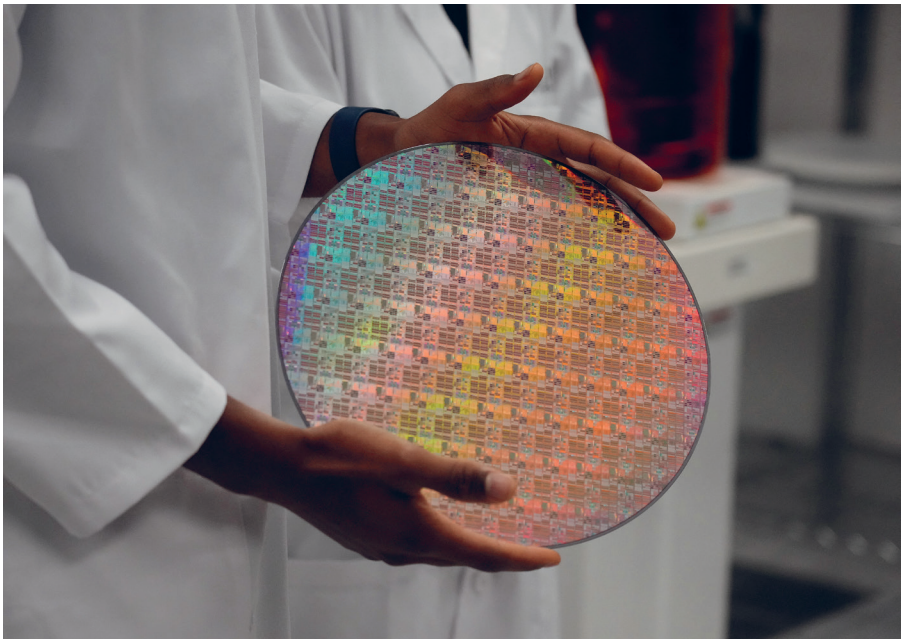
Chips Supply Chain: Bifurcation and Localization

Semiconductors are at the heart of the global economy and governments' security thinking. The semiconductor supply chain is geared toward gradual bifurcation, the slow separation into a US and China controlled supply chain. Another trend is regional localization, with East Asia, Southeast Asia, and Europe remaining crucial.

By Quentin Merle



A silicon wafer shown at a site where Applied Materials plans to build a research facility, in Sunnyvale California in May 2023. *Jim Wilson / Reuters*

Globalization in the semiconductor industry is "dead," as governments increasingly consider technology through the lens of national security, stated Morris Chang, the founder of Taiwan Semiconductor Manufacturing Company (TSMC). The prime example is the US-China semiconductor rivalry, as both countries aim to reduce their mutual dependencies through security strategies of decoupling or, more recently, de-risking (see CSS Analysis n°337). According to the 2023 World Trade Report, security-induced tensions between the two countries significantly slowed the trade of technologies such as semiconductors in 2022.

On the May 2024 cover of *The Economist*, the world map has been teared apart, illustrating a fragile economic order close to collapse. In an increasingly volatile global economy, the question arises of how the semiconductor supply chain will evolve as governments' strategies push it apart.

The first trend is the gradual bifurcation of the semiconductor supply chain, which is characterized by an ambiguous and porous grouping process of divergence rather than a clear and quick separation of trade relations, as often desired by governments' security strategies. As the US and China attempt to exert control over their semiconductor supply chains, they remain strongly interlinked by mutual economic interdependencies, resulting in gradual bifurcation.

The second trend is expanding localization dynamics in the global semiconductor supply chain. Localization refers to developing national or regional production to reduce dependency on foreign sources, driven by geopolitical tensions and the need for greater supply chain resilience. This is particularly apparent in regional clusters in East Asia, Southeast Asia, and Europe. This analysis will examine both these trends in the semiconductor supply chain in more detail.

The Interlinked Supply Chain

Not only are they fundamental to modern life, semiconductors are also the most complex technology that has ever been pro-

duced at scale in human history. The highly complex semiconductor supply chain is cyclical and interconnected, thus difficult to untangle. Throughout the last several decades, the semiconductor supply chain has fragmented, simply put, into three main production steps, focusing on performance and power efficiency innovations while reducing cost and chip size. First, engineers design the chip and meticulously plan how to structure its electronic circuits. Second, the chip designs are manufactured onto silicon wafers in cleanrooms through processes like photolithography, where the tiny circuits are built layer by layer. Finally, the fabricated chips are cut from the wafers, packaged in protective casings, and rigorously tested to ensure functionality before being integrated into electronic devices (see CSS Study).

