Foundational Chips: China's Ambitions and Implications for the U.S. Manufacturing Base

Toys and tractors; planes and pacemakers; coffeemakers and construction equipment; microwaves and medical devices—inside almost every device with an on-off switch is a foundational semiconductor.[1] These chips don't require the most advanced manufacturing processes, but modern economies can't work without them. A new car can have a thousand such chips inside, managing fuel injection, controlling windshield wipers, operating the automatic braking system, or modulating power supply from the battery. It was shortages of foundational chips during the pandemic that disrupted supply chains and cost U.S. manufacturers hundreds billions of dollars in losses. And it isn't only the civilian economy that requires foundational chips. Military systems, have dozens, hundreds, or thousands of foundational chips inside.

Today most foundational chips are manufactured either in the U.S. or in close partner countries like Japan, Europe, Taiwan, Korea, or Singapore. Yet China is pouring billions of dollars into several dozen major new chipmaking facilities, known as fabs. Though China's efforts to reach cutting edge capabilities have attracted the most attention, most of China's new chipmaking facilities will produce foundational chips. China's subsidy campaign for semiconductors is rivalled only by its effort to build solar panels and electric cars. The implications for America's manufacturing base are even greater, because every industry relies on foundational chips.

Today, China has open access to the tools and components needed to manufacture foundational chips. It also has sufficient domestic expertise needed to manufacture them. In some segments of the foundational chip market, Western firms may retain technological differentiation for years to come, but for more commoditized foundational chips, China's growing production volumes coupled with state subsidies and Beijing's mandates to "buy Chinese" make Chinese firms highly likely to win market share, both in China and—unless policy action is taken—abroad.

This creates four risks for U.S. security and the U.S. manufacturing base:

1. Chinese firms receiving vast state funding or benefiting from state ownership don't operate according to market principles. If they produce uneconomic volumes and sell below market prices, they will put pressure on Western semiconductor firms' profitability. Most problematic, they will deter new chipmaking investments in the West. This is already impacting the calculus of Western chipmakers and their investors.[2]

2. If U.S. or Western manufacturers—of autos, airplanes, medical devices, tractors, or any other important sector—become more reliant on Chinese-made chips, Beijing gains new opportunities for economic coercion. Beijing regularly uses export restrictions as a foreign policy tool. It is already restricting exports of critical chipmaking materials like gallium and germanium. If Western firms become dependent on Chinese chips, Beijing could threaten to cut them off. The pandemic-era shortages illustrated that losing access even to a small volume of foundational chips can cause many billions of dollars in losses.

[1] Foundational chips are also referred to as "lagging edge" or as "legacy chips" and are generally defined as chips produced at 22nm or older manufacturing processes.
[2] "Activist investor Elliot discloses $2.5 bln stake in Texas Instruments," *Reuters,* May 28, 2024, https://www.reuters.com/business/activist-investor-elliott-takes-25-bln-stake-texas-instruments-cnbc-reports-2024-05-28/.

Becoming more reliant on Chinese foundational chips presents severe economic security risks.

3. China's growing role in foundational chip production will likely serve as a beachhead for increased reliance on Chinese electronics in Western manufacturing supply chains, raising data security concerns. One cyber security researcher recently found that 90% of the data collected by a Chinese electric vehicle—including geolocation data, camera data, voice data, and other types of data—was transmitted to servers in China.[3] Greater reliance on Chinese chips will likely lead to greater reliance on Chinese electronics systems more generally—and thus intensified data security issues.

4. China's race toward self-sufficiency in foundational chips degrades the "mutually assured economic destruction" that many analysts hope will keep peace in the Taiwan Strait. Today, China is the world's largest *importer* of semiconductors, largely from the U.S., allies, and partners. However, on current trends, China will be substantially more self-sufficient in producing foundational chips in just a handful of years. Without policy action, U.S. manufacturers will become meaningfully more dependent on Chinese chips. This would be a highly destabilizing dynamic.

Why Foundational Chips Matter

Foundational chips (also called "legacy," "lagging edge," and "mature node" semiconductors) are often defined as chips made with a 22nm manufacturing process or above. Some of the terms used to described foundational chips imply that they use older technology, yet that is only partially true. In spheres like power management and sensors, there is still substantial R&D underway to develop better capabilities. For some of these applications, moving to smaller node sizes provides no performance improvement. In other words, not all foundational chips are "low-tech" or commodity products.

