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RBC Wealth Management

Special report

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The chip industry's reshoring revolution

National and economic security concerns have countries bringing chipmaking back home. We look at the challenges and opportunities from this strategy.

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For important disclosures, see page 11.

All values in U.S. dollars and priced as of market close, Oct. 27, 2023 unless otherwise stated.
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Special report

The chip industry's reshoring revolution

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The semiconductor industry has achieved a truly global status over time, driven by the desire to maximize capital efficiency. But recent trade tensions together with the COVID-19 pandemic and geopolitical conflicts have exposed vulnerabilities of dispersed supply chains. Governments are now focused on establishing a critical level of technological sovereignty while scrambling to bolster supply chain resilience. To this end, many are subsidizing the repatriation of certain elements of the production process. We explore the challenges and opportunities arising from this strategy, and discuss how to position portfolios to take advantage of this reshaping.

Key points

- **The wide-scale disruption of the global semiconductor supply chain during the COVID-19 pandemic and increasing tensions between the U.S. and China set off alarm bells within government circles.**
- **Many governments are focusing on chip security and proposing bold new incentives to manufacture critical technology closer to home as a hedge against overreliance on foreign supplies.**
- **The reshoring strategy, which prioritizes supply chain resilience over cost efficiencies, should bolster national security, but it comes with its own challenges.**
- **Once these challenges are overcome, the industry should benefit from secular (long-term) growth, though some cyclical (economically sensitive) elements do remain. Semiconductor equipment manufacturers could provide a useful hedge to geopolitical tensions heating up.**

Semiconductor manufacturing: A truly global industry

Powering everything from emails to advanced military systems, semiconductors, or chips, are the critical enablers of our modern society and economy. This prominence has brought them to the forefront of national security.

Created in the U.S. in the 1950s, the semiconductor industry has evolved into a highly efficient but deceptively complex, dispersed, and truly global supply chain. And with each step of the production process, highly intricate and critical, specialization has developed naturally.

Such a complex supply chain has evolved as the most cost-efficient way to produce the chips. So long as all the steps ran smoothly, such complexity was of little to no concern. But after COVID-19 burst onto the scene, many factories were shuttered during the pandemic, causing wide-scale disruption. Meanwhile, increasing tensions between the U.S. and China have also highlighted a number of pressure points along the supply chain, setting off alarm bells within government circles.

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In his book *Chip War*, author Chris Miller lays out the complex web of production:

"A typical chip might be designed with blueprints from the Japanese-owned, UK-based company called Arm, by a team of engineers in California and Israel, using design software from the United States. When a design is complete, it's sent to a facility in Taiwan, which buys ultrapure silicon wafers and specialized gases from Japan. The design is carved into silicon using [precision] tools produced primarily by five companies, one Dutch, one Japanese, and three Californian. […] The chip is then packaged and tested, often in Southeast Asia, before being sent to China for assembly."

In particular, parts of the supply chain are dominated by an uncomfortably small number of firms. For instance, ASML, a company based in the Netherlands with a $200 billion market capitalization, builds 100 percent of the world's extreme ultraviolet lithography machines, which are essential to produce the most advanced chips that go into smartphones and data centers. Two South Korean companies, Samsung Electronics and SK Hynix, produce more than half of the world's memory chips. But the biggest concern is probably the outsized role that Taiwan plays, given it is caught in the geopolitical crosshairs amid U.S.-China tensions.

Taiwan today manufactures 60 percent of the world's semiconductors under the "outsourced foundry" model and 90 percent of the most technologically advanced ones, the logic chips that perform advanced processing. Moreover, most are manufactured by a single company, Taiwan Semiconductor Manufacturing Corporation (TSMC).

Semiconductor primer

Chip type	Functions	Main manufacturers
Memory	Storing data *DRAM chips provide temporary data storage.* *NAND chips are used for long-term data storage.*	South Korea produces 60% of all DRAM chips; Japan produces 20%. More than half of all NAND chips are produced in South Korea.
Logic	Processing data *Leading-edge chips are used in smartphones, personal computers, data centers, and artificial intelligence.*	Taiwan currently produces approximately 90% of the most advanced logic chips. South Korea produces roughly 10%.
Discrete, analog, optoelectronic & sensor	Audio and video signal processing Power regulation Data conversion	Japan is home to 27% of global production capacity. Europe hosts 22% of global capacity.

