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Huawei is Quietly Dominating China's Semiconductor Supply Chain

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Summary

Huawei is emerging as the leader of China's national team in semiconductors, dominating chip manufacturing and seeking to integrate the country's entire supply chain. Its ambitions stem from both its placement on the U.S. Entity List and strong government support at the national and local level. Internationally, Huawei is coy about these ambitions, hiding its supply chain involvement and often operating under a different company's name. Meanwhile, Huawei's experience is also encouraging other Chinese technology companies to support China's quest for chip self-sufficiency, developing new hardware and software for that purpose. The clandestine nature of Huawei's involvement—it is not known who serves what role in semiconductor production—makes it more difficult for Western companies and governments to assess China's progress in technology, vet potential partners and customers, and conduct risk assessments.

This brief is part of a special series organized jointly by the University of California Institute on Global Conflict and Cooperation (IGCC) and the Mercator Institute for China Studies (MERICS). This analysis was originally presented at the Conference on the Chinese National Innovation and Techno-Industrial Ecosystems in Berlin, September 5–6, 2023.

Key Findings

- Huawei is emerging as the leader of a national team in semiconductors. It dominates the supply chain, particularly in chip manufacturing.
- Huawei is transforming from a telecommunications national champion to a company that oversees the complete value chain for semiconductors. This comes as a result of both Chinese government support and U.S. government restrictions.
- Huawei is quietly expanding its presence across the supply chain, including in lithography, a key chokepoint for China's semiconductor progress. As "team lead," Huawei often performs the role of integrator, becoming more and more like its competitor Samsung, a large South Korean conglomerate.
- The new Huawei Mate 60 Pro phone, released in September 2023, exemplifies Huawei's success in supply chain integration. The phone's use of advanced chips—which U.S. restrictions had sought to prevent—demonstrates how Huawei has cooperated with other Chinese companies and invested in the semiconductor supply chain.
- For instruction set architecture, the software for executing chip production which represents another key supply chain chokepoint with high levels of market concentration, China's government has chosen an open-source architecture that was pioneered in the United States: RISC-V. Top artificial intelligence and software companies like Alibaba and Tencent have been charged with furthering progress in using RISC-V.
- For international partners and rivals, these developments make strategies to simultaneously de-risk in some areas while continuing cooperation and trade in others—what the United States calls the "small yard, high fence" approach—difficult. With Huawei quietly present across the Chinese semiconductor supply chain and its role serving national, military, and strategic goals, it is becoming ever more difficult to ensure that products delivered to China are not diverted to the military or other restricted end uses.
- For policymakers, analyzing China's progress in semiconductors is becoming more difficult, because U.S. technology restrictions on firms included on its Entity List create an incentive for companies to hide their achievements.

Introduction

China has reinvigorated its effort to become "self-sufficient in science and technology" (科技自立自强), motivated by the shock of the U.S.-China trade and technology war and President Xi Jinping's emphasis on security.[1] China's new-style whole-of-nation effort is characterized by building national teams under the guidance of large private or state-owned companies. This should enable, officials hope, the formation of a "complete industrial chain" within China.[2]

Belonging to a national team confers domestic advantages but international disadvantages, such as being put on the U.S. Department of Commerce's Entity List, which places restrictions on the export or transfer of specific strategic American technologies. Due to these international disadvantages, Beijing has become more circumspect in making these "national team" assignments, and Chinese companies avoid making their designation as part of a national team public. This makes it more difficult for stakeholders outside of China to gauge China's technological progress and formulate strategies that weigh the benefits and risks of collaboration with or supplying Chinese companies.

Semiconductors are Key to China's Drive for Self-Reliance

While Chinese state support for technology development can be seen across many sectors, semiconductors are key to China's self-sufficiency goals because they are fundamental to both national security and critical high-tech growth industries identified by the Chinese Communist Party (CCP).[3] The Made in China 2025 plan set a goal that by 2020, 40 percent of chips used in China would be domestically produced. That goal was updated in 2019 to 58 percent.[4] In 2020, only 16 percent of chips used in China were domestically manufactured.