There are many thousands of types of foundational chips. A new car can have dozens or even hundreds of types of foundational chips, many of which are not easily interchangeable, because the electronics or software has been designed around a specific type of chip. Changing the type of chip used often requires time-consuming and costly redesigns, which is why manufacturers are highly reliant on a steady supply of exactly the right type of foundational chips.

The pandemic-era foundational chip shortages demonstrated just how dependent the manufacturing base is on foundational semiconductors. Car companies reported losing several hundred billion dollars in sales globally due to cars that couldn't be produced because chips—and often only a single chip—were unavailable.[4]

And it wasn't only cars that faced delays. Farmers struggled to buy new tractors, because—like cars—tractors rely on many hundreds of semiconductors. Medical device manufacturers also

[3] Jordan Robertson, "Probing a $69,000 Electric Vehicle for Clues on Spying," *Bloomberg,* May 15, 2024, https://www.bloomberg.com/news/newsletters/2024-05-15/probing-a-69-000-chinese-electric-vehicle-for-clues-on-spying?sref=ojq9DljU

[4] See, eg, https://www.alixpartners.com/newsroom/press-release-shortages-related-to-semiconductors-to-cost-the-auto-industry-210-billion-in-revenues-this-year-says-new-alixpartners-forecast/

reported widespread shortages of chips during the 2021-2023 period.[5] As a result, manufacturers produced fewer robotic surgery devices and hearing aids.[6] These are just several of many industries that faced foundational chip-related disruptions during the pandemic.

Production of Foundational Chips Today

Today most of the world's foundational chips are manufactured in the U.S., Japan, Europe, Taiwan, Singapore, or Korea. China plays a role, but not an outsized one. For most major foundational chip manufacturing nodes, Chinese firms produce 25% or less of world production. Because of this, China is still a major importer of foundational chips from Western suppliers, both for goods that are assembled in China and exported, as well as for domestic Chinese consumption.

Thanks to the CHIPS Act, companies like Texas Instruments, Microchip, GlobalFoundries, and Polar Semiconductor will open new manufacturing capacity for foundational chips in the United States. Allies and partners in Europe, Japan, Singapore, and other countries are also supporting the construction of new facilities.

However, China's state-backed investment in foundational nodes far exceeds any other country. It may even exceed the rest of the world's government support combined, though the opacity of Chinese subsidies makes it complex to provide specific numbers. In addition to China's national-level integrated circuit investment funds—the most recent of which was just finalized, to provide $47.5 billion—China also has a series of provincial and local government funds that support the chip industry.[7] Chinese state-owned companies often invest in chipmakers. Ostensibly "private" investment firms active in the industry have government institutions and state-owned firms as limited partners. Chinese state subsidies are occasionally direct, but often indirect and opaque—and thus difficult to measure.[8]

China's subsidy programs have often struggled to produce profitable companies or successful technologies. They have been riddled with fraud. Directors of subsidy funds have been arrested on corruption charges. China's chip plants still rely heavily on equipment, software, intellectual property, and materials imported from the West. Many of the new facilities China is bringing online may never be profitable.

However, China's rate of building new fabs threatens the profitability of Western firms. Of the world's fabs under construction, fully a third (measured by wafer capacity) are in China. This implies a substantial increase in China's market share. Western firms will often schedule fab construction and tool installation based on market factors, so that they don't bring capacity online before it is needed. Even with Chips Act funds (which will generally only support around 10% of a typical project cost) Western firms will be careful to time their construction plans based on market factors.

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[5] Hannah Kucher, "Smith & Nephew warns chip shortages still affecting medical industry," *Financial Times* Feb 21, 2023, https://www.ft.com/content/54a4f238-b4ea-40d4-b6d6-ec0a60b27485

[6] See, eg, https://www.hearingloss.org/wp-content/uploads/hl-2023-1-lewitt.pdf

[7] "China sets up third fund with $47.5 billion to boost semiconductor sector," *Reuters,* May 27, 2024, https://www.reuters.com/technology/china-sets-up-475-bln-state-fund-boost-semiconductor-industry-2024-05-27/

[8] See, eg, OECD, "Measuring Distortions in International Markets: The Semiconductor Value Chain," https://www.oecd-ilibrary.org/trade/measuring-distortions-in-international-markets_8fe4491d-en

By contrast, many of the biggest fab projects in China are not only funded by the government—they are owned by the government. China's National Integrated Circuit Investment Fund owns stakes in several major chipmakers. The Wuhan government owns a quarter of chipmaker XMC. The Chinese state—via either the central government, local governments, or state-owned firms—has an ownership stake in almost every segment of the Chinese chip industry. Because of this, Chinese firms will operate in a non-economic manner, expanding capacity regardless of market dynamics. One of SMIC's co-CEOs recently publicly stated that he expected "excess production capacity"—and promptly announced an 18% increase in his firm's capital expenditure budget.[9]

Western firms—which will carefully assess whether the market for a certain category of chips is over or undersupplied—are much less likely to invest in new capacity than Chinese firms whose leaders are rewarded not for making profit but for building fabs. As Chinese provinces and localities now face pressure to demonstrate their prowess in advanced manufacturing, they have a political incentive to bring online chipmaking capacity even if it is obviously unprofitable to do so.

