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Semiconductors at the Heart of the US-China Tech War

How a New Era of Techno-Nationalism is Shaking up Semiconductor Value Chains

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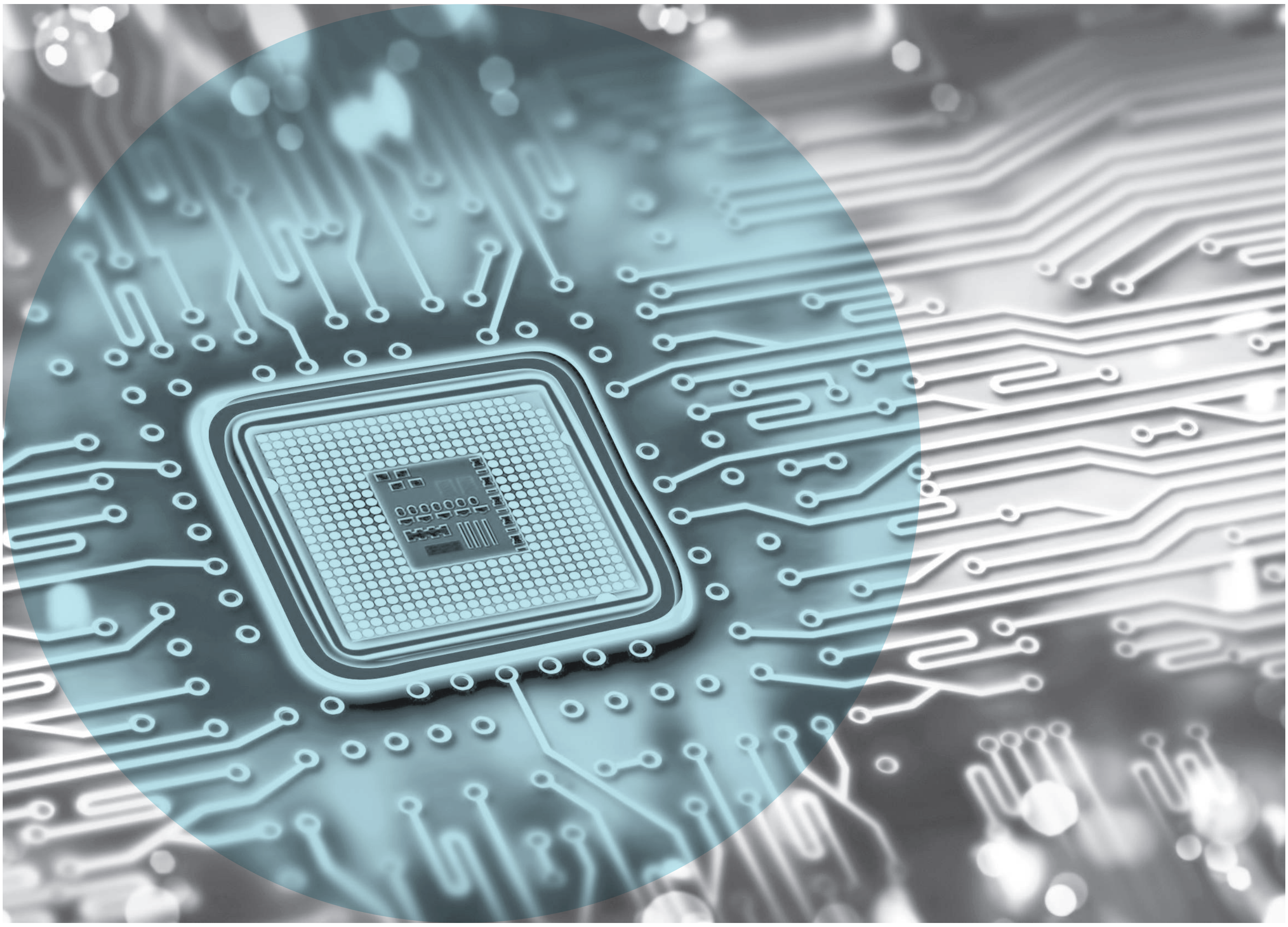

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Foreword

Semiconductors have become essential to our modern life and the world's commercial and military technology. Extraordinary innovations have occurred in semiconductors in the last 20 years, for the benefit of consumers and industry.