Over the past few decades, the semiconductor industry has operated as an interlinked supply chain, with all players collaborating to ensure economic efficiency. US firms initially dominated in all production steps, but over time the second and third steps shifted to Asia. China became a bigger player in the 2000s, especially as an important consumer market. Meanwhile, foundries like TSMC and Samsung, which also produce their own chips, specialized in manufacturing globally designed chips. By the late 2000s, the semiconductor supply chain was characterized by sourcing chip materials globally and manufacturing in East Asia, enabling rapid progress and efficiency. Starting in the 2010s, the semiconductor supply chain began to slowly unravel, as governments' security considerations emerged as increasingly important factors alongside economic efficiency.

US and China: Push for Control

The US and Chinese governments' national security logics are pushing the semiconductor supply chain apart. The US and China pursue their respective semiconductor ecosystems, which they intend to control. The US effort to revamp its semiconductor industry began in 2019 when the Trump administration rallied its partners to cut off the supply of advanced chips to Huawei. The Biden administration refined its industrial policy – often called "small yard, high fence" – by aiming to protect critical technologies such as Artificial Intelligence (AI) while maintaining wider economic interaction. The 2022 "Inflation Reduction Act" and the "CHIPS and Science Act" were key components underpinning this new industrial policy approach by allocating substantial government subsidies to – among others – incentivize domestic semiconductor manufacturing and research. Additionally, the US sought to build a semiconductor ecosystem with "like-minded" allies that is both resilient to outside shocks and could be wielded strategically within the global economy.

Under Xi Jinping's economic security agenda, China has similarly pushed for an indigenous, self-reliant semiconductor ecosystem with self-reliance as central to Xi's agenda. Since the early 2000s, the Chinese government has advanced its domestic semiconductor industry. This industrial policy push was accelerated with the 2014 "China Integrated Circuit Industry Investment Fund (Big Fund)" and the 2015 "Made in China 2025" roadmap. The massive government subsidies of the Big Fund were intended to create Chinese semiconductor champions and increase state control over the industry. The "Made in China 2025" roadmap set the government's goal to achieve 40 per cent self-sufficiency in chips by 2020 and 70 per cent by 2025. Almost a decade later, the Chinese self-sufficiency rate is around 20 per cent. Beijing has since begun to implement a more sophisticated industrial policy, as demonstrated by the anticorruption campaign against Big Fund executives, increased investment in research and development (R&D), and efforts to make public-private partnerships more efficient. Symbolizing China's renewed efforts, in 2024, the Big Fund raised a record amount of 47 billion USD.

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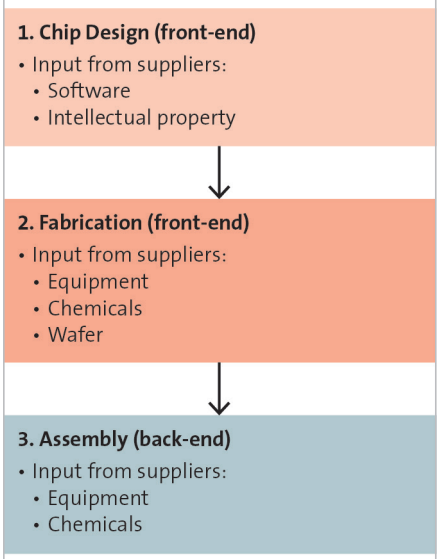
A Crucial Chinese Market

Unlike the governments' security logics suggest, the global semiconductor supply chain will not likely fragment into entirely separate ecosystems soon. Instead, we observe slow bifurcation as the market forces are too strong; US companies are still largely dependent on the Chinese market, and Chinese firms can only stay competitive with access to the most advanced chip technology and input materials from abroad.

The leading semiconductor companies in the US and Europe still majorly rely on the Chinese market and only reluctantly follow their governments' aim of reducing China's role in the supply chain. In 2023, China was the world's largest semiconductor consumer market, making up more than 50 per cent of the world market. Despite the US government's restrictive actions, US companies' sales to China rose 36 per cent in the 2021 fiscal year and another 4 per cent in 2022. In 2023, most US semiconductor firms had China as at least their top three market.