In addition, the Chinese government is now openly pressing manufacturers like automakers to use Chinese chips in their products—and, by implication, to use fewer U.S. and Western made chips.[10] Several Western chip design firms have publicly discussed their plans to source more chips from Chinese providers.[11] It's true that Chinese-made chips are initially more likely to be purchased by Chinese firms. However, electronics supply chains are complex and intermixed that Chinese made chips cannot somehow only stay in China. They will proliferate in Western supply chains, raising the security risks described above.

Policy Responses Thus Far

To address China's subsidies for foundational chip manufacturing and the economic security risks, the U.S. has pursued six main strategies:

a) The Chips Act provides incentives for foundational chip manufacturing in the U.S., via the investment tax credit as well as grants to Microchip, GlobalFoundries, Polar Semiconductor and potentially other firms in the future.
b) The Trump Administration imposed tariffs on imports of semiconductors from China, and the Biden Administration increased the tariff rate.
c) The Biden Administration announced an investigation into connected car components, which will have implications for use of Chinese-made chips in the auto sector.[12]
d) The Biden Administration has conducted dialogues with partners in Europe, Japan, and others about Chinese non-market practices in foundational chips and economic security

[9] Qianer Lu, "China's biggest chipmaker warns geopolitics is stoking global glut," *Financial Times,* Nov 10, 2023 https://www.ft.com/content/30e61fb3-ac48-4ece-94fb-af0c3763d99c
[10] Cheng Ting-Fang, Lauly Li, and Shunsuke Tabeta, "China asks carmakers to use up to 25% local chips by 2025," *Financial Times,* May 22, 2024, https://www.ft.com/content/98a50ed8-1265-4f31-986f-6c874bc815f0
[11] See the NXP Q1 2024 earnings call: https://www.fool.com/earnings/call-transcripts/2024/04/30/nxp-semiconductors-nxpi-q1-2024-earnings-call-tran/
[12] https://www.whitehouse.gov/briefing-room/statements-releases/2024/02/29/fact-sheet-biden-harris-administration-takes-action-to-address-risks-of-autos-from-china-and-other-countries-of-concern/

concerns, though allied governments are either internally divided or are waiting for the United States to act.

e) Outbound investment restrictions will impact U.S. (and by implication, allied) investments in Chinese chip firms.
f) Section 5949 of the 2023 NDAA will limit federal procurement of Chinese-origin semiconductors.

Thus far, existing measures have been insufficient to change the trend line of increasing U.S. reliance on Chinese-made foundational chips. Federal procurement restrictions are significant, but most chips are used in consumer applications. Tariffs are a significant signal to companies about future risks of relying on Chinese-made chips, but most of the Chinese chips in the U.S. market are not directly imported (in which case they face tariffs) but rather imported as components of a system (and thus face no chip-specific tariffs). It is possible to impose component-based tariffs, but companies express concerns about the logistics of implementing such a system. Allies are also unlikely to impose tariffs. Meanwhile, incentives provided by the Chips Act have dramatically boosted investment in the U.S. but remain smaller than China's vast subsidies. To prevent over-reliance by the U.S. manufacturing base on Chinese-made chips, more action is needed.

Except for firms that manufacture foundational chips, other firms in the semiconductor industry are skeptical of additional restrictions on Chinese chips. Firms that produce advanced chips or chipmaking equipment have no incentive to see additional restrictions, while users of foundational chips appreciate that Chinese competition will force Western foundational chipmakers to cut prices. Companies that support additional restrictions are afraid to say so publicly, fearing that Beijing will retaliate by limiting their access to the Chinese market. Manufacturing firms that use foundational chips also have a valid concern that poorly designed regulation could cause new shortages and supply chain disruptions. Phasing in any new restrictions over multiple years would address this.

Allies and partners also worry about China's foundational chip subsidies, though they are waiting to see whether and how the United States will act. European trade and competition regulators are focused on foundational chips but are constrained by the German government's opposition to taking tougher measures. Some European officials and political leaders see this issue only through the lens of market distortion rather than recognizing the economic security dimensions, too.

