATECH made two transformative pivots. The first pivot was to separate from government funding. The original agreement at the outset of the consortium was that the federal government would contribute the annual $100 million for the first five years of SEMATECH’s existence. By 1997, the consortium decided that federal funding was no longer necessary. The second pivot, also in 1997, was to allow international firms to join the consortium. This was a departure from the consortium’s initial objective of a U.S.-only supply chain. “While SEMATECH was founded to shore up the position of U.S. semiconductor firms against the assault of foreign firms, this rationale no longer makes sense in the current globalized industry. SEMATECH’s members are no longer the only key players in the U.S. market” (Carayannis et al., 2004).

In summary, SEMATECH made key impacts within the semiconductor industry. The first was that SEMATECH improved manufacturing technology, including processes and quality control. The second was that it established standards for manufacturing equipment across the industry. The third was that the consortium accentuated the need to create “roadmap” guides for technological development before spending begins. (Wessner, 2003)

Analysis

The study of SEMATECH serves as useful in answering the question of this research project, which is: how will The Chips Act prospectively impact the U.S. semiconductor industry in supply recovery, in stability and integrity of vertical supply chains, and in R & D to take advantage of emerging technologies? To draw useful comparisons between SEMATECH and The Chips Act, it is helpful to introduce the concepts of Techno-nationalism and Techno-globalism.

Techno-nationalism is a term in the field of Science, Technology, and Society (STS) that refers to “a set of mercantilist-like behaviors that link tech innovation and enterprise directly to the national security, economic prosperity and social stability of a nation” (Capri, 2020). Techno-globalism is an STS term that is “characterized by the support of technology development jointly conducted with international participants and the adoption across national borders” (Kim et al., 2020).

The consortium case of SEMATECH started out with Techno-nationalist pursuits, but transitioned into Techno-globalist endeavors after a decade of the consortium’s existence. There were several factors that made possible this transition. The fall of the Soviet Union, the emergence of the Internet as a means of interconnection, and the rise of east Asia as a source for offshore labor, all made it seem not only possible but inevitable for the U.S. semiconductor industry to expand globally.

At the time, it seemed as though no possible downsides to Techno-globalism existed. However, three decades of history would prove that perception to be wrong. Both the threat of Chinese encroachment upon Taiwan's foundries, and the global pandemic of 2020 have demonstrated that global supply chains are indeed susceptible to severe and prolonged disruptions.

The Chips Act benefits from two forms of hindsight. These forms are the lessons learned from SEMATECH, and the teachings of Techno-globalism's flaws over the last three decades. While SEMATECH followed a model of Techno-nationalism by originally trying to achieve a supply chain that was exclusively U.S.-based, The Chips Act allows for Techno-globalism by letting U.S. firms participate in joint research projects with international partners using the act's funds. This difference between The Chips Act and SEMATECH will help bring about lasting supply sufficiency by drawing from credible domestic and foreign suppliers instead of just constraining U.S. regrowth to within its own shores.

Furthermore, The Chips Act actually allocates $500 million for "coordinating with foreign government partners to support … semiconductor supply chain activities, including supporting the development and adoption of secure and trusted… semiconductors" (Sargent Jr. et al., 2023). By drawing from viable foreign suppliers in addition to the rebolstered domestic suppliers, the U.S. semiconductor industry can recover more supply with The Chips Act's approach than it could with SEMATECH's policies. Additionally, The Chips Act looks to secure the integrity of supply processes, which SEMATECH did not seek to achieve. This will protect the United States's supply of key military technology against sabotage and tampering. Thus, The Chips Act's differences from SEMATECH support supply recovery, and both the stabilization and integrity of the U.S.'s vertical supply chain as noted in the research question.