US semiconductor companies also challenge their government's approach. After the second round of US export controls in October 2023, Nvidia, Intel, and Qualcomm reportedly pushed back against the US government, warning of unintended consequences, such as US firms losing their competitive advantage. They have also tried to adapt their chips to the Chinese market, circumventing US export controls. For instance, Nvidia, a leader in AI chip design, responded to the 2022 export controls limiting sales of advanced AI chips to China by producing special chips (A800 and H800) just below the restriction limit. When the US further tightened export controls in October 2023, Nvidia adjusted its AI chips for the Chinese market again. In 2023, Nvidia still generated over a fifth of its revenue from China, and fears that further export controls could severely disadvantage them competitively. In 2023, Qualcomm and Intel, the two most

Simplified Chip Production Steps



Source: Stiftung Neue Verantwortung

dependent US firms most dependent on the Chinese market, made two-thirds and a quarter of their respective sales from China.

The Chinese market remains substantial not only for US firms but for Europeans. Europe's most important semiconductor company, ASML, made 7.251 billion EUR in net sales to China, more than triple that of its 2021 sales and a quarter of its 2023 overall sales. While some of that increase can be explained by supply chain disruptions before 2023 and new export controls leading to bulk buying by Chinese companies, losing the Chinese market would considerably concern ASML.

China's Global Dependencies

Because Chinese semiconductor firms still heavily rely on foreign companies at all production stages, China's quest for self-sufficiency under Xi Jinping's security agenda will not be achieved soon.

While China's share of global production capacity along the semiconductor supply chain increased from 10 per cent in 2016 to around 20 per cent in 2024, even half of that was still produced by foreign-invested companies in China, such as South Korea's Samsung and SK Hynix or Taiwan's TSMC. In the first production step, chip design, no Chinese company ranks in the top ten, and only two are part of the 15 biggest companies by revenue in the world. And even those two companies are majorly reliant on US input design tools, like Electronic Design Automation or core Intellectual Property (IP). In the second production step, chip manufacturing, only two Chinese companies are among the world's ten biggest producers. While the Chinese manufacturers like SMIC and Huahong Group are growing quickly, they lag behind their global competitors and rely heavily on foreign semiconductor manufacturing equipment such as ASML's extreme ultraviolet machines. On the materials input level, China depends on foreign countries, mainly on its East Asian neighbors. For example, the Chinese semiconductor supply chain would not work without Japanese photoresists. China only produces 2 per cent of its photoresist material for advanced chip production and imports the majority from Japanese suppliers.

The only sector where China is achieving a leading global share of production is in "legacy chips," older generations of semiconductors. The threshold for legacy chips is not universally defined and changes over time but is currently considered 28nm or larger process nodes. Legacy chips are primarily used in cost-sensitive applications such as mobile processors, automotive systems, and networking equipment, offering a balance of performance and power efficiency. China now accounts for a third of global legacy chips production, which doubled over the past ten years and is estimated to further grow in the coming years. Moreover, China is best positioned in the third step of chip production, the packaging, assembly, and testing step, which has historically seen the lowest profit margins in the industry and is very labor-intensive.

While China is making progress, it is dependent on foreign suppliers in all production steps, which are not easily replaced in the coming years. Facing the risk of the middle-income trap and stagnating productivity gains, the Chinese leadership is particularly concerned about missing out on advancements in generative AI (GenAI), artificial intelligence capable of generating new content from a prompt by learning from a large database of examples. The most promising development in recent years, GenAI is expected to drive the next wave of productivity. However, being cut off from advanced chips and only slowly becoming self-reliant, China faces significant challenges in realizing these productivity gains.

Localization Across the Globe

The semiconductor supply chain is only slowly bifurcating into two distinct supply chains, as their mutual economic dependence is strong. Equally, the trend is moving toward localization across different world regions, which makes supply chains more resilient but also costlier. Most notable examples are Southeast Asia, the importance of East Asia with the resurgence of Japan and the crucial position of Taiwan, and Europe.

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The Association of Southeast Asian Nations (ASEAN) region is an increasingly essential neutral hub for the semiconductor landscape. A skilled workforce, a favorable business environment, and strong government support make the region a lucrative investment spot for companies worldwide, including China. ASEAN countries are the second largest exporter of semiconductors, with around 25 per cent of global exports. While Singapore and Malaysia have a long history in the semiconductor supply chain, Vietnam has only recently increased its footprint in the semiconductor landscape. US companies like Intel, whose first foreign production facility was in Malaysia in the 1970s, are doubling down on the region with investments of seven billion USD. European firms are also heavily investing in the region; Infineon, a leader in automotive chipmaking, will spend over five billion USD in the coming five years. So too are Chinese firms expanding in Southeast Asia, sometimes even partnering with US firms like in the case of Tong-Fu Microelectronics and US-based chip designer AMD.