However, the commercial competition between industry participants from the US and China (and indeed, participants from Taiwan, South Korea and Japan) has not been allowed to develop in a market-driven way. Whilst value chains have developed across borders in the search for competitive advantage, government intervention for long term geopolitical purposes has distorted markets. Recent events threaten to disintegrate previously integrated value chains, dilute the efficiencies gained over past decades, fracture common standards and slow innovation.

Because of the ubiquitous nature of semiconductors, much is at stake in this new era, including fundamental values about how business enterprises contribute to the national security agenda. Is it possible that the unapologetic industrial policy approach of the Chinese Communist Party could find its way into liberal democratic economies?

The Hinrich Foundation focuses on advancing mutually beneficial and sustainable global trade. We support original research into the causes and effects of trade issues. The ongoing disintegration of technology-driven global value chains (GVCs) will have impacts on growth, innovation and geopolitics.

This report discusses whether the self-sufficiency narratives and national security-related neo-mercantilist approaches that are now playing out in the semiconductor industry – what the author calls "techno-nationalism" – might erode the last 70 years of gains from trade. The report looks at the impacts that a fragmentation of semiconductor value chains along geopolitical lines may have in the longer term on innovation, economic transformation and growth.

We initiated this research to trigger a broader discussion about the effects of the US China technology rivalry on sustainable and inclusive growth. Please join us in the discussion.

Merle Hinrich

Founder
Hinrich Foundation

Executive Summary

Techno-nationalism is at the core of the US-China tech war. Tech-nationalsim is a set of mercantilist-like policies that link tech innovation and enterprise directly to the national security policies, economic prosperity and social stability of a nation.

This report analyzes the growing US-China tech war and how it is impacting the global semiconductor industry — the critical technology at the core of the world's commercial and military technology.

The purpose of the report is to answer questions about how the US-China tech war is changing global value chains and trade flows in semiconductors, and how both state and non-state actors are behaving in this fluid landscape.

More specifically, this report attempts to answer questions about government intervention and protectionist policies and how they impact and influence behaviors in semiconductor value chains. To put the US-China tech war in context, the author defines and develops an emergent narrative: "Techno-nationalism".

This includes a focus on China's industrial policies, which employ state subsidies and funding as well as forced technology transfer and intellectual property acquisition mandates. It also focuses on countermeasures taken by the US government, such as export controls, investment restrictions, the BIS's Restricted Entity List, blocked technology acquisitions and new industrial policies.

Finally, the study drills down into the consequences and possible outcomes resulting from techno-nationalism, including how companies devise strategies to circumvent onerous controls and mitigate collateral damage. This includes an analysis of scenarios involving the so-called US-China decoupling and "de-Americanization" of semiconductor value chains, the fragmentation and reshoring of global value chains, and the formation of new corporate and national alliances.

Introduction

At stake is supremacy in the industries of the future: data analytics, robotics, AI and machine learning, surveillance technology and 5G networks

The United States and China are in the early stages of an historic tech war or era of techno-nationalism.

Techno-nationalism is a new strain of mercantilist thought that links tech innovation directly to economic prosperity, social stability and to the national security policies of a nation. In this regard, government intervention in markets is justified as protection against opportunistic or hostile state and non-state actors.

Techno-nationalism seeks to attain competitive advantage for its own stakeholders, on a global scale, in order to leverage this advantage for geopolitical gain.