Semiconductors are a foundational technology for future-oriented industries like quantum computing and what officials call the "new three industries" of electric vehicles, lithium-ion batteries, and solar cells. Semiconductors are also necessary for the integration of artificial intelligence (AI) into existing industries. All of these applications are mentioned in the 2024 Government Work Report.[5] Moreover, semiconductors are key to China's military modernization.

At the same time, the United States has also identified semiconductors as a key technology for national security, and the European Union has classified advanced semiconductors as one of the four critical technologies which require a risk assessment.[6,7] This makes China's national team assignments in semiconductors more high profile than in other technologies. Since semiconductors are also inherently dual use—having both civilian and military applications—they have been the focus of recent geopolitical competition between China and the United States. Recent advances in AI have further put semiconductors—the enablers of these advances—on the radar globally.

Government funding for semiconductor production is provided through a variety of channels. The most prominent is the central government's China Integrated Circuit Investment Fund (国家集成电路产业投资基金), also known as the "Big Fund." Established in 2014, the fund is now on its third tranche of investments. It co-exists alongside a variety of local and provincial semiconductor funding programs. Firms in the semiconductor industry have also received a multitude of tax breaks, including corporate income tax exemptions and an R&D tax credit.[8,9]

The Rise of Huawei: From Telecoms Champion to Supply Chain Integrator

China's efforts to become self-sufficient in science and technology have spanned decades. During the 2000s, China aimed to "catch-up" with the West in fundamental technologies, efforts in which Huawei played a leading role. Huawei benefited from import substitution to build up a homegrown information and communication technology (ICT) industry, transforming it into a national champion in this space.

Huawei was founded in 1987 in the Special Economic Zone of Shenzhen, where its founder, Ren Zhengfei, held strong ties to local government that enabled Huawei to get government contracts.[10]

The telecommunications market was dominated by foreign producers, so Huawei worked from the outset to decrease dependence on foreign core technologies and develop self-reliant research and development (R&D). Huawei "rearticulated the state's nationalistic development discourse with the company's growth mission," wrote Yun Wen in the 2020 book The *Huawei Model*, showing how the Ren tied the revival of the Chinese nation from its past humiliation to the company's technological development. Ren, who had served in the military for 20 years, also engendered a military-like culture within Huawei, often called "wolf culture," in which the company sees itself as being at war with its competitors.[11]

The technology embargo following the crackdown on protests at Tiananmen Square in 1989 contributed to China's growing realization of the strategic importance of indigenous core information technologies. As a result, China became increasingly determined to produce domestic champions in these sectors. In the 1990s, Ren Zhengfei began to articulate the importance of telecommunication equipment to China's military.

At the same time, China's government started to implement preferential tax and government procurement policies for Chinese companies while ending preferential import policies in the telecommunications equipment market.[12]

Huawei's ties to Xi Jinping reach back to 1999, when Xi, then governor of Fujian province, stated that he hoped Huawei could "contribute to Fujian's network construction."[13] In the 2000s, Huawei also laid the foundation for extending its control over the whole telecommunications value chain.

During the 4G wireless network era, China's government used its standardization and regulatory powers to ensure that domestic manufacturers dominate the home market. China backed its own standard, time division long-term evolution (TD-LTE) against the international one, frequency division duplex long-term evolution (FDD-LTE). By providing licenses only for TD-LTE, which European vendors did not offer, the government made sure Chinese equipment manufacturers dominated the market. This "China-only accumulation regime" played a critical role in furthering Huawei's role, which was strengthened after the Edward Snowden revelations about Western telecoms' role in U.S. government surveillance programs, which put China's self-reliance push into overdrive.[14] Huawei was able to leverage market dominance in China to become a global player, overtaking Apple as second-largest smartphone seller globally in 2018.

As far back as 2009, Huawei received more than 5 billion yuan (roughly $732 million at 2009 exchange rates) in unconditional government grants because of its contributions to the development of new high-tech industries in China.[15] Since the early 2000s, Huawei has consistently received both local and central government funds. For instance, in 2023, the Shanghai Municipal Development and Reform Commission announced that it would support the construction of the Huawei Qingpu R&D Center.[16] In addition, Huawei benefited from generous public procurement and domestic protectionism.[17]

Huawei's Designation as National Champion

For Huawei, the government of its hometown, Shenzhen, has played an outsized role in its development. The local government-backed Shenzhen Major Industry Investment Group has invested in a number of companies that are helping Huawei build a self-sufficient chip network in China.[18] This includes investments in three chip manufacturers for the different classes of chips Huawei needs, a third-generation chip development firm, and a materials and machinery company, representing the breadth of the supply chain.