Source - RBC Wealth Management, RBC Brewin Dolphin, Boston Consulting Group

Taiwan's prominent role in the semiconductor ecosystem

Taiwan rose to prominence in the 1990s as a hub for semiconductor manufacturing thanks to the creation of a new "outsourced foundry" business model: making chips designed by customers. A relentless focus on research and development (R&D), a successful drive for production efficiencies, and generous state subsidies propelled the country's dominance.

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Until the mid-1980s, most large chipmakers both designed *and* manufactured their chips in-house. But as chips became more advanced, the cost of building semiconductor fabrication plants, or "fabs," escalated. At the same time, it became apparent that scale and process know-how were necessary to produce a healthy yield, i.e., a high percentage of well-functioning chips, at low cost.

With these concepts in mind and with generous state support, TSMC soon thrived. As it did not design chips, it did not compete with its customers. In time, most U.S. chip manufacturers ceased making state-of-the-art chips in-house in order to avoid having to build hugely expensive new fabs on a regular basis. Instead, those American chip firms focused solely on chip design, outsourcing the manufacturing process to TSMC. Technology sharing with the U.S. and Europe also allowed TSMC to successfully commercialize advanced semiconductor manufacturing. The company ultimately grew to be the largest chipmaker globally by market value. TSMC, South Korea's Samsung, and the U.S.'s Intel are now the only chipmakers capable of manufacturing the most advanced logic chips.

Yet TSMC finds itself in a precarious position today. Taiwan is in the crosshairs of U.S.-China tensions and ensnared in the technological and geopolitical competition between the two rival powers, both of which are highly dependent on TSMC's semiconductor supply.

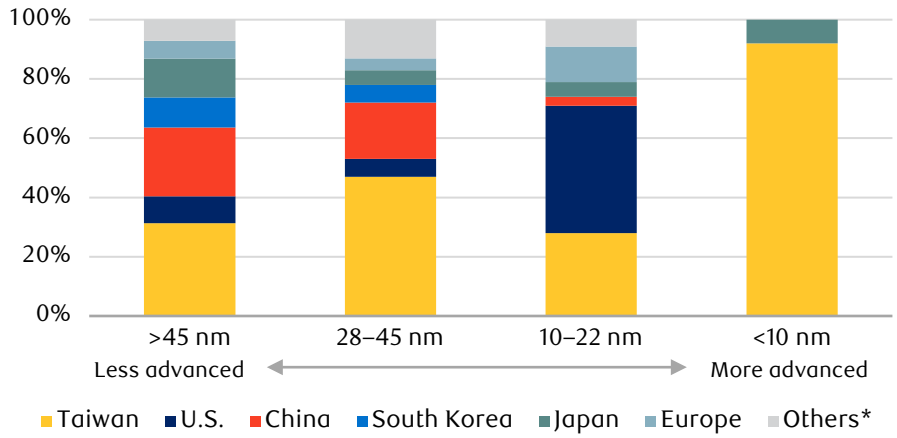
In an effort to protect itself, Taiwan strives to retain its prominent place in the semiconductor ecosystem. While TSMC is building new fabs in the U.S. and Europe, it will keep its R&D and cutting-edge technology at home in Taiwan.

For the many nations and regions, such as the U.S., Europe, Japan, and China, whose phones, data centers, autos, and telecom exchanges among others all depend so heavily on semiconductors made in Taiwan, this presents an uncomfortable situation.

It is impossible to know how U.S.-China tensions over Taiwan will play out, but they do periodically affect financial markets and supply chains.

Wafer fabrication capacity for logic chips by country/region, 2019

Taiwan dominates fabrication of the most advanced chips, while China produces more than 40% of less advanced chips



Note: A wafer is a thin slice of semiconductor material used to manufacture chips. Fabrication capacity includes wafers for memory and logic as well as discrete, analog, and optoelectronic & sensor chips.

* "Others" category includes Israel, Singapore, and the rest of the world.

Source - Boston Consulting Group, based on data from the SEMI global fab database

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The geopolitical tensions, U.S.-China trade disputes, and supply chain disruptions wrought by the pandemic have made many governments around the world sensitive to semiconductor supply chain vulnerabilities.

