China's Domestic Battle for Semiconductor Self-Sufficiency

Yipei Lu
Master's student, International Relations Department, Tsinghua University

Abstract
China's semiconductor industry, despite accounting for half of the global market, faces substantial challenges in achieving technological relevance and self-sufficiency amidst Western sanctions. The industry is mischaracterized by alleged overcapacity; rather, the true hurdle is its focus on low-level, non-innovative competition within the mature market segment, which represents only 30% of the industry. This internal competition undermines progress as 70% of the market, involving higher technology and specialized processes, remains largely untapped. This transition is crucial as global market dynamics shift toward upstream technologies, where innovations in AI and computing demand advanced process technologies below 7nm. Strategically, the path to self-reliance hinges on differentiation and innovation to foster advanced technologies and reduce reliance on foreign equipment. Government-supported initiatives, such as the National Integrated Circuit Industry Investment Fund (Big Fund), play a quintessential role in this transition by targeting high-tech developments and fostering a domestically-sustained supply chain. Huawei and SMIC's advancements in process technologies, despite constraints on acquiring state-of-the-art foreign technology, exemplify the potential for domestic firms to secure a competitive edge in the global semiconductor industry. Nonetheless, national competitiveness and technological advancement cannot rely on the efforts of two firms whatsoever, and the future for China's semiconductor sector is largely dependent on whether domestic firms can break through the cycle of internal involution and move toward the upstream.

Keywords: Huawei, SMIC, semiconductors, upstream/advanced technology, big fund, overcapacity

Overcapacity in China's semiconductor industry is a *pseudo-proposition*. Skeptics argue that despite China accounting for half of the global semiconductor market, its dominance is skewed toward lower-value segments of the supply chain, such as packaging, while its contributions to higher-value, technology-intensive areas like equipment and design remain minimal. This argument carries some validity—within China's current semiconductor value chain, packaging accounts for one-third of the market share, foundry one-sixth, materials one-eighth, and equipment a mere two percent—figures that seem disproportionate to China's overall share of the global semiconductor market. However, the true challenge facing China's semiconductor sector lies not only in overcapacity and Western export controls but also in the deeper issue of superficial, low-level "involution" 「内卷」(a Chinese slang for burnout or diminishing returns).[1]

The global semiconductor landscape is undergoing sizable transformations, with the main battlefield shifting towards upstream 「上游」technology.[2] Whether the Chinese semiconductor industry can focus on the future and keep pace with industry trends will determine its ability to stay technologically relevant in this era. Again, overcapacity in China's semiconductor industry, as promoted by the West, is a narrative trap. From both national security and market demand perspectives, China's semiconductor industry still possesses substantial opportunities, but the path forward is thorny.

The global semiconductor market can generally be segmented into three distinct categories: *one-third high-tech, one-third specialized, and one-third mature*. Taking foundries as an example:

- High-tech, or cutting-edge processes, refer to those below 7nm, which are used to manufacture advanced products such as AI chips, GPUs, and CPUs.
- Above 7nm, the market further subdivides into specialized and mature segments. The specialized market includes personalized products such as RF, SiGe, SOI, MEMS, high voltage, certain analog, high-end automotive, and embedded storage.
- The mature market is characterized by the production of relatively standard products using established, non-advanced processes, where most Chinese companies are entangled in intense internal competition.

Due to highly similar products and lack of technological differentiation, competition in downstream manufacturing is primarily on price.[3] This strife turns the market, which only represents 30% of the entire industry, into an internal bloodbath. However, the mid-water and deep-water (upstream) areas,[4] which account for 70% of the market, remain largely untapped by domestic firms. While it may appear that the Chinese semiconductor market is highly saturated, in

[1] Slotta, Dan. 2023. "Semiconductors in China: Statistics & Facts." *Statista.;* Khan, Saif, Alexander Mann, and Diana Peterson. 2021. *The Semiconductor Supply Chain: Assessing National Competitiveness.* Center for Security and Emerging Technology, Georgetown University. https://doi.org/10.51593/20190016.

[2] SIA (Semiconductor Industry Association). 2020. *SIA Factbook.* San Jose, CA: Semiconductor Industry Association. https://www.semiconductors.org/wp-content/uploads/2020/04/2020-SIA-FactbookFINAL_reduced-size.pdf.