The central government also supports Huawei. Bloomberg and others report that Huawei's assignment to lead the national team in chip manufacturing was a direct order from top central government officials. Huawei reportedly received 215 billion yuan ($30 billion) in funding from the central and Shenzhen governments since 2021 to build its own chip fabs or to support other companies in doing so.[19]

Being chosen as part of—or especially to lead—a national team confers many advantages to a company. Semiconductor Manufacturing International Corporation (SMIC), for instance, received 1.95 billion yuan ($282.1 million) in subsidies in 2022.[20] SMIC has been one of the big winners of the Big Fund and has emerged as a central player in China's self-sufficiency efforts since at least 2019. But there are also negatives from the company's participation in a national team, especially for its international role. SMIC was added to the U.S. Entity List in 2020.

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Huawei is able to have such an outsized role in Chinese semiconductor manufacturing partly because it was added to the U.S. Entity List early and has needed to shift its business model toward domestic production as a result.[21] Similarly, Huawei has also had to diversify its overall business. Having started out as a narrowly focused telecommunications firm, it is now branching out toward automotive, cloud, e-government, and software products in response to U.S. trade restrictions. In August 2019, at the Shanghai World Artificial Intelligence Conference, Huawei was named as a new national champion in AI, being designated to spearhead research on AI infrastructure and software. In March 2023, Huawei's rotating chairman mentioned that Huawei's goal is to become self-sufficient in three R&D lines: hardware, software, and chip development.

The Mate 60 Pro: Huawei's Victory over U.S. Containment?

In 2019, with the establishment of Huawei's Hubble Technology Investment Co, the company started investing in semiconductor value chains.[22]

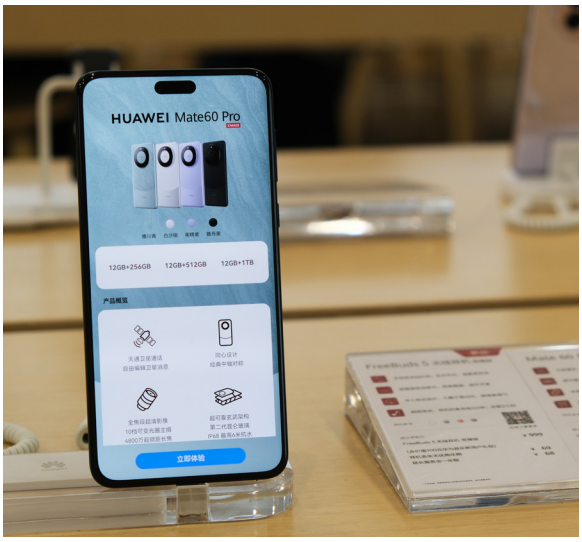
Ren Zhengfei explained in early 2023 that Huawei's struggle as a result of U.S. "containment" was coming to an end because its engineers are now able to replace many international products.[23] The fruits of this effort were apparent in September 2023 when the company released a new smartphone, the Huawei Mate 60 Pro, containing a 5G-enabled chip that was designed and manufactured domestically.[24]

This chip, the Kirin 9000S, has reportedly been manufactured using SMIC's 7 nanometer (nm)-class process. HiSilicon, Huawei's chip design arm, based this chip on a previous server processor that it had designed for production at Taiwan Semiconductor Manufacting Company Ltd. (TSMC) before its entity listing. HiSilicon developed its own core based on an instruction set architecture (ISA) known as ARM, its own graphics processing unit (GPU), its own 5G modem, and an AI accelerator.[25] Other components also come from Chinese companies, including the 5G-speed radio frequency module. Many of these companies received investments from Huawei's Hubble Technology Venture Capital, which invested in 28 semiconductor-related enterprises in 2021. Notably, however, the memory came from stockpiled South Korean-made inventory.[26,27]

