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Technology & Innovation – China

Semiconductor self-reliance will support tech growth but pose overcapacity risk

Summary

China has signaled that it plans to invest heavily in the coming years to develop its semiconductor industry, as global chip shortages and trade tensions reveal the large gap in its domestic supply and demand for these products. However, achieving semiconductor self-reliance likely will be a long and challenging process, with the potential for a range of credit effects on the sovereign, domestic companies and international manufacturers.

» **Effort to ramp up capabilities reflects supply-and-demand mismatch and strategic vulnerabilities**. China (A1 stable) is the biggest consumption market for semiconductors globally, yet its production is far below that of the US (Aaa stable), Korea (Aa2 stable) and Taiwan, China (Aa3 positive). China aims to achieve a semiconductor self-sufficiency ratio of 70% by 2025, significantly higher than current levels.

» **Semiconductor industry growth would support China's tech progress**. China's semiconductor industry plan would bring credit benefits for the sovereign, if it successfully leads to advanced development in the sector and mitigates strategic vulnerabilities. If the plan can also lead to enhanced productivity and growth potential over the longer term, that would also be positive for the sovereign's credit quality.

» **But potential overcapacity and investment inefficiency are risks**. China's plans could lead to rapid expansion and over-investment in certain types of semiconductors. At the macro level, overinvestment could lead to investment inefficiency and resource misallocation, and hurt long-term potential growth. At the company level, aggressive expansion could reduce financial viability and increase credit risks, while efficiency could decline and costs could rise.

» **Smaller Chinese producers would be most exposed to credit risks from overcapacity in the medium term.** The semiconductor industry's strategic importance to China will help large companies obtain strong government support and financing. But smaller and private domestic producers with less support will likely face higher credit risk resulting from potential overcapacity of semiconductors with fewer technological barriers in the medium term.

» **Competitive risks for non-Chinese manufacturers will intensify**. Development of China's semiconductor capacity has the potential to add competitive risks for certain global producers over time. This will have increasingly negative implications for some non-Chinese manufacturers.

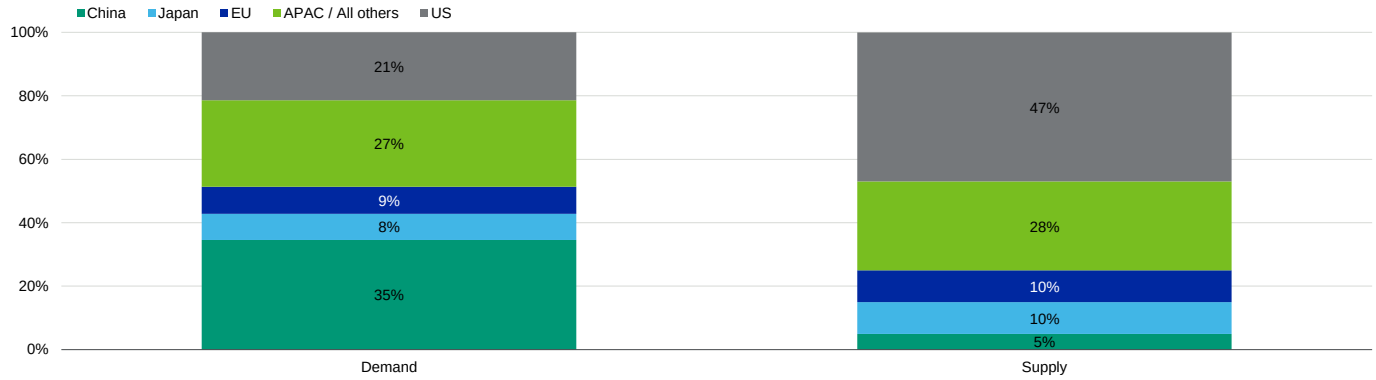
Effort to ramp up capabilities reflects supply-and-demand mismatch and strategic vulnerabilities