[3] Shilov, Anton. 2024a. "Chip Price War Unfolds as Chinese Foundries Cut Tape-Out Prices – Taiwan and South

[4] By "mid-water" and "deep-water" areas, I refer to the upstream and specialty segments of the semiconductor value chain, which are characterized by higher levels of technological complexity and innovation. These include advanced material development, high-end equipment manufacturing, cutting-edge chip design, and specialized processes tailored for niche markets such as RF, SiGe, SOI, and MEMS. These segments contrast with the "shallow-water" areas of the industry, which represent mature, commoditized markets with limited technological differentiation and intense price-based competition.

reality, the involution has only turned this 30% of the market into its own red ocean. The other 70% remains blue ocean.

Concurrently, the industry is undergoing dramatic changes, with growing disparities among the three market segments.[5] Taking wafer foundries as an example again, which is currently valued at $110 billion, the market was initially evenly split among the three segments.[6] However, emerging technologies like artificial intelligence are breaking the equilibrium of this tripartite structure—the market share of high-tech chips and upstream design is swiftly increasing while the proportion of mature processes is rapidly declining.[7]

Previously characterized by high profits yet limited in scale, the upstream market now boasts both extremely high profits and a substantial scale. Over time, the high-tech (upstream) segment has increasingly become the *"gold" with a growing share, while the specialized market remains the "silver" with steady growth*. The mature (downstream) market will progressively rust with lesser value and on a smaller scale. Comparing the trend with the current Chinese semiconductor market, this is a dangerous sign.

The shifts within the wafer foundry market are merely a microcosm of the transformations sweeping across the entire semiconductor industry. *Every segment is rapidly pivoting towards the upstream.* For instance, in the design domain, Nvidia's revenue reached $60.9 billion in 2023, with projections for 2024 expecting revenues to surpass $100 billion.[8] Previously, high-tech processes were synonymous with "high technological barriers and small market size," the jewel in the crown. Now, high-tech processes not only maintain high technological barriers but also command a vast market size, essentially becoming the crown itself. Despite tremendous hurdles posed by U.S. sanctions, *upstream is the battleground for the future.*[9] Chinese firms down the road will find it imperative to ascend from downstream manufacturing.

Over the years, China's semiconductor industry will continue to occupy an outstanding share of the mature sector.[10] However, by then, this market will have become severely marginalized. The primary competitive arena will shift away from the mature market, which Chinese companies now dominate. Whether ensuring self-reliance in high-tech products or catering to the large Chinese and global market, China cannot afford to miss out on the main battlefield or become mere spectators.[11]

Chinese Firms Must Embrace the Grueling Process Amid Government Long-haul

On this watch, the road to self-sufficiency extends beyond overcoming bottlenecks from Western repression.[12] China will need to figure out the play at home. The attainment of

[5] Varas, Antonio, Raj Varadarajan, Jimmy Goodrich, and Falan Yinug. 2021. *Strengthening the Global Semiconductor Supply Chain in an Uncertain Era.* Boston Consulting Group and Semiconductor Industry Association.
[6] Göke, Sebastian, Kate Staight, and Rolf Vrijen. 2021. "Scaling AI in the Sector That Enables It: Lessons for Semiconductor-Device Makers." *McKinsey & Company.*
[7] Lam, Terri. 2022. "Anchor of Global Semiconductor: Asia Pacific Takes Off." *Deloitte.*
[8] Nvidia. 2024. *Nvidia Announces Financial Results for Fourth Quarter and Fiscal 2024.*
[9] Pan, Che. 2023. "Tech War: China's Semiconductor Industry Weathers Tough Year Amid Tighter US Sanctions." *South China Morning Post.*
[10] Triolo, Paul. 2024. "A New Era for the Chinese Semiconductor Industry: Beijing Responds to Export Controls." *American Affairs Journal* 8, no. 1.
[11] Farrell, Henry, and Abraham L. Newman. 2019. "Weaponized Interdependence: How Global Economic Networks Shape State Coercion." *International Security* 44, no. 1: 42–79.
[12] 清华大学五道口金融学院国际金融与经济研究中心 (Tsinghua University PBC School of Finance International Finance and Economics Research Center). 2017–2024. 中美贸易争端事件跟踪. [Tracking the Sino-US Trade Dispute Events.] http://cifer.pbcsf.tsinghua.edu.cn/yjzti/gjmyi/zmmyzdsjgz.htm.

semiconductor autarky in China hinges on three fundamentals: *upward mobility, differentiated competition, and collaborative specialization*. In simpler terms, state-supported national giants must focus on future-oriented, cutting-edge, precision technologies; local government-backed entities should tap into specialized processes; and market-driven new forces should concentrate on current markets and seek to boost revenue.