Keeping Quiet About Achievements

In communicating the breakthrough of the Mate 60 Pro, Huawei seemed torn between showing strength to the world while trying to avoid further U.S. controls. The new smartphone was not discussed at Huawei's showcase only a week after its official launch and was not billed as having 5G capability.[28,29] At the same time, domestic commentators lauded Huawei and pointed out the timing of the release coincided with U.S. commerce secretary Gina Raimondo's visit to China.[30] This was reportedly influenced by direct encouragement from senior officials in China's government.[31]

While Huawei clearly produced the chip on an SMIC 7nm node, it is unclear if it was produced in a fab owned by Huawei or SMIC. Huawei is currently building or supporting the construction of five semiconductor fabs. In these projects, Huawei does not use its own name, instead relying on other semiconductor companies in China like Fujian Jinhua Integrated Circuit Co.[32,33]



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Huawei is Addressing Supply Chain Vulnerabilities in Lithography and Electronic Design Automation

Lithography is one of the most concentrated and complex steps of the semiconductor supply chain. There is no alternative method to photolithography for producing chips, which is the process of "printing" integrated circuits onto wafers using ultraviolet light. Currently, there are only three companies in the world producing lithography machines: the Netherlands' Advanced Semiconductor Materials Lithography (ASML) and Japan's Canon and Nikon.[34] ASML is the undisputed market leader and the only company able to build an Extreme Ultraviolet (EUV) machine needed for modern chipmaking. ASML has never been able to sell its most advanced lithography machines to China. Recent U.S. and Dutch restrictions extend to even less advanced machines.[35]

In China, Shanghai Micro Electronics Equipment Group (SMEE) has been charged by officials with lithography development since 2003.[36,37] SMEE has built up a supplier network consisting of both state-owned and private companies hoping to integrate their technologies into one lithography machine. While SMEE has seen some success, their products are roughly on par with 20-year-old technology.[38] Current SMEE machines are able to produce chips at the 90nm node, while latest-gen chips use a 3nm node. Since 2018, SMEE has promised to produce a deep ultraviolet machine that would enable production of 28nm chips, which are important for many industrial applications. In late 2023, media reports of SMEE's breakthrough in creating a 28nm lithography machine have surfaced, but these have not been confirmed.[39]

In 2022, Huawei registered a patent for an EUV-capable light source, which suggests it could try to use such a light source in its own lithography machine.[40,41] In 2021, Huawei's Hubble Investment Company invested in a producer of lithography light sources. Industry sources reported that year that lithography was explicitly included in Huawei's strategic plans.[42] Huawei's close relationship with SiCarrier and Zetop Technologies, developers of light sources for lithography, further strengthened the impression that Huawei is becoming a coordinator for a Chinese lithography supply chain.[43]

Huawei is also working with Chinese Electronic Design Automation (EDA) companies, which produce software to design chips. Currently, EDA is dominated by Mentor Graphics, Synopsis, and Cadence, all Western companies using U.S. technology subject to export restrictions.[44] In March 2023, Huawei announced that it would team up with domestic companies to create EDA software capable of designing 14nm chips.[45]

Huawei's Example Pulls Other Companies into China's Drive for Self-Reliance in Chips

With the Chinese government's desire to become self-reliant across the supply chain, developing "key and core technologies" is now priority number one. As opposed to previous self-reliance drives that did not receive much buy-in from private sector actors, businesses across the economy are now on board. This is a result of both an expanded government toolkit and—most importantly—Huawei's example of being cut off from Western technology.[46] As a result of U.S. restrictions which cut it off from Google's Android operating system, Huawei has also become a leader in the mobile operating system space, developing a competitor in its HarmonyOS.

Other companies have been given more specialized roles. Alibaba and Tencent are reportedly now responsible for both further developing RISC-V—an open-source ISA—and developing cores based on RISC-V for other chip designers to use.[47,48] Currently, there are two mainstream instruction set architectures for designing chips: x86 and ARM. While x86 is the most common desktop and laptop architecture, ARM is the most common mobile and embedded architecture. U.S.-based Intel owns the intellectual property (IP) of x86. ARM, a British company with U.S. IP, also has to follow U.S. export controls, and cut off Huawei in 2018. Ever since, China has looked for a different ISA.