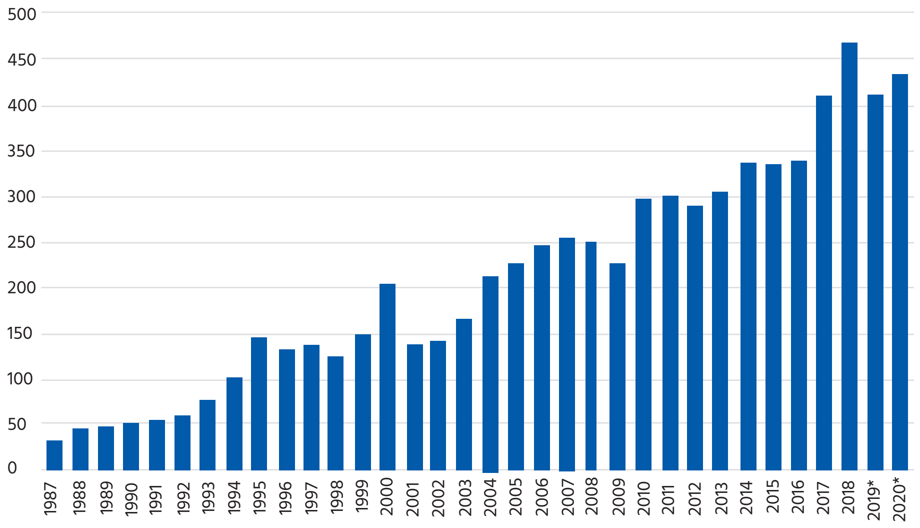
At stake is supremacy in the industries of the future: data analytics, robotics, AI and machine learning, surveillance technology and 5G networks, to name a few.

And at the core of all these future technologies are semiconductors, which provide the vital materials and circuitry necessary to produce microchips — which, in turn, are required to operate everything from a smart phone to an advanced satellite weapons system. In short, microchips are the central nervous systems and brains inside all new age technology.

In 2018, global sales of semiconductors and related technology topped $468 billion.[1] China's semiconductor market represents, by far, the world's largest importer. Semiconductor-related technologies are China's largest import products, exceeding even its imports of oil.[2]

As will be revealed in this study, China depends almost entirely on American and other foreign companies to supply its needs for integrated circuits, either as imports, or as foreign producers within China's domestic market.

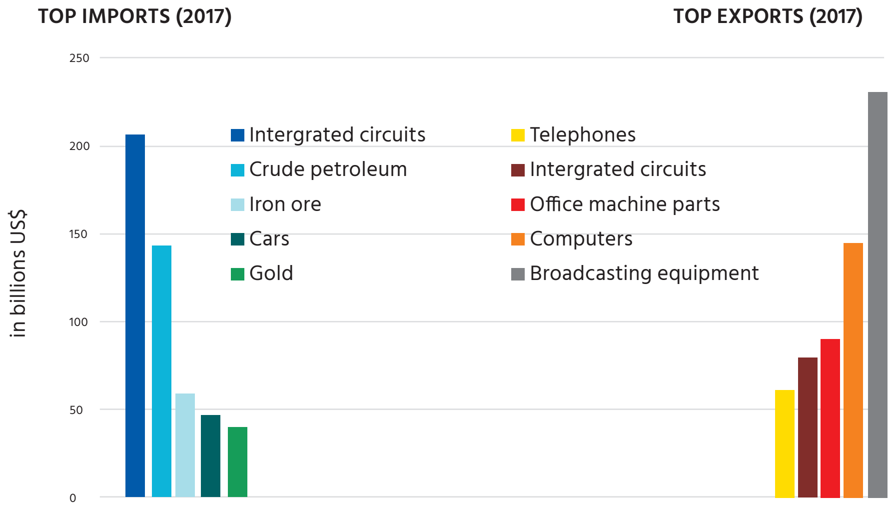
Graph I – Global Semiconductor Sales Revenue from 1987 to 2020
(in billion US dollar) [3]



Source: WSTS (2019)

China has rolled out ambitious strategies to acquire and develop semiconductor technology to reduce its dependence on foreign producers.