Security through subsidies

Many governments are focusing on chip security and proposing bold new incentives to fund and safeguard domestic semiconductor manufacturing industries. They have been backing this strategy with money and plenty of intervention. The aim is to manufacture critical technology closer to home as a hedge against overreliance on foreign supplies.

RBC BlueBay Asset Management estimates total incentives towards the chips industry over the period 2014 to 2030 are in the range of $350 billion to $400 billion for the U.S., Europe, China, Taiwan, South Korea, Japan, and India.

Subsidies are often looked at skeptically by economists as they tend to lead to a misallocation of capital. While there is certainly some truth in this, the brief history of the chips industry suggests that advances in semiconductor technology are often successful when supported by generous government grants, as was the case in Taiwan. Below, we look at the use of subsidies in China, the U.S., and Europe.

China

China was the first country to actively and openly reduce dependencies on foreign-made chips and encourage the development of a domestic industry. It launched the China Integrated Circuit Industry Investment Fund, also known as the Big Fund, in 2014 to encourage technological self-reliance. It initially poured $50 billion into chipmaking, aspiring to meet 70 percent of domestic chip demand by 2025. In total, $100 billion to $150 billion will be allocated in China's quest to catch up with global technology leaders.

China entered the industry decades after the U.S., but with generous subsidies along with wooing expertise and executives from Taiwan (and, according to Miller's book, allegations of industrial espionage), it now manages to produce a growing share of the world's chips—though its focus so far has been mostly on less advanced chips. Since 2014, the Big Fund has nurtured domestic champions such as Semiconductor Manufacturing International Corporation (SMIC), a producer of logic chips, and Yangtze Memory Technologies Company (YMTC), a manufacturer of memory chips for data storage.

Despite efforts at promoting its domestic semiconductor industry, China hasn't quite achieved self-reliance yet. China notably spends far more importing semiconductors than oil. It imported some $400 billion worth of semiconductors and semiconductor manufacturing equipment in 2021—about twice as much as it spent on oil. The country's large domestic market is an advantage, however, in that it should enable it to reduce production costs significantly and increase its market share for less advanced chips.

Key government incentives for the semiconductor industry

	Taiwan	South Korea	Japan	China	U.S.	EU
Share of global wafer fabrication capacity	20%	19%	17%	16%	13%	8%
Program	Statute for Industrial Innovation	K-Chips Act	National Semis Project	14th Five-Year Plan	CHIPS and Science Act	European Chips Act
Time frame	2023–2039	2022–2031	2022–2025	2021–2025	2022–2026	2022–2030
Broad value of incentives (USD billions)	$15–$20	$55–$65	$10	$150	$74	$49

Source - RBC Wealth Management, RBC BlueBay Asset Management, Boston Consulting Group, Semiconductor Industry Association

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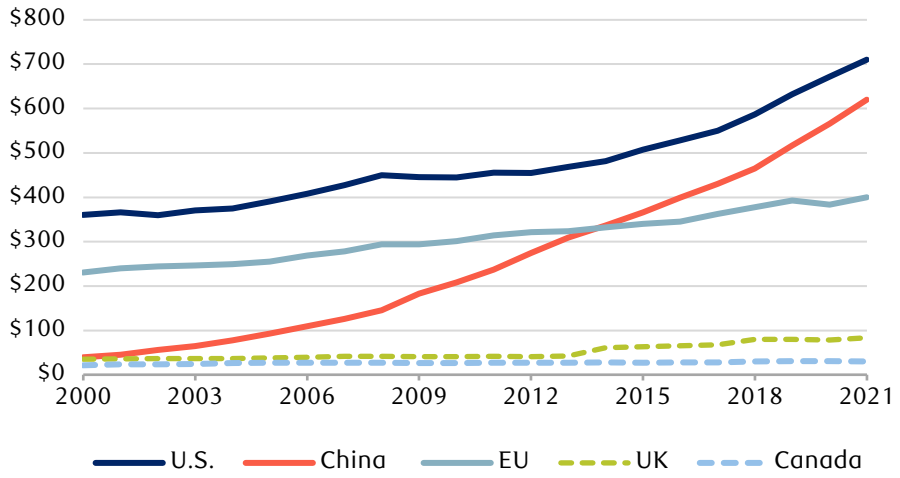
China's R&D investment has risen dramatically to rival that of the U.S.