Semiconductors remain the sole major industry in China yet to achieve complete domestic substitution.[13] Broadly speaking, chips are the lifeblood of Chinese manufacturing and the engines driving industrial upgrades. With the premise of reducing supply chain risks and bolstering supply chain security, achieving a high degree of self-reliance across the entire semiconductor industry is indispensable for China.[14]

Meanwhile, it is undeniable that the industry is entering a phase of elimination, where the intensity and difficulty of competition are only increasing. Government support has become more selective and targeted compared to the previous uniform approach.[15] As China's semiconductor sector progresses, an increasing number of outstanding companies are starting to develop platforms that not only enhance the overall industry level-standard but also hasten the process of natural selection.

Nevertheless, government support must adhere to long-termism. Following initial developments, the Chinese semiconductor industry is at a juncture where it will either progress or regress. The hope is that the government will continue its robust support. Historically, the slow development of domestic semiconductors was partly due to a lack of sustained government backing. Considering the semiconductor industry's unique characteristics—its long-cycle nature, rapid evolution, and global competitiveness—it is clear that support for this industry is not a short-term commitment. It is a highway without off-ramps that demands prolonged and persistent efforts. Once the government commits to this support, it cannot turn back. Therefore, the government's readiness for long-term support is a decisive factor in overcoming industry bottlenecks.

Fifteen years ago, there was little capital willing to flow into semiconductors;[16] today, however, investment continues to flourish. The establishment of the third phase of the Big Fund recently completed a financing round of $47 billion (344 billion RMB) half-a-year ago, the largest to date.[17] Officially designated as China Integrated Circuit Industry Investment Fund, the initiative aims to address the bottlenecks in China's semiconductor industry and to nurture domestic enterprises and technologies. This round of financing was jointly funded by the Ministry of Finance, local governments, state-owned enterprises, and for the first time, state-owned banks. The fund now comprises 19 shareholders, with the Chinese Ministry of Finance as the largest, contributing 60 billion RMB and holding a 17.4% stake. The China Development Bank Capital (CDB Capital) is the second-largest shareholder with a 10.5% stake. Additionally, state-owned giants such as China National Tobacco Corporation and China Telecom have also participated in this funding round.

The inception of the Big Fund forms a crucial component of China's overarching strategy to diminish dependency on foreign technologies, particularly amidst escalating technological

[13] Wübbeke, Jost, Max J. Meissner, Mirjam Zenglein, Jaqueline Ives, and Björn Conrad. 2016. *Made in China 2025.* Merics Paper on China, no. 2.
[14] O'Keefe, Kate, and Brian Spegele. 2019. "How a Big U.S. Chip Maker Gave China the 'Keys to the Kingdom.'" *Wall Street Journal.*
[15] Lee, Lingling. 2024. "China's Big Fund 3.0: Xi's Boldest Gamble Yet for Chip Supremacy." *The Diplomat.*
[16] SIA (Semiconductor Industry Association). 2020. *SIA Factbook.* San Jose, CA: Semiconductor Industry Association. https://www.semiconductors.org/wp-content/uploads/2020/04/2020-SIA-FactbookFINAL_reduced-size.pdf.
[17] Q., Min & H., Wei. China Piles $47.5 Billion Into 'Big Fund III' to Boost Chip Development. *Caixin Global*, 2024.

constraints imposed by the west. These restrictions have curtailed China's access to critical advanced technologies essential for semiconductor manufacturing. Launched in 2014 and 2019, the first two phases of the fund amassed 138.7 billion RMB and 204 billion RMB, respectively, predominantly directed towards the development of necessary equipment and materials for production. By the close of 2018, the first phase of the Big Fund had effectively completed its investments, totaling around 104.7 billion RMB. The allocation of funds across different sectors was as follows: 20.59 billion RMB went to IC design, which represented 19.7% of the total funds; integrated circuit manufacturing received 50.014 billion RMB, or 47.8% of the investments; the packaging and testing sector was granted approximately 11.552 billion RMB, constituting 11.0%; around 1.415 billion RMB was allocated to semiconductor materials, making up 1.4% of the investments; semiconductor equipment got 1.298 billion RMB, about 1.2% of the total; and roughly 19.858 billion RMB was invested in the development of the industrial ecosystem, accounting for 19.0% of the overall investments. It is notable that the portions of investment directed towards semiconductor equipment and materials—the upstream segments of the supply chain—were relatively modest, each comprising about 1.4% and 1.2% of the overall investment, respectively.[18]