With Japan's renaissance and Taiwan's ever-increasing importance, East Asia symbolizes supply chain localization. Japan, with a long history of leading-edge semiconductor production—in the 1980s, six of the top ten companies were Japanese—is having a revival in the semiconductor supply chain. In 2021, the Japanese government initiated a strategy to focus on semiconductors as part of economic security to triple domestic chip sales by 2030 by having a Japanese venture, Rapidus, and JASM (a TSMC joint venture), producing advanced chips from 2027 onwards.

Switzerland: A Closer Look

Less than one percent of total Swiss trade, Switzerland's chip industry is relatively small and diversified, if clustered around East Asia. Switzerland's main strength lies in R&D. Thus, the emphasis is on productive EU relations, which provide access to research collaborations. For now, the Federal Council is opposing industrial policy for chips, but in mid-June 2024, the National Assembly approved a motion mandating the Federal Council to develop a "Swiss Chip Strategy" due to its growing strategic importance.

One noteworthy development is the 2020 move by the RISC-V foundation from the US to neutral Switzerland due to geopolitical tensions. With its open-source hardware architecture, RISC-V is an attractive industry-standard alternative and, therefore, increasingly used by Chinese companies like Huawei. In early 2024, the Biden administration is said to scrutinize the Chinese use of RISC-V, so it is worth closely observing this development and preparing for different scenarios.

Meanwhile, Taiwan's semiconductor supply chain is a strong leader in all production steps. In 2023, Taiwan had close to half of the global semiconductor foundry capacity, was the leader in the third production step of assembly, testing and packaging, and was responsible for over 20 per cent of the integrated circuit (IC) design, second only to the US. While TSMC, Taiwan's most important player, is expanding globally, its latest technology will stay in Taiwan, so Taiwan will remain a key player for the foreseeable future.

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Despite its long history in the semiconductor industry, Europe has been stagnant in recent times. The 2023 creation of the "EU Chips Act" marks a strategic shift to strengthen Europe's presence in the global semiconductor industry. The EU Chips Act aims to support startups, enhance member states' industrial policies, and coordinate efforts to double Europe's global chip production share to 20 per cent by 2030. While its ambitious approach and goal have been heavily criticized, Europe nevertheless seeks to reestablish itself as a dominant player. As such, bifurcation between the US and China is not the singular trend of the global semiconductor industry; there is also a notable move towards localization in regions such as ASEAN, East Asia, and Europe.

Future Developments

Semiconductors are central to national security thinking and the global economy. The semiconductor supply chain is evolving in two key ways: a gradual bifurcation between the US and China, limited by their mutual economic interdependencies, and an increasing trend of localization efforts worldwide. Policymakers and companies must consider the developments ahead.

For one, ASML estimates that in 2030, 10 per cent of the planned global supply will be a result of governments' security requirements, not economic needs. A potential misalignment of economic needs and security requirements will challenge the highly interlinked semiconductor supply chain, for which efficient resource allocation is vital.

The fast advancement of GenAI is only increasing the world's dependence on Taiwan as the global hub for AI chips. TSMC produces the vast majority of AI chips for companies like Nvidia and has indispensable technology leadership. The future development of AI is not only highly intertwined with the resilience of the semiconductor supply chain but also makes Taiwan ever more important.

Finally, the semiconductor industry is set to double from its 2021 size to a one trillion USD industry in 2030. Witnessing this growing market, the executives of semiconductor companies do not rank geopolitical risks as their highest concern, but rather the lack of talent needed for global expansions. Private companies and governments have different concerns, a fact so simple that it is too often overlooked.

Further Readings

John Lee, "**Southeast Asia and the Chip Wars: Navigating a Decoupling World**," *Yusof Ishak Institute*, 29.04.2024.

Paul Triolo, "**A New Era for the Chinese Semiconductor Industry: Beijing Responds to Export Controls**," *American Affairs* 8:1 (2024).

Rava Goujon / Jan Peter Kleinhans / Laura Gormley, "**Thin Ice: US Pathways to Regulating China-Sourced Legacy Chips**," *Rhodium Group*, 13.06.2024.

For more on Artificial Intelligence and Security Politics, see CSS core theme page.

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