China is the biggest consumption market for semiconductors globally, accounting for 35% of demand in 2020, according to the Semiconductor Industry Association. However, its supply accounted for only 5% of global semiconductor revenue, far behind the US, Korea and Taiwan (see Exhibit 1). This supply-and-demand mismatch has become glaringly apparent in a global environment in which geopolitically strategic considerations increasingly prevail over commercial factors, and amid a worldwide semiconductor shortage as the global economy has begun to bounce back from the economic crisis triggered by the COVID-19 pandemic. Ongoing US-China tensions also have revealed this mismatch as a vulnerability for China. As a result, China is increasingly focused on boosting development of its semiconductor industry, with the aim of achieving a semiconductor self-sufficiency ratio of 70% by 2025 from estimates of 10% to 30% currently.[1]

Exhibit 1

China has a large mismatch its semiconductor needs and production capacity

Breakdown of semiconductor demand and supply, 2020

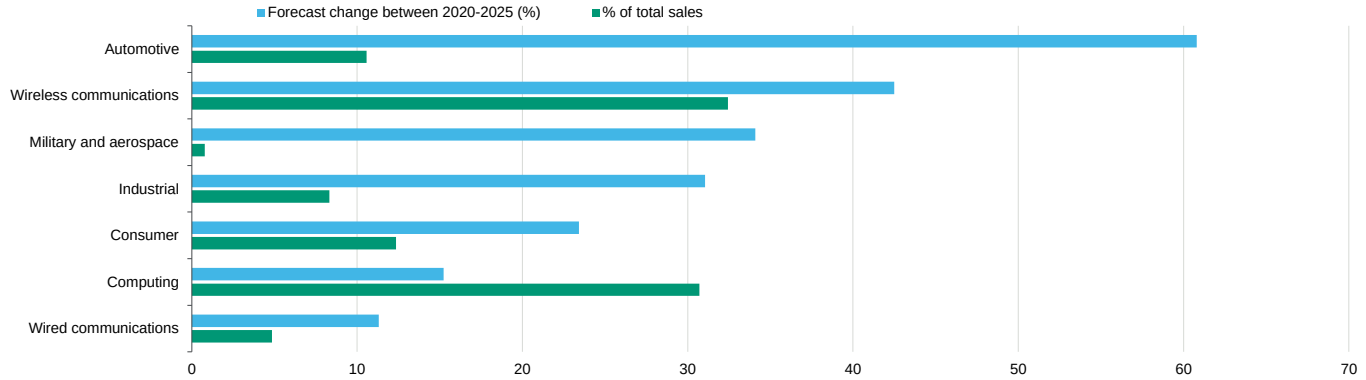


Sources: Semiconductor Industry Association and Moody's Investors Service

Semiconductors are critical production inputs for many industries, from consumer electronics and autos, to 5G equipment, artificial intelligence, and military and aerospace equipment (see Exhibit 2).[2] A semiconductor supply shortage that leads to lower industrial production, rising prices and lower quality of goods will have negative credit implications for companies in a wide range of sectors. A long-term shortage would pose risks to technological progress and productivity growth, and potentially reduce economic and geopolitical competitiveness, a credit negative for sovereigns.

Exhibit 2

Semiconductors are critical inputs in production for many sectors



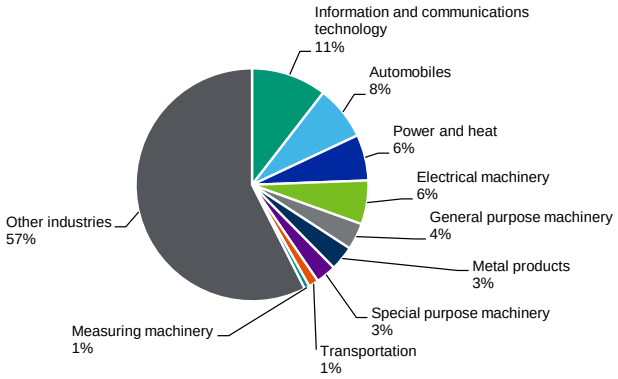
Sources: Bloomberg and Moody's Investors Service

For China, the economic impact of a long-term semiconductor supply shortage could be significant. Semiconductor-related industries, including telecommunications, computing, automobiles, healthcare and agriculture equipment, made up more than 43% of the country's total industrial sales in 2020. Without significant advancement in the production of more sophisticated semiconductors, the technological gap between China and the leading semiconductor-producing countries will widen, constraining China's competitiveness in industries such as robotics, data centers, Internet of Things, automation and robotics (see Exhibit 3).