During the corresponding timeframe, statistics involving 42 prominent domestic semiconductor equipment producers revealed that in 2018, the sales figures for domestically produced semiconductor equipment reached roughly 10.9 billion RMB, achieving a self-sufficiency rate close to 15%. It is important to note that this statistic includes equipment used for LEDs, displays, and photovoltaics, making the genuine self-sufficiency rate for integrated circuit equipment in the domestic market hover only between 4% to 6%. The semiconductor materials sector exhibits similarly low self-sufficiency, with domestic production primarily concentrated on process nodes of 28nm and above, resulting in an estimated self-sufficiency rate of approximately 10% to 20%. In contrast, the self-sufficiency rate for sub-14nm products is effectively negligible.[19]

The Big Fund's second phase was particularly tailored towards bolstering the equipment and materials sectors, delivering robust, sustained support to firms already operational in areas such as etching machines, thin-film equipment, testing equipment, and cleaning apparatuses. This initiative is designed to reinforce the capabilities and scope of leading companies. The fund is actively working to bridge gaps by ramping up investments in essential equipment and critical components, including photolithography machines and chemical mechanical polishing equipment, thereby securing the integrity of the supply chain.[20]

Now, the foremost objective of the Big Fund's third phase is to foster the development of advanced computing and storage chips for AI applications and to establish a domestically-sustained semiconductor supply chain. This phase specifically looks to construct the entire supply chain—*a strategic, pragmatic pivot towards prioritizing advanced semiconductor technologies*. This notion marks a departure from the first two funds, which were mainly focused developing the equipment and materials sectors. It's a good sign. Considering the challenges faced by Chinese firms in global capital markets, the decision to substantially inject capital into the semiconductor sector is of particular importance. Moreover, the extensive financial backing from the fund showcases the Chinese government's dedication to strengthening self-sufficiency in the domestic

[18] Shihua, Ouyang, and Tang Hongyi. 2019. "Layout of the First Phase of the Big Fund." *East Money Information Co., Ltd.* (上海东方财富证券咨询有限公司).

[19] Shihua, Ouyang, and Tang Hongyi. 2019. "Layout of the First Phase of the Big Fund." *East Money Information Co., Ltd.* (上海东方财富证券咨询有限公司).

[20] Luffy, Lucy. 2019. "China's 'Big Fund' Phase II Aims at IC Self-Sufficiency." *EE Times.*

semiconductor industry, as it recognizes the seminal role of the sector in national security and economic competitiveness.

The Hope for Upstream Chip Development in China

Huawei has once again made sizable strides in chipmaking, as it continues to push forward with advanced process technologies despite facing U.S. sanctions. Earlier, in collaboration with SMIC and chip equipment developer SiCarrier, Huawei applied for a patent for Self-Aligned Quadruple Patterning (SAQP) lithography technology, which most expect will be used for 5nm manufacturing processes.[21] However, the latest patents reveal that Huawei has now set its sights on the 3nm.[22]

Traditionally, the metal pitch for 7nm process technology ranges from 36nm to 38nm, which narrows down to 30nm to 32nm for the 5nm node. For the 3nm node, the metal pitch is projected to shrink further to between 21nm and 24nm, with the critical dimension for mass production at approximately 12nm. This dimension is challenging to achieve even with low numerical aperture (NA) Extreme Ultraviolet (EUV) tools, unless dual EUV lithography is employed. Nevertheless, Huawei and SMIC plan to use Deep Ultraviolet (DUV) lithography to implement SAQP.

Owing to U.S.-led export restrictions, Chinese companies struggle to obtain advanced lithography equipment from ASML, such as the Twinscan NXT:2100i and NXE:3400C/3600D/3800E, among others.[23] SAQP technology enhances transistor density by repeatedly etching lines on the silicon wafer, which in turn reduces power consumption and boosts performance. This technique is similar to Intel's attempts between 2019 and 2021 at the 10nm node, which were designed to reduce reliance on EUVs. It is worth mentioning that Intel's similar attempts with SAQP on its 10nm process chips during this period failed on yield turnaround. Nonetheless, SAQP remains vital for Huawei and SMIC, as Chinese firms fundamentally lack access to the most cutting-edge lithography machines.

Faced with extensive Western sanctions, Chinese semiconductor giants must shift their focus from mere cost containment to broader strategic objectives, while emerging entities need to look beyond IPOs. The new competitive landscape requires a full-scale commitment to innovation in order to carve out an independent technological trajectory. In tackling the upstream challenges—similar to those that impeded Intel's efforts—Chinese companies must adopt a "break the cauldrons and sink the boats" 「破釜沉舟」 approach, which refers to an all-or-nothing commitment, which draws from a historical Chinese idiom that signifies a decisive and irreversible effort to achieve success. Huawei and SMIC have set benchmarks; it is now time for the remainder competitive domestic players to rise to the occasion and join the force.