In Japan and Taiwan—both of which produce large numbers of foundational chips and have suffered from Chinese economic coercion—the economic security implications are widely understood. However, Japan is more skeptical of tariff-based approaches and instead seeks policies that limit reliance on unreliable chip suppliers. Unreliable suppliers could be defined as companies operating in jurisdictions without the rule of law or with incompatible data and cybersecurity standards.

Policy Options

The U.S. has several policy options for addressing China's foundational chip subsidies:

1. **Restricting the use of chips from unreliable suppliers in critical systems.** Chinese chipmakers are unreliable suppliers because they are subject to the whim of a government unconstrained by the rule of law, regularly imposes opaque export restrictions, and sees the United States as an adversary. Given this, Chinese-made chips could be restricted from use in critical systems like communications infrastructure, datacenter infrastructure, energy, transportation, healthcare, and government services.

   Imposing such restrictions effectively may require that Congress provide new authorities to the executive branch. It will also require that manufacturers understand where they are sourcing their chips from. Such a policy would likely align with the approach of key allies in Asia and at least some allies in Europe. Any such restriction would need to be phased over multiple years to give Western manufacturers time to adjust.

2. **Increasing the supply of foundational chips manufactured in the U.S. by cutting tax and regulatory burdens, offering new tax credits, or providing new subsidies, or by encourage allies and partners to do the same.** The current investment tax credit expires in 2026 and will need to be extended if existing investment levels are to continue. However, even a new Chips Act will constitute only a fraction of the resources that China is spending.

3. **Imposing export controls or sanctions on Chinese chipmakers, such as SMIC.** Today, China has only a handful of chipmakers such as SMIC that are deeply internationally integrated. Export controls and/or sanctions could be used to limit the ability of Western manufacturers to procure chips from one or more Chinese companies. However, any such move would have to be phased in to avoid impacting Western supply chains, given that leading Chinese firms like SMIC already produce chips that are used by Western manufacturers.

4. **Imposing export controls on the sale of chipmaking tools, chemicals, materials, software, and intellectual property to Chinese chipmakers.** Today most foundational chips produced in China are made with imported chipmaking tools, using some imported chemicals and materials. If such a move were imposed immediately, it would risk disruptions in chip supply that could impact Western supply chains. If it were imposed over time, it would give China scope to replace foreign chipmaking tool and material suppliers with domestic ones—something that is easier to do for foundational chips than it is for advanced chips. Allies would be unlikely to support such a move, so it would require forcing them to comply via extraterritorial sanctions or export controls.

5. **Imposing tariffs not only on Chinese chips directly imported to the U.S., but also on Chinese chips that are components of other systems.** For example, if an imported TV has a Chinese-made chip inside, tariffs could be imposed on the TV at a rate commensurate with the number and cost of Chinese-made chips inside. This approach would provide some incentive not to buy Chinese-made chips, though probably only if tariff rates were imposed at a very high level. In addition, component tariffs would increase administrative complexity. In such an approach, policymakers would need to

clarify the meaning of a "Chinese chip"—ie, what about chips made by Western firms in facilities located in China? What about chips manufactured in the West but tested and/or packaged in China? Policymakers may decide to treat legacy Western-owned facilities in China differently from a newly built facility funded by the Chinese government.

Conclusion

Allowing the U.S. manufacturing base to become more reliant on Chinese-made semiconductors presents a severe economic security risk. The pandemic illustrated that losing access to even a small quantity of foundational chips creates disruptions across the manufacturing base. We need a reliable supply of foundational chips produced in the U.S. and in friendly countries, while limiting dependence on made-in-China chips, particularly in critical sectors.

Current trends—above all, China's vast subsidy campaign and non-market practices—imply that without policy changes, the U.S. manufacturing base will become more reliant on Chinese-made chips. Allies and partners broadly agree with this assessment. However, many industry players—including some semiconductor supply chain players as well as consumers of foundational chips—are driven by parochial interests to oppose action.

Any action in this sphere must be careful not to threaten the operations of the many U.S. manufacturers that currently use Chinese chips. Phasing in changes over time will give U.S. industry space to adjust. In addition, policymakers must consider whether restrictions should differentiate between chips made or assembled in Western owned and operated manufacturing facilities in China, versus chips made by Chinese manufacturers. Providing the executive branch with expanded authorities to restrict use of chips from unreliable suppliers—and mandating the development of a strategy to do so—would facilitate action that addresses economic security concerns without disrupting manufacturing supply chains.