RISC-V, which is popular among hackers, fit the bill for an alternative ISA, as its open-source nature protects it from export restrictions. RISC-V, however, is not mature enough for some applications, notably AI.[49] Alibaba and Tencent—both behemoths in cloud computing and AI in China—are trying to change this. The companies aim to support RISC-V development by building an ecosystem, including new core designs and other silicon building blocks, that can serve as the basis for future chipmaking.[50]

Many Chinese companies, research institutions, and universities have created chips using RISC-V and have contributed to global development of the ISA and key extensions of it since the founding of the RISC-V Foundation in 2015. Chinese involvement in the foundation led to its relocation to Switzerland in 2019 to ensure the U.S. government could not sanction it.[51] The Chinese Academy of Sciences (CAS), meanwhile, launched a countrywide initiative to increase RISC-V uptake in 2019.[52] In 2021, China's government initiated a big push to increase the use of RISC-V, opening the new "Beijing Open Source Chip Research Institute" (北京开芯院), co-founded by CAS.[53] Other founding partners include Alibaba and Tencent, along with other major Chinese tech firms such as Baidu and ZTE.

The institute is a member of the RISC-V Foundation, hosted the RISC-V China Summit in 2023, and has published its own RISC-V core, Xiangshan, which can run Linux.[54,55] Despite RISC-V's high-level backing, Chinese companies continue to use ARM when possible, since ARM is the current de-facto standard for many chips. Alibaba, for instance, has built a chip called Yitian 710 to be compatible with ARM for data center work.[56] By investing in RISC-V now, Chinese companies are preparing for an eventual future in which they cannot use modern ARM instruction set and cores, which Huawei is already experiencing.

Policy Implications

Taking Huawei and other big tech companies together, China now has national teams in place for almost all steps of the semiconductor supply chain, from design to front-end and back-end manufacturing, the latter of which is already a strength in China. In addition, China is building up specialized supply chains, like electric carmaker BYD's initiative to manufacture its own chips.[57]

For international partners and rivals, Huawei's vertical integration of the supply chain and its close ties to all of the companies within that chain spell trouble. Cooperation and supply decisions are more difficult for European and U.S. technology firms if they cannot be sure whom they are cooperating with. Huawei's ties to China's military and state security have been well-documented.[58] Its military-civil fusion strategy, though still aspirational, also makes discerning end use and end users difficult. As more and more companies are being tasked with fulfilling strategic goals for China's government, selective de-risking is becoming a greater challenge for the West.[59]

At the same time, recent announcements by national champions like Huawei or large companies like Tencent have been sparse in details. For instance, a video transcoding chip designed by Tencent has been shrouded in mystery.[60] This makes market intelligence and due diligence efforts—already hampered by China's legal set-up with the anti-espionage law—more difficult for foreign companies. For Western governments, assessing China's progress in advanced chips is also becoming more difficult. For example, Huawei's recent announcement of its domestically produced, application-specific integrated circuit (ASIC) chips took many governments by surprise.[61]

Conclusion

Pressure from the United States and China's own turn to security-focused development have raised the importance of supply chain security.[62] Semiconductors have been key to China's drive for technological self-reliance, because they are both fundamental to many future technologies and have been the main target of U.S. restrictions so far.

Huawei, which started out as an equipment manufacturer for telecommunications, has taken an especially prominent role in China's technological self-reliance drive. In some respects, Huawei is developing into a behemoth similar to a South Korean chaebol, like the massive conglomerate Samsung. Instead of relying on other, especially foreign companies for many components, Huawei is integrating as much of the semiconductor and wider electronics supply chain into Huawei-owned companies, or a tight network of other Chinese companies.[63] Such a conglomerate has the advantage of being able to subsidize loss leaders, a necessary but not alone sufficient step for advanced manufacturing of semiconductors.

Huawei has proven that it can achieve self-reliance goals in key and core technologies with its success in 5G networks. It has also shown that it is willing to forego quick profits to support strategic goals. Huawei has therefore been given more responsibility for the semiconductor supply chain writ large, receiving generous government support in turn. Huawei even plays the role of ecosystem orchestrator for technologies like EDA software. Its claims of being a private company like any other are therefore less credible.

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