In terms of R & D, the amount of Chips Act money allocated for the advancement of chip design is substantially higher than that of SEMATECH, even when adjusted for 3.5 decades of inflation. This money is also used to benefit businesses of all sizes, rather than just the biggest firms in the industry. SEMATECH had membership dues of $1 million per year, and the less than 15 members that made up its consortium constituted 85% of the domestic manufacturing industry's total output (Carayannis et al., 2004). The high entry barrier to membership kept small and medium sized firms out of the consortium's activities, and unable to experience benefits from SEMATECH's R & D work. "Cypress Semiconductor CEO T.J. Rodgers complained that SEMATECH was an 'exclusive country club' of large chip makers that for too long didn't share technologies with smaller companies" (Hof, 2011). Contrastingly, The Chips Act actually devotes some of its R & D funding precisely to these small and medium sized manufacturers. The act established a Defense Department fund for bridging the "lab-to-fab gap," which "refers generally to the inability of certain entities (e.g., universities, startups, small businesses) to prototype and scale the manufacturing of their advanced semiconductor designs due to barriers such as high costs and difficulties in competing with demand for manufacturing capacity from larger firms" (Sargent Jr. et al., 2023). The distinctions of The Chips Act from SEMATECH in R & D spending will foster contributions from small and medium sized entities to take advantage of emerging technologies, as posed in the research question.

Now that the prospective impacts of The Chips Act have been explored in terms of the research question, the effects of these impacts on the lives of Americans can be examined. Among the many effects, three stand out as direct extensions of the research question. The first effect is on consumers and their access to everyday conveniences. A lack of fabs obstructs the production of semiconductors, which in turn results in a lack of electronic devices and products that rely on semiconductors. Electronic technology which relies upon semiconductors includes automobiles, refrigerators, and mobile phones among others. Technologies such as these are essential for a person to live and function in American society.

The second effect is on the U.S. military and national security. An inability to produce semiconductors results in an inability for the armed forces to develop or obtain new equipment for usage in combat against foreign enemies. Additionally, electronic military equipment that has been tampered with defects, or sabotaged with malware, will be vulnerable to malfunction and compromise our nation's ability to defend ourselves. The risks of this to everyday Americans are their fundamental security and liberties.

The third effect relates to R & D and its opportunities with regard to emerging technologies. Advanced chip technology allows us to harness greater software computing capabilities to solve problems such as automobile safety, and medical diagnostic imaging. Without both advanced chips, and the fabs that combine with them into semiconductors, the U.S. will not manage to technologically overcome these problems. Consequentially, everyday Americans will continue to be impacted by these problems.

The concepts of Techno-nationalism and Techno-globalism also apply to these American quality of life questions. Techno-nationalism and Techno-globalism came to a clash in the instance of America's TikTok ban. A bill signed by President Biden in April of 2024 has required ByteDance, the Chinese company that owns TikTok, to sell the video-streaming app within 12 months, or face a shutdown of the service in the United States. (Allyn, 2024) This ban was prompted by concerns about the private data of American citizens, and its potential misuse by foreign parties. The ban is a current example of Techno-nationalism in the U.S. because it involves the federal government of a nation removing the influence of a foreign technology from its citizens in the interest of national security. Conversely, the popularity of TikTok in the U.S. was an example of Techno-globalism because the app stores available to Americans permitted the app of a foreign tech company to be hosted on its platform. This app has been embraced by 170 million American citizens, and demonstrates how Techno-Globalism can bring happiness to the lives of people. In this case, Techno-nationalism took priority over Techno-Globalism.

Conclusion

Overall, The Chips Act will restore necessary sources to America’s fab supply. This act will serve to restabilize the vertical supply chain of U.S. semiconductors, while upholding their operational integrity. Lastly, the act will accelerate U.S. advancement from R & D, so that the U.S. can transition its infrastructure to incorporate emerging technology. Unlike SEMATECH, The Chips Act accounts for the potential of firms beyond those of topmost size, and initiates rebolstering of the semiconductor industry with a blend of both Techno-nationalism and Techno-globalism. Funds allocated by The Chips Act are key to counteracting the threats and difficulties posed to the American people by the foreseeable impacts of the U.S.’s present semiconductor shortage.

A sustainable initiative to domestic semiconductor revitalization requires an adaptive mix of both Techno-nationalism and Techno-globalism over the evolution of that initiative. Although a Techno-nationalist approach to industrial manufacturing in semiconductors may be utilized to regain a country's competitiveness, shifting to a Techno-Globalist approach is necessary for a country to thrive in the long term.

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