Graph II: China's Top Imports and Exports[4]



Source: https://oec.world/en/profile/country/chm/

The intensifying nature of the US-China tech war, combined with the scale and depth of China's market—and the massive economic gains it provides to American and foreign semiconductor companies—creates a collision of vested interests that has sparked a flurry of protectionist policies in Washington and elsewhere.

China's Semiconductor "National IC" Plan

In an attempt to reduce its dependence on American and other foreign semiconductor technologies, as well as advance China's own innovation, the Chinese Communist Party (CCP) has rolled out ambitious strategies to promote and fund the development of China's technology in critical sectors. This funding is earmarked for attracting key investment and technology transfer into China as well as acquiring critical technology overseas, through state-backed acquisition initiatives.

One such initiative is the Made in China 2025 government plan,[5] with some estimates putting the Chinese Communist Party's funding commitment at $300 billion over a ten-year period.[6]

The Chinese Communist Party's semiconductor financing efforts go well beyond Made in China 2025, however. For example, China's official government numbers claim that, as of 2019, some $29 billion of funding has been provided for the China National Integrated Circuit Industry Investment Fund.[7]

Simultaneously, the government has been pumping large sums of money into other technology funds, such as Tsinghua Holdings, the technology investment arm of one of China's top state-led universities, which the Chinese Communist Party has charged with funding and advancing China innovation in the semiconductor industry.[8]

The US has passed a slew of laws aimed at controlling the ownership and export of strategic technology.

U.S. Counter-Measures

In response to Beijing's semiconductor initiatives, the U.S. passed the Export Control Reform Act (ECRA), in 2018.[9] This was born largely from a broader narrative shift that links the level of development of a nation's commercial technology directly with national security —which increasing numbers of policy makers in the U.S. military and security establishment argue is more important than trade deficits or tariff rates.

Under the ECRA, The Department of Commerce's Bureau of Industry and Security (BIS) is currently reviewing the addition of new "emerging" and "foundational" technologies,[10] for inclusion on U.S. Department of Commerce's Controlled Commodity List (CCL)[11], which would require export licenses for the sale and transfer of such technologies. At issue is the relevance of "dual use," which is defined as a commercial technology or product which can be used for military purposes–which would apply to virtually all of the industries of the future.

These new measures will spill over into other markets, as the U.S. will likely propose that the ECRA's newly added tech controls also be adopted by its allies under the multilateral framework of the Wassenaar Arrangement[12], which includes 41 other member countries. Meanwhile, the Foreign Investment Risk Review Modernization Act (FIRRMA)[13] of 2018, enforced by the U.S. Department of the Treasury, has led to a substantial increase in foreign investment reviews by the Committee on Foreign investment in the United States (CFIUS). As such, the number of high-profile acquisitions of US technology companies by Chinese entities have ground to a halt.

The Proliferation of Non-Tariff Measures (NTMs)

The US-China technology rivalry is driving an escalation of non-tariff measures (NTMs), which could have more profound effects on global supply chains than tariffs.

The most noteworthy NTMs include:

- Sanctions
- Export controls
- Licensing requirements
- Restricted entity lists
- Blocked acquisitions and investments

US export controls are damaging American semi-conductor companies, with ripple effects throughout extended global value chains.

By definition, an export control is simply a regulation that is put in place to protect national security, promote foreign or domestic policy, and, in some instances, control the export of items in short supply. An export control is not, by itself, a prohibition to sell or buy something.

Export controls, however, mean that an export license may have to be issued by the appropriate government licensing agency to allow an exporter to sell, transfer or transport a product to a foreign market, depending on where the final buyer is located, who the buyer is, and how the controlled item will be used. In almost all cases, when the facts surrounding a controlled item are reviewed, US government agencies issue export licenses in the vast majority of instances.