Exhibit 3

Semiconductor-related industries make a significant contribution to China's economy

Output by sector relative to the country's total industrial sales, 2019



Selected industries for which semiconductors are important inputs.

Sources: China National Bureau of Statistics and Moody's Investors Service

The US dominates the global supply of semiconductors (47% of global supply), because of its leading position in the market of integrated circuit design, fabrication equipment and integrated device manufacturing. China accounts for 37% of US semiconductor sales. The next largest global producer is Korea, with 20% of global supply, followed by the EU, at 10%, according to the Semiconductor Industry Association.

In 2018, the US began restricting supplies to China of high-end semiconductors, which are used for 5G, artificial intelligence and super computers. This policy would continue under the US Innovation and Competition Act, which has passed the Senate and now awaits approval by the US House of Representatives. The US restrictions have led to a decline in US semiconductor exports to China, which fell to a total of $3.07 billion in the first half of 2018, from $3.41 billion in the second half of 2017.

The US restrictions on supplying certain semiconductor components and equipment to China have led to revenue and market share loss for Chinese companies. For example, because of US-restricted chip supplies that are designed or fabricated by the US manufacturers to Huawei Technologies, Huawei's share of the global mobile market fell to 4% in the first quarter of 2021 from 18% in the third quarter of 2019. The company previously was the world's second-largest smartphone manufacturer (after Samsung) but has now fallen out of the Top 5 altogether. For Semiconductor Manufacturing International Corp. (SMIC, Baa3 stable), one of China's largest semiconductor producers, the US restrictions on supplying it with equipment for fabricating certain type of chips will likely constrain its capacity in advanced semiconductors. An inability to catch up to market leaders in this area would hurt SMIC's long-term competitiveness.

China will remain the largest global consumer and producer for electronic devices and systems, according to forecasts from the Semiconductor Industry Association, and thus also the world's largest consumer of key inputs to advanced manufacturing in the semiconductor sector. Without a leapfrog advancement in domestic production capacity, however, the supply-and-demand imbalance would threaten China's competitiveness and slow its development in the tech-led world economy.

Semiconductor industry growth would support China's technological progress, with limited near-term sovereign risk

China's plan to boost domestic semiconductor capacity poses low near-term credit risk for the sovereign, because government support related to the substantial state-led investment and spending in the sector likely will be modest compared with China's overall GDP. In the long run we expect the plan to be supportive of sovereign credit quality. This is because technological advancement in this sector will support economic growth by promoting productivity and pushing China up the value chain, while mitigating major strategic vulnerabilities in a more hostile geopolitical environment.

At the same time, the strategy poses both near-term and longer-term risks. In the near term. as with any import substitution strategy, an aggressive push for self-reliance could have negative consequences for both the cost and quality of semiconductors, posing risks to Chinese companies that rely on these components. And in the longer term, the strategy has the potential to lead to a perpetuation of the over-investment cycle in certain industries, a dynamic that has been eroding China's potential growth over time through the misallocation of capital and credit. If this cycle were to repeat itself in the semiconductor industry, it could have negative implications for growth potential and, therefore, for sovereign credit quality.

The Chinese authorities' financial support for technological advancement has been reflected in the recent 14th Five-Year Plan. It is also a key component of the "dual circulation" strategy. The support also includes a commitment to increase spending on fundamental research in technology to more than 8% of the government's total R&D spending by 2025 from 6% in 2019, backed by a 10-year action plan.

China already has successfully developed its capabilities in other areas of technology, such as in power generation, high-speed rail, autos, telecommunications and aerospace, which have supported its industrial upgrade and productivity growth. For the semiconductor sector specifically, the government plans to make direct capital injections, provide favorable tax treatment and credit facilities, build a favorable regulatory environment, and push for adoption of domestically produced semiconductor technologies and products.