Gross domestic spending on research and development (USD billions)



Source - Organisation for Economic Co-operation and Development

United States

As part of its more vigorous industrial policy, the U.S. announced the CHIPS and Science Act in 2022. First proposed under former U.S. President Donald Trump's administration, and then championed by President Joe Biden, it is a bipartisan effort which aims to respond to China's focus on the industries of the future. It proposes some $52 billion in subsidies to support the expansion of local semiconductor manufacturing capacity. Three-quarters of the funds will be dedicated to building and upgrading semiconductor manufacturing facilities. The legislation also includes another $24 billion worth of tax credits for chip production.

Thanks to these incentives, semiconductor companies are building fabs in the U.S. TSMC has a new facility under construction in Arizona, and intends to triple its investment in the state to $40 billion, planning to open another fab in 2026. Samsung is also planning to build a fab in Texas.

But it is not only foreign chip manufacturers that will benefit from the CHIPS Act. Intel, the U.S.'s semiconductor champion, also appears poised to benefit from U.S. policymakers' support as it doubles down on its manufacturing capabilities via two state-of-the-art fabs it is building in Arizona and Ohio, investing $20 billion in each. Beyond that, other U.S. players are jumping back in with new fabs of their own in the works.

Europe

The EU has its own landmark plan to beef up its chip industry. The European Chips Act aims to generate public and private investment worth €45.75 billion ($49 billion) in semiconductor R&D and production. The scheme intends to double the EU's share of the global semiconductor market to 20 percent from 10 percent by the end of the decade. Some €35 billion ($37.5 billion) will be allocated for mega fabs, with the rest going to chip-design platforms and other infrastructure. As a result, TSMC, in a joint project with three European companies, announced it will construct a €10 billion ($10.7 billion) plant in Germany. TSMC is linking up with Bosch, a German auto supplier, as well as Infineon Technologies and NXP Semiconductors, two chip manufacturers from Germany and the Netherlands, respectively, to build a factory near Dresden in response to customer concerns over geopolitical tensions. This follows a similar move by Intel, which is planning to build two wafer fabs in east-central Germany.

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Europe's semiconductor industry doesn't have as high a profile as that of the U.S. That may be because more than half of the continent's capacity is for chips with structures measuring at least 180 nanometers (1 nanometer equals 1 billionth of a meter), much larger than the most sophisticated chips produced by TSMC and Samsung, which measure just a few nanometers wide. But the latter are mostly used in consumer electronics, whereas the larger European structures are used by the continent's industrial firms, which need them for applications spanning autos, machine tools, and sensors. In a way, Europe's largest chipmakers, such as Infineon and STMicroelectronics, focus on their local customer base.

Fab idea but will it work?

While reshoring some production may be practical, it is difficult to conceive that all production of logic chips can be successfully moved closer to consumer points.

Yes, the subsidies that governments are pumping into their chip industries are substantial and a promising step. Still, they are clearly insufficient to uproot an ecosystem developed and fine-tuned over four decades, in our view. Moreover, government efforts are aiming to replicate a business model that companies—focused on optimizing capital utilization—had previously chosen to exit by offshoring.

The reshoring strategy, which prioritizes supply chain resilience, should bolster national security. But in November 2022, CNN reported that at a press briefing, Morris Chang, founder of TSMC, commented that the cost to manufacture chips in the U.S. would be 55 percent higher than in Taiwan.

Another big hurdle is a talent shortage. Having outsourced and offshored the process of turning silicon wafers into electronic circuits at scale to Asia, the U.S. finds itself low on skilled workers to build, operate, and run the new fabs. A worker shortage could result in either higher labor costs or a factory running below capacity. The start of production at one of TSMC's new fabs in Arizona was pushed back by a year to 2025 due to several challenges, chief among them being a lack of workers with suitable skills.

Working in close collaboration with semiconductor companies, universities and community colleges are creating new fields of study to address these staffing issues, including some shorter programs with hands-on experience for both undergraduate and graduate semiconductor degree programs. TSMC may also send some of its own technicians from Taiwan to train its American staff.

Over time, the industry's hope is that labor shortages wane as the skilled workforce grows.