[21] ———. 2024c. "SMIC and Huawei Could Use Quadruple Patterning for China-Made 5nm Chips: Report." *Tom's Hardware.*

[22] ———. 2024b. "Huawei Patent Reveals 3nm-Class Process Technology Plans: China Continues to Move Forward Despite US Sanctions." *Tom's Hardware.*

[23] ASML. 2024. *Statement regarding partial revocation export license.*

Bibliography

ASML. 2024. *Statement Regarding Partial Revocation Export License.*

Farrell, Henry, and Abraham L. Newman. 2019. "Weaponized Interdependence: How Global Economic Networks Shape State Coercion." *International Security* 44, no. 1: 42–79.

Göke, Sebastian, Kate Staight, and Rolf Vrijen. 2021. "Scaling AI in the Sector That Enables It: Lessons for Semiconductor-Device Makers." *McKinsey & Company.*

Khan, Saif, Alexander Mann, and Diana Peterson. 2021. *The Semiconductor Supply Chain: Assessing National Competitiveness.* Center for Security and Emerging Technology, Georgetown University. https://doi.org/10.51593/20190016.

Korean Foundries Face New Price Pressures: Report." *Tom's Hardware.*

Lam, Terri. 2022. "Anchor of Global Semiconductor: Asia Pacific Takes Off." *Deloitte.*
Lee, Lingling. 2024. "China's Big Fund 3.0: Xi's Boldest Gamble Yet for Chip Supremacy." *The Diplomat.*

Luffy, Lucy. 2019. "China's 'Big Fund' Phase II Aims at IC Self-Sufficiency." *EE Times.*
Min, Qing, and Hao Wei. 2024. "China Piles $47.5 Billion into 'Big Fund III' to Boost Chip Development." *Caixin Global.*

Nvidia. 2024. *Nvidia Announces Financial Results for Fourth Quarter and Fiscal 2024.*
O'Keefe, Kate, and Brian Spegele. 2019. "How a Big U.S. Chip Maker Gave China the 'Keys to the Kingdom.'" *Wall Street Journal.*

Pan, Che. 2023. "Tech War: China's Semiconductor Industry Weathers Tough Year Amid Tighter US Sanctions." *South China Morning Post.*

Shihua, Ouyang, and Tang Hongyi. 2019. "Layout of the First Phase of the Big Fund." *East Money Information Co., Ltd.* (上海东方财富证券咨询有限公司).

Shilov, Anton. 2024a. "Chip Price War Unfolds as Chinese Foundries Cut Tape-Out Prices – Taiwan and South

SIA (Semiconductor Industry Association). 2020. *SIA Factbook.* San Jose, CA: Semiconductor Industry Association. https://www.semiconductors.org/wp-content/uploads/2020/04/2020-SIA-FactbookFINAL_reduced-size.pdf.

Slotta, Dan. 2023. "Semiconductors in China: Statistics & Facts." *Statista.*

———. 2021. *Taking Stock of China's Semiconductor Industry.* Semiconductor Industry Association.

———. 2024b. “Huawei Patent Reveals 3nm-Class Process Technology Plans: China Continues to Move Forward Despite US Sanctions.” *Tom’s Hardware.*

———. 2024c. “SMIC and Huawei Could Use Quadruple Patterning for China-Made 5nm Chips: Report.” *Tom’s Hardware.*

Triolo, Paul. 2024. “A New Era for the Chinese Semiconductor Industry: Beijing Responds to Export Controls.” *American Affairs Journal* 8, no. 1.

Varas, Antonio, Raj Varadarajan, Jimmy Goodrich, and Falan Yinug. 2021. *Strengthening the Global Semiconductor Supply Chain in an Uncertain Era.* Boston Consulting Group and Semiconductor Industry Association.

Wübbeke, Jost, Max J. Meissner, Mirjam Zenglein, Jaqueline Ives, and Björn Conrad. 2016. *Made in China 2025.* Merics Paper on China, no. 2.

清华大学五道口金融学院国际金融与经济研究中心 (Tsinghua University PBC School of Finance International Finance and Economics Research Center). 2017–2024. 中美贸易争端事件跟踪. [Tracking the Sino-US Trade Dispute Events.] http://cifer.pbcsf.tsinghua.edu.cn/yjzti/gjmyi/zmmyzdsjgz.htm.