China's investment in semiconductors is largely state led and state backed. The total investment size of the largest national fund, the China Integrated Circuit Industry Investment Fund amounts to around $16 billion in the first phase[3], and will be financed by the Ministry of Finance (36%), China Development Bank Capital Co. Ltd (22%) and other state-owned or state-backed financial and nonfinancial enterprises (42%)[4] The size of the second phase will be around $30 billion.[5] The total investment in the fund including those from central governments, local governments and private funds is estimated to amount to more than $200 billion.[6]. The Semiconductor Industry Association also has estimated that Chinese government support for semiconductors will total at least $100 billion over the next 10 years. Therefore, overall investment in this sector could be roughly 0.1% to 0.2% GDP per year over the next decade.

The US and the EU have made comparable investments. For example, the American Jobs Plan has directed about $480 billion for the US to develop domestic manufacturing capacity in semiconductors and other advanced technologies, as well as basic R&D over 10 years, or roughly 0.3% of GDP annually. Meanwhile, the EU plans to allocate more than $150 billion for semiconductor investment over the next 10 years, or 0.1% of GDP per year, to double its share of global production to 20% by 2030.[7]

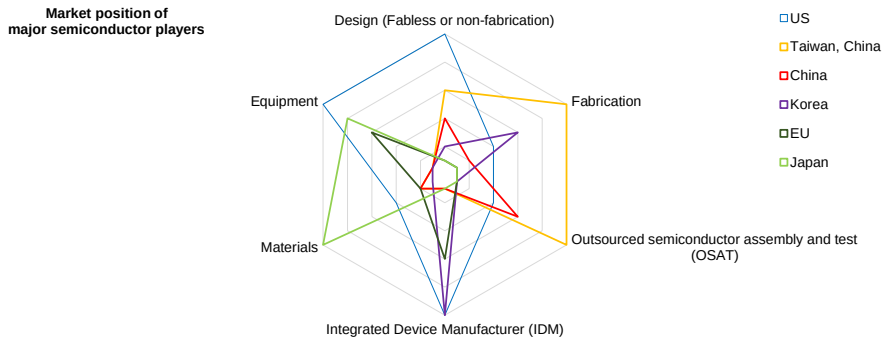
Achieving semiconductor self-reliance in China will be challenging

China's semiconductor production capacity lags that of global semiconductor leaders, mainly because it lacks the necessary technology and equipment to design and fabricate more advanced semiconductors.

The production of semiconductors includes design (fabless or non-fabrication), fabrication and outsourced assembly and testing (OSAT) stages, as Exhibit 4 illustrates. Equipment and material supplies are two critical factors that support the production. The US, Taiwan, Korea, the EU and Japan have leading positions in some of these areas, while China is catching up in the OSAT and design stages. There are a few integrated device manufacturers (IDMs) in the US, Korea and the EU that have achieved vertical integration in some semiconductor production.

Exhibit 4

China lags global peers in many aspects along the semiconductor production line



This exhibit shows the estimated market position of key global producers in each segment. For design and fabrication, the relative position reflects the extent of the country's technological capability in designing or fabricating 10 nm-and-smaller chips in recent years. The market position of the outer ring is stronger than that of the inner ring.
Source: Moody's Investors Service

China currently could produce at scale less-sophisticated chips (14 nanometer [nm] and larger), with SMIC and Shanghai Huahong Integrated Circuit Co. Ltd. the domestic leaders. In contrast, Taiwan Semiconductor Manufacturing Co Ltd (Aa3 stable) in Taiwan, Samsung Electronics Co., Ltd (Aa3 stable) in Korea, and Intel and Global Foundries in the US supply more-sophisticated chips (smaller than 14 nm). It usually takes a couple of years to advance chips by one generation, for example from 28 nm to 14 nm.

China has made significant progress in the design stage in recent years, led by Yangze Memory Technologies Co. Ltd. (YMTC), as well as at the OSAT stage, with JCET Group the domestic leader in this market. However, China lags far behind its global peers at the fabrication stage, even with government support. According to TrendForce, a Taiwanese research firm, TSMC accounts for 54% of global fabrication market revenue in 2020, followed by Samsung (17%), Global Foundries (7%), and UMC (7%).

