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Combating Chinese Legacy Chip Manufacturing: An Economic and National Security Imperative

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In recent years, China has heavily subsidized its legacy chip manufacturing capabilities.[1] Although US sanctions have restricted China's access to and ability to develop advanced AI chips, they have done nothing to undermine China's production of "legacy chips," which are semiconductors built on process nodes 28nm or larger. The prominence of these chips makes them a critical technological component in applications as diverse as medical devices, fighter jets, computers, and industrial equipment. Since 2014, state-run funds in China have invested more than $40 billion into legacy chip production to meet their goal of 70 percent chip sufficiency by 2030.[2] Chinese legacy chip dominance—made possible only through the government's extensive and unfair support—will undermine the position of Western firms and render them less competitive against distorted market dynamics.

Growing Chinese capacity and "dumping" will deprive non-Chinese chipmakers of substantial revenue, making it more difficult for these firms to maintain a comparative advantage.[3] China's profligate industrial policy has damaged global trade equity and threatens to create an asymmetrical market. The ramifications of this economic problem will be most felt in America's national security, as opposed to consumers, who will benefit from the low costs of Chinese dumping programs until a hostile monopoly is established. Investors—anticipating an impending global supply glut—are already encouraging US firms to reduce capital expenditures by canceling semiconductor fabrication plants, undermining the nation's supply chain and self-sufficiency.[4] In some cases, firms have decided to cease manufacturing particular types of chips outright due to profitability concerns and pricing pressures.

China's legacy chip manufacturing is fundamentally an economic problem with national security consequences. The state ought to interfere in the economy only when markets do not operate efficiently and in cases where the conduct of foreign adversaries creates market distortion. While this author does not support carte blanche industrial policy to advance the position of American firms, the Chinese government's efforts to promote legacy chip manufacturing warrant American interference to ameliorate the harms that China has invented. US regulators have forced American companies to grapple with the sourcing problems surrounding Chinese chips; however, the issue with chip control is largely epistemic. It is not clear which firms do and do not use Chinese chips, and even if US regulators knew, there is little political appetite to ban them as corporations would then have to pass higher costs onto consumers and exacerbate headline inflation. Traditional policy tools for achieving economic objectives—such as sanctions—are therefore largely ineffectual in this circumstance. More innovative solutions are required.

If China's government fully commits to the policy, there is little US domestic or foreign policy can do to prevent it from developing chip independence. While American firms can be incentivized to outcompete their Chinese counterparts, America cannot usurp Chinese political directives to source chips locally. This is true not only because China lacks the political restraints of Western countries in financially incentivizing production, but also because in the past—under lighter sanctions regimes—China's Semiconductor Manufacturing International Corporation (SMIC) acquired multiple Advanced Semiconductor Materials Lithography (ASML) DUV (deep ultraviolet light) machines.[5] Consequently, any policy that seeks to mitigate the perverse impact of Chinese dominance of the legacy chip market must favor the competitiveness of American and allied firms in "third markets" such as Indonesia, Vietnam, and Brazil and de-risk America's supply chain from market distortions and the overreliance that Chinese policies have affected. China's growing global share of legacy chip manufacturing threatens to re-create the global chip landscape in a way that will displace US commercial and security interests. Consequently, the United States must undertake both defensive and offensive measures to ensure a coordinated response to Chinese disruption.

Considering the above, the United States ought to enact a policy mutually predicated on innovative technological reform. Policymakers must understand that from a lithography perspective, the United States controls all essential technologies when it comes to the design and manufacturing of integrated circuits. This is a critically overlooked dimension in contemporary policy debates because electronic design automation (EDA) software closes the gap between high-level chip design in software and the lithography system itself. Good design simulates a proposed circuit before manufacturing, plans large integrated circuits (IC) by "bundling" small subcomponents together, and verifies the design is connected correctly and will deliver the required performance. Although often overlooked, the photolithography process, as well as the steps required before it, is a process as complex as coming up with the design of the chip itself.

To curtail Chinese legacy chip dominance, the United States should weaponize its monopoly on electronic design automation software. In effectively forcing Chinese firms to purchase computing services from a US-based cloud, American EDA software firms can audit and monitor Chinese innovations while reserving the ability to deny them service during armed conflict. Restricting allied firms' ability to supply Chinese manufacturers with ancillary components can likewise slow the pace of Chinese legacy chip ascendance.

No profit-maximizing manufacturer would print a chip "as designed" because it would suffer certain distortions and degradations throughout the printing process; therefore, EDA software is imperative to mitigate imperfections throughout the photolithography process. In much the same way that software within a home-use printer automatically screens for paper material (i.e., regular printer paper vs. glossy photo paper) and automatically adjusts the mixture of solvent, resins, and additives to display properly, EDA software learns design kinks and responds dynamically. In the absence of such software, the yield of usable chips would be much lower, making these products less commercially viable. Contemporary public policy discourse focuses only on chips as a commodified product, without recognizing the software ecosystem that is imperative in their design and use.