Maintaining a leading edge through restrictions

The U.S.'s semiconductor policy isn't solely based on subsidizing local manufacturing processes. It also aims to stymie China's efforts at developing advanced chips, so that the U.S. can retain its technological superiority. In particular, the U.S. is concerned China may be developing technology which could give it a military edge. Washington has closed down paths that have enabled China's technological rise. In 2022, the Biden administration banned the export of all advanced semiconductor chips and equipment to Chinese companies on the grounds of national security. It also pressured allies, such as the Netherlands and Japan, to follow suit. The Dutch government, which had

already restricted exports of the most advanced semiconductor equipment to China in 2019, increased the scope of technology that would fall under export controls. In October 2023, the U.S. tightened export restrictions further to include leading-edge artificial intelligence chips.

China retaliated by imposing export controls on gallium and germanium, two critical minerals used in high-end semiconductors. China is the overwhelming producer of these rare earths, accounting for 90 percent and 60 percent of global production, respectively.

It is likely that U.S. restrictions on the export of advanced chips have spurred China's resolve to support its domestic semiconductor industry. After all, the U.S. could expand its restrictions to include less advanced technology, a move that would mean semiconductor capacity in China could become difficult to maintain and service. Chinese companies, encouraged by ample state funding, have thus redoubled their efforts to develop their own versions of chip technologies imported from the U.S., seeking to limit the impact of U.S. restrictions.

China may have found a way around the U.S. export ban on cutting-edge chips that come from foundries using American technology. It was recently revealed that Chinese tech giant Huawei and SMIC seem to have been able to manufacture 7-nanometer (nm) chips, only two generations behind TSMC's and Samsung's 3 nm nodes.

Positioning for the semiconductor manufacturing industry reshoring

The surge in investment in the semiconductor industry is happening at a time when there is a glut of chips. This is typical of the notoriously cyclical chips industry. It takes a few years to construct a fab and bring it online, by which time the demand trends may no longer be as strong as when the decision to build was taken. Semiconductor product lifecycles tend to be short due to technological innovation, particularly at the leading edge. The new subsidies and investments into reshoring are turbocharging the current cycle, with supply being boosted just as America is reducing the sale of all U.S.-made advanced semiconductor chips and chip equipment to China. Sales to China will not be easily replaced—the country is the second-largest market for many U.S. firms. For instance, it represents slightly over a quarter of 2022 revenues at NVIDIA and Intel.

Once these challenges are overcome, new applications, such as artificial intelligence, and greater chip content throughout the economy should enable the semiconductor industry to grow by mid-single digits through 2030, in our view. The industry should benefit from secular (long-term) growth, though some cyclical (economically sensitive) elements do remain.

Semiconductor equipment manufacturers also operate in a cyclical industry, but they enjoy a much stronger backlog and healthy order book, given the new fabs being built on the back of the reshoring trend. Should geopolitical tensions flare up over Taiwan, this segment could provide a useful hedge. Still, it is not entirely immune to geopolitical risk—when reports came out that the U.S. would restrict exports of semiconductor equipment to China, the share prices of U.S. tool makers, which generate one-third of sales from China, duly corrected. But the strong order books provide some degree of cushion, and share prices have since recovered.

As for Asian semiconductor manufacturers, RBC BlueBay Asset Management Emerging Markets Portfolio Manager Guido Giammattei has noted their returns could potentially be diluted by the lower return on investments outside of Taiwan and China. The impact would be marginal, in his view, as this new

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capital expenditure and related capacity will be gradual and relatively small. For instance, TSMC's U.S. factories could produce 600,000 wafers per year, versus total capacity of some 15 million wafers per year. To a large extent, the impact of new capacity on returns is already reflected in current industry valuations, in his view.

Furthermore, Giammattei believes the U.S. government's friendshoring strategy should encourage further supply chain relocations into Southeast Asian nations such as Vietnam, Thailand, and Malaysia, given the region's supportive policies, cost competitiveness, and ties to existing manufacturing hubs. Nearshoring also presents a distinct opportunity for Mexico to expand its economic role and to become the leading supplier to North America.

Overall, the broad semiconductor sector awaits a favorable cyclical entry point, which may be delayed by what we see as a likely recession on the horizon. But with the prospects of new applications, greater chip content, and further strength in semiconductor equipment order books on the back of government support and rising technological complexity requirements, we think investors should now consider this specialized sector for global equity portfolios, particularly with the need for governments to be less reliant on Taiwanese supply, as tensions regarding Taiwan might flare up from time to time.

With contributions from Nishad Subramaniam, CA, CFA, Senior Analyst, Technology and Industrials, RBC Brewin Dolphin.

Research resources

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