While Chinese companies can make gains in some limited market segments, it would be difficult for them to scale operations more broadly by relying on Chinese-developed equipment. Because of lack of technological capacity, Chinese equipment suppliers face difficulties scaling up production to meet increased sustained demand. Domestic semiconductor equipment suppliers include Advanced Micro-Fabrication Equipment, Hangzhou Changchuan Technology, and Shenyang Piotech, which produce integrated circuits equipment.

But potential overcapacity and investment inefficiency are risks

China's semiconductor self-reliance targets have the potential to result in rapid expansion, over-investment and overcapacity in the domestic semiconductor sector.

State-led investment efforts in other industries have led to overcapacity issues in the past. For example, after the global financial crisis, the RMB 4 trillion stimulus from the Chinese government led to heavy overcapacity in the steel and cement sectors, as well as high leverage ratios in state-owned enterprises in these sectors and an increase in bad loans in the banking sector. In the early 2010s, huge global demand for solar photovoltaic equipment, accompanied by loose domestic regulations, led to irrational expansion of the Chinese solar sector. This resulted in overcapacity, price declines, a collapse in profit, and consequently, high leverage and bankruptcies in the domestic solar sector.

Repeated cycles of over-investment in certain industries can lead to investment inefficiency and erode potential growth over time through the misallocation of capital and credit, with negative implications for a range of industrial sectors, as well as ultimately the sovereign.

The government's semiconductor industry investment plans could add to fierce competition, resulting in overcapacity of certain types of semiconductors, starting with less-sophisticated products. Overcapacity is a particular risk at the fabrication stage as a result of the large amount of capital spending needed to set up fabrication plants, and the large amount of time necessary to plan production and step up technologies. New technology development and supply chain disruptions can also pose risks. For example, overcapacity has occurred in the global market for less-sophisticated semiconductors. In 2018, the price of memory chips for personal computers and handsets fell as a result of lower-than-expected demand and a massive build-up in supply by global chipmakers.

As discussed in the previous section, the US and the EU plan large investments in semiconductors over the next 10 years. Additionally, Samsung plans to spend around $150 billion by 2030 for logic IC and wafer capacity expansion, while TSMC plans to spend $100 billion in the 2021-23 period for capacity expansion.

China adds fuel to this global investment race. Its investment in the semiconductor industry surged to $35.2 billion in 2020, a 407% annual increase, according to TechNode's research. And China's overall capacity of semiconductor will expand by 12%, with foundry capacity growing 16% and memory chip capacity up 11% between 2020 and 2022, according to International Data Corporation and Bloomberg. According the SEMI, an industry association comprising companies in the electronics manufacturing and design supply chain, the number of 12-inch wafer fabrication plants will increase by 38 globally to reach 161 until 2024, with half located on the China mainland or in Taiwan, which will lead to monthly production capacity of 7.2 million wafers, above 30% more than in 2019, for fabrication of logic IC, MCU and chips for power equipment.

More than half of the Big Fund phase-one investment is being invested in wafer fabrication. [8] The focus is on 12-inch wafer production for scaled-production technologies (28 nm chips) and more advanced technologies (smaller chips). The capital spending needed is huge: $3 billion-$5 billion for 12-inch wafer production for scaled-production technologies (such as 50,000 wafers per month), and $10 billion for advanced technologies, according to Isaiah Research.

However, the capital expenditure needed for building capacity of semiconductors is large and the investment return could be low at the initial stage, especially for more sophisticated products. Given the technological challenges, the Chinese government would have to provide sustainable and strong support for companies in this sector to make up for the large capital expenditure and potential multiyear financial losses. A sustainable financial model is also needed to incentivize long-term investment from both the state and the private sector, while also avoiding short-term financial risk for producers and investors.

The recent default of Tsinghua Unigroup Co. Ltd. has highlighted the importance of the government's role in supporting the financial viability of high-tech companies. Tsinghua Unigroup, a high-tech high-profile private company that owns YMTC and specializes in designing chips, once had strong government support but has subsequently been forced into restructuring under China's bankruptcy law. The financial collapse stems from its aggressive expansion into the capital-intensive chip sector. Government support has become selective to such entity which has been gone through a very aggressive expansion but still cannot financially sustain itself amid volatility in the sector.