Today, there exist only two major suppliers of EDA software for semiconductor manufacturing: Synopsys and Cadence Design Systems.[6] This reality presents a great opportunity for the United States to assert dominance in the legacy chips space. In hosting all EDA in a US-based cloud—for instance, a data center located in Las Vegas or another secure location—America can force China to purchase computing power needed for simulation and verification for each chip they design. This policy would mandate Chinese reliance on US cloud services to run electromagnetic simulations and validate chip design. Under this proposal, China would only be able to use the latest EDA software if such software is hosted in the United States, allowing American firms to (a) cut off access at will, rendering their technology useless; and (b) gain insight into homegrown Chinese designs built on this platform. Since such software would be hosted on a US-based cloud, Chinese users would not download the software, which would greatly mitigate the risk of foreign hacking or intellectual property theft. While the United States cannot control chips outright considering Chinese production, it can control where they are integrated. A machine without instructions is inoperable, and the United States can make China's semiconductors obsolete.

Moreover, the emergence of machine learning has introduced substantial design innovation in older lithography technologies. For instance, Synopsys has used new technologies to discern the optimal route for wires that link chip circuits, which can factor in all the environmental variables to simulate the patterns a photo mask design would project throughout the lithography process.[7] While the 22nm process is not cutting edge, it is legacy only in the sense of its architecture. Advancements in hardware design and software illustrate the dynamism of this facet in the semiconductor supply chain. In extraordinary circumstances, the United States could also curtail the usage of such software in the event of a total trade war. Weaponizing this proprietary software could compel China to divulge all source code for auditing purposes since hardware cannot work without a software element.

The United States must also utilize its allied partnerships to restrict critical replacement components from enabling injurious competition from the Chinese. Software notwithstanding, China currently has the capability to produce 14nm nodes because SMIC acquired multiple ASML DUV machines under less onerous Department of Commerce restrictions; however, SMIC heavily relies on chip-making equipment imported from the Netherlands and Japan.[8] While the United States cannot alter the fact of possession, it can take limited action against the realization of these tools' potential by restricting China's ability to import replacement parts to service these machines, such as the lenses they require to operate. Only the German firm Zeiss can produce such lenses that ArF lasers require to focus—illustrating the importance of adopting a regulatory outlook that encompasses all verticals within the supply chain.[9] The utility of controlling critical components is further amplified by the fact that American and European firms have limited efficacy in enforcing copyright laws against Chinese entities. For instance, while different ICs are manufactured within the 22nm instruction set, not all run on a common instruction set such as ARM. However, even if such designs run on a copyrighted instruction set, the United States has no power to enforce domestic copyright law in a Chinese jurisdiction. China's capability to reverse engineer and replicate Western-designed chips further underscores the importance of controlling the EDA landscape and ancillary components in the chip manufacturing process. This reality presents a tremendous yet overlooked opportunity for the United States to reassert control over China's legacy chip market.

Furthermore, in the policy discourse surrounding semiconductor manufacturing, too much emphasis has been placed on the chips themselves. It is important to note that there are some areas in which the United States is not commercially competitive with China, such as in the NAND flash memory space. China's Yangtze Memory Technologies has become a world leader in flash storage and can now manufacture a 232-layer 3D NAND on par with the most sophisticated American and Korean firms, such as Western Digital and Samsung, at a lower cost. However, these shortcomings do not preclude America from asserting dominance over the semiconductor market as a whole by leveraging its dynamic random-access memory (DRAM) dominance, bolstering nearshore NAND manufacturing, and developing critical mineral processing capabilities. Both DRAM and NAND are essential components for any computationally integrated technology.

Although China no longer relies on the United States or allied countries for NAND manufacturing, the United States and its allies maintain DRAM superiority. The United States must leverage capabilities to maintain Chinese reliance on its DRAM prowess and sustain its competitive edge while considering restricting exports of this technology for Chinese defense applications under extraordinary circumstances. Simultaneously, efforts to nearshore NAND technologies in South America can delay the pace of Chinese legacy chip ascendance. Synergy between greater competitiveness, capital solvency, and de-risked supply chains would enable US firms to compete against Chinese counterparts in critical "third markets" and to reduce supply chain vulnerabilities that undermine national security. As subsidy-induced Chinese market distortions weigh less on the commercial landscape, the integrity of American defense capabilities will simultaneously improve, especially if bureaucratic agencies move to further insulate critical US infrastructure against potential cyber espionage.

Considering China's growing global share of legacy chip manufacturing as a predominantly economic problem with substantial national security consequences, the American foreign policy establishment ought to pursue a new technological outlook that exploits all facets of the integrated chip supply chain—including EDA software and allied replacement component suppliers. Were the United States to engage in armed conflict with China, reduced industrial capacity could quickly impede the military's ability to manufacture weapons and other matériel. Critical supply chain disruptions during the COVID-19 pandemic illustrated how the absence of a single chip can hold hostage entire manufacturing processes. If China gains absolute legacy chip manufacturing dominance, these concerns would be further amplified as Chinese firms become able to outright deny American access to critical chips, impose harsh costs through price hikes, or impose diplomatic compromises and quid pro quo.[10] Furthermore, decreased Chinese reliance on Taiwanese semiconductors reduces their economic incentive to pursue a diplomatic solution in the Taiwan Strait—making armed conflict in the region more likely. This weakened posture endangers global norms and the balance of power in Asia—undermining American economic and military hegemony in the region.

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Endnotes

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