Moreover, the self-reliance strategy also promotes import substitutions, even if it is forced on China by geopolitical considerations, which could drive resource inefficiencies and capital misallocation, leading to lower productivity and lower potential growth.

Smaller Chinese producers would be most exposed to overcapacity risks in the medium term

China's semiconductor industry development plan poses limited credit risk for large companies with strong market positions and solid financial profiles, as semiconductors' strategic importance to China will help these entities obtain sufficient government support and access to financing, limiting the negative pressure on their balance sheets from increased capital spending or overcapacity.

For example, for SMIC, despite a large increase in capital spending (up 182% in 2020 to $5.3 billion), the company's financial profile has remained strong. The company's revenue increased 25.4% to $3.91 billion in 2020 from 2019, supported by strong growth in its smartphone, smart home and other segments, as well as by higher average selling prices from a better product mix. Its adjusted EBITDA margin improved to 45.9% in 2020 from 39.6% in 2019, mainly driven by its better gross margin from higher capacity utilization and higher average selling prices from a better product mix; and a lower expense-to-revenue ratio because of better expense controls. The rising strategic importance of the semiconductor industry in China, strong government support, and the company's stable liquidity and capital structure through down cycles will help SMIC position itself amid vigorous competition in the market and maintain a healthy credit profile.

However, compared with stronger peers, smaller and private domestic producers with less government support would likely face higher credit risk resulting from potential overcapacity in less-sophisticated semiconductor sectors in the medium term. From 2015 to 2020, driven by strong demand and the government plan to support semiconductor development, the number of Chinese semiconductor producers doubled to 2,218, according to Tsinghua University estimates. The newcomers include a large number of smaller and private chipmakers in sectors with fewer technological barriers. Potential overcapacity will likely expose these small companies to high price volatility, low profit margin and operational inefficiencies. Without strong government and financing support, these companies will face refinancing risk as they are likely to accumulate large debt burdens at the initial investment stage.

However, strong growth prospects for the semiconductor sector in the near term will support the revenue growth of most domestic companies in the sector. According to recent forecasts from World Semiconductor Trade Statistics, an association comprised of 55 semiconductor companies, the global sales of semiconductors will likely to grow 19.7% and 8.8% in 2021 and 2022, respectively, while bit growth is like to hit 31.7% in 2021 and 17.4% in 2022. Sales in this sector reached $439.0 billion in 2020, up 6.5% from 2019, according to the Semiconductor Industry Association. On a regional basis, China remained the largest individual market for semiconductors, with total sales of $151.7 billion in 2020, up 5.0% from the prior year.

If sustained funding and sufficient policy support successfully help them overcome technology shortages, Chinese companies could enhance their global competitiveness and gain more market share, a longer-term credit positive.

Competitive risks for non-Chinese semiconductor manufacturers will intensify

Development of China's semiconductor capacity has the potential to add competitive risks for certain global producers over time. Given the complexity of semiconductor production, vertical integration by one region is not cost efficient. As a result, there is a close interdependence between major producers globally, as shown by high bilateral trade flows (see Exhibit 5). China plays an important role in providing semiconductor products to producers in other regions and was the largest single source of semiconductor inputs for production in Taiwan, Korea and the EU in 2020.

The ramp-up of China's semiconductor production will likely spread overcapacity-related risks, such as subdued price to producers in other regions, via the interconnectedness of semiconductor supply chains. The potential for reduced market share and profit margin would add credit pressure for these global companies.

Exhibit 5

Trade interdependence between major semiconductor producers is high
2020, $ billions

		Origin (export)					
		China	US	Taiwan, China	Korea	EU	All others
Destination (import)	China		$ 11.0	$ 44.4	$ 37.5	$ 11.0	$ 154.0
	US	$ 1.9		$ 1.8	$ 2.2	$ 1.8	$ 33.1
	Taiwan, China	$ 17.5	$ 3.7		$ 6.0	$ 2.0	$ 31.3
	Korea	$ 18.0	$ 3.2	$ 8.8		$ 1.1	$ 11.3
	EU	$ 9.1	$ 3.2	$ 2.7	$ 1.2		
	All others	$ 106.3	$ 29.2	$ 70.2	$ 40.8		

The dollar figures represent the trade of goods for products including electronic integrated circuits, diodes, transistors, similar semiconductor devices and photosensitive semiconductor devices.
Sources: UN Comtrade and Moody's Investors Service

As mentioned earlier, over the past 10 years China has been gradually increasing its share of design and testing markets of semiconductor production, as well as in the fabrication market for larger-sized chips. For example, SMIC and JCET are becoming increasingly competitive. SMIC's revenue share in fabrication market increased to 5% in Q1 2021 from 4.3% in 2019, and JCET's revenue share of the OSAT market increased to 14.4% in Q1 2021 from 13.8% a year ago, according to the data from a market intelligence firm, TrendForce.

However, Chinese companies likely will not pose as much competition to leading producers such as TSMC and Samsung, which make smaller and more advanced chips, even over the medium or long term, given the time and resources needed for Chinese companies to fill in the technology gaps.

For example, TSMC and Samsung dominate the global supply of the smallest chips (7nm and 5nm). Chinese companies are behind the two global leaders by at least one generation of semiconductors, which means it would take at least three to five years for China to produce advanced chips at scale.

Also in the DRAM and NAND memory chip market, Chinese companies are unlikely to pose near-term competitive risks to global leaders including Samsung Electronics Co., Ltd. (Aa3 stable), SK Hynix Inc. (Baa2 ratings under review), Micron Technology, Inc. (Baa3 stable) and Kioxia. The DRAM market is difficult for newcomers to penetrate because market leaders hold process intellectual property in this market, Domestic leader Changxin Memory Technologies started scaled production of 19 nm DRAM in 2020, lagging two to three years behind Samsung. In the NAND market, a market with relatively newer technologies than DRAM, China could narrow the gap. YMTC has unveiled a 128-layer 3D NAND flash memory chips, according to a MTC press release.[9] If YMTC is able to scale production, the gap with Micron, Samsung and SK Hynix could narrow somewhat.

However, significant state-led investment would not likely to lead to dramatic technological advancement or overcapacity in more sophisticated semiconductors in the near term, because it would take several years for China to develop scaled production capacity for more sophisticated semiconductors. Restriction on China's access to advanced technology and equipment will add further difficulties for Chinese producers.

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Endnotes

1 Made in China 2025 and Several Policies for Promoting the High-Quality Development of the Integrated Circuit Industry and the Software Industry in the New Era.

2 Semiconductors include integrated circuit (IC), discrete, sensors and actuators, and optoelectronics. The commonly used term "chips" refers to IC, including analog IC, logic IC (such as CPU, GPU), memory chip, micro-components (such as MCU), and specific application. The amount of transistors on a wafer is one important measure of the sophistication or advancement of IC. On a certain size of wafer (measured by inch), the smaller distance between transistors (measured by nanometer, nm), the more transistors the wafer can hold. The chip shortage in the auto sector in the past year refers to the shortage of 12-inch wafers with 5-7 nm advanced MCU and 40-65 nm matured MCU.

3 How China's 'Big Fund' is helping the country catch up in the global semiconductor race, South China Morning Post, 10 May 2018.

4 Annual report 2018, China Integrated Circuit Industry Investment Fund Co. Ltd.

5 The second phase of the large national fund with a scale of over RMB200 billion was established. Invest in multiple A-share companies in the first phase, China Securities Journal, 27 October 2019.

6 The registered capital of $16 billion and $30 billion are from the first and second phases of the fund stemming from central government, and according to Sino IC Capital Limited and DRAMeXchange, the scale of the fund will reach more than $200 billion.

7 EU Seeks to Double Share of World Chip Market by 2030 in 'Digital Sovereignty' Drive, Wall Street Journal, 9 March 2021.

8 Annual report 2018, China Integrated Circuit Industry Investment Fund Co. Ltd.

9 YMTC Introduces 128-Layer 1.33Tb QLC 3D NAND, company press release, 13 April 2020.

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