But NTMs such as export controls add a layer of uncertainty to GVCs and threaten to turn a long-time supplier into an unreliable supplier. Export controls also mean that a company's global value chains will be examined under the proverbial regulatory compliance microscope, adding compliance costs, delays and risks.

Such was the case when the US threatened to block the sale of American technology to Chinese telecoms company ZTE (which was later rolled back). Subsequently, Huawei, HikVision, SenseTime and other key Chinese tech firms have been placed on the US Restricted Entities List.

And then there are military, space and defense related articles as defined under the International Traffic in Arms Regulations (ITAR) in the US, which control the manufacture, sale and distributions of such items. Here, a simple transaction with a restricted party is forbidden. Many companies are asking how broad might the ITAR controlled list become?

Impact on Trade Flows and Global Value Chains

The world's semiconductor companies are now caught in the middle of the US-China tech war.

Export restrictions on Huawei and other Chinese entities have inflicted collateral damage on American semiconductor companies such as Broadcom, Qualcomm, Intel, Nvidia, and others, while the ripple effects of these actions are being felt throughout extended global value chains.

The US-China tech war presents an historic inflection point, therefore, for technology companies, with far-reaching consequences for trade flows. This rivalry signals the beginning of a momentous shift in global value chains. Multinational companies in the semiconductor industry and beyond will need to react and adjust to this changing landscape.

The ensuing sections of this report delve into these issues and aim to answer the key questions, outlined below.

Report Objectives and Focus

As the US-China tech war escalates, trade flows and supply chains involving semiconductors are being disrupted.

Key Questions

- What are semiconductor products? Where are semiconductor products manufactured? What do semiconductor value chains look like today and how extensive is the interconnectivity between international firms?
- What countries produce the most semiconductors? What are the top semiconductor companies? How significant is their lead?
- Can China make chips and what are its current capabilities in the semiconductor industry?
- How will non-tariff measures such as export controls, export licensing and BIS entity lists disrupt the semiconductor industry?
- Are semiconductor value chains destined to fragment along geopolitical lines?
- How will companies mitigate risks and circumvent industrial policies and/or protectionist measures?
- How will "techno-nationalism" fuel new industrial policies?
- Is US-China decoupling for semiconductor companies inevitable?
- What does the future hold for semiconductor trade flows?

Key Sections of the Report

To answer the above questions, the research, data and analysis are broken into eight distinct sections.

The report begins with an overview of the complexity and nature of semiconductor global value chains. Then it reveals the market leaders and dominant players, and describes the current semiconductor industry landscape in China. This is covered in the following sections:

1. **What are Semiconductors and Where are Semiconductors Manufactured?**
2. **Top Semiconductor Companies, Innovators and Market Leaders**
3. **China's Semiconductor Industry**

The report then delves into China's funding initiatives and the Chinese Communist Party's techno-nationalist efforts to promote the development of Chinese semiconductor companies or national champions. The analysis features a deep dive into its inward and outward strategies to attract specialized foreign direct investment (FDI) and its efforts to acquire semiconductor companies, assets and technology abroad.

This is followed by an examination of US protectionist policies designed to prevent China from obtaining sensitive and controlled US tech. Here, the reader is introduced to the different kinds of enforcement mechanisms being used in the export control process and how they impact global value chains and

trade flows.
Next, the reader is presented with different scenarios whereby semiconductor companies leverage strategies to circumvent and reduce the risks of export controls and restrictions, with an analysis of how these different outcomes could transform the global semiconductor industry.

These themes are explored in sections:

4. **China's Tech Funds, Government Subsidies and Industrial Policies**

5. **US Export Controls and the BIS Entity List**

6. **Strategies to Manage Tech Controls Within Global Value Chains**

Finally, the report concludes by looking at the direction in which semiconductor value chains appear to be heading under techno-nationalist pressures, and outlines potential scenarios for re-alignment, restructuring and US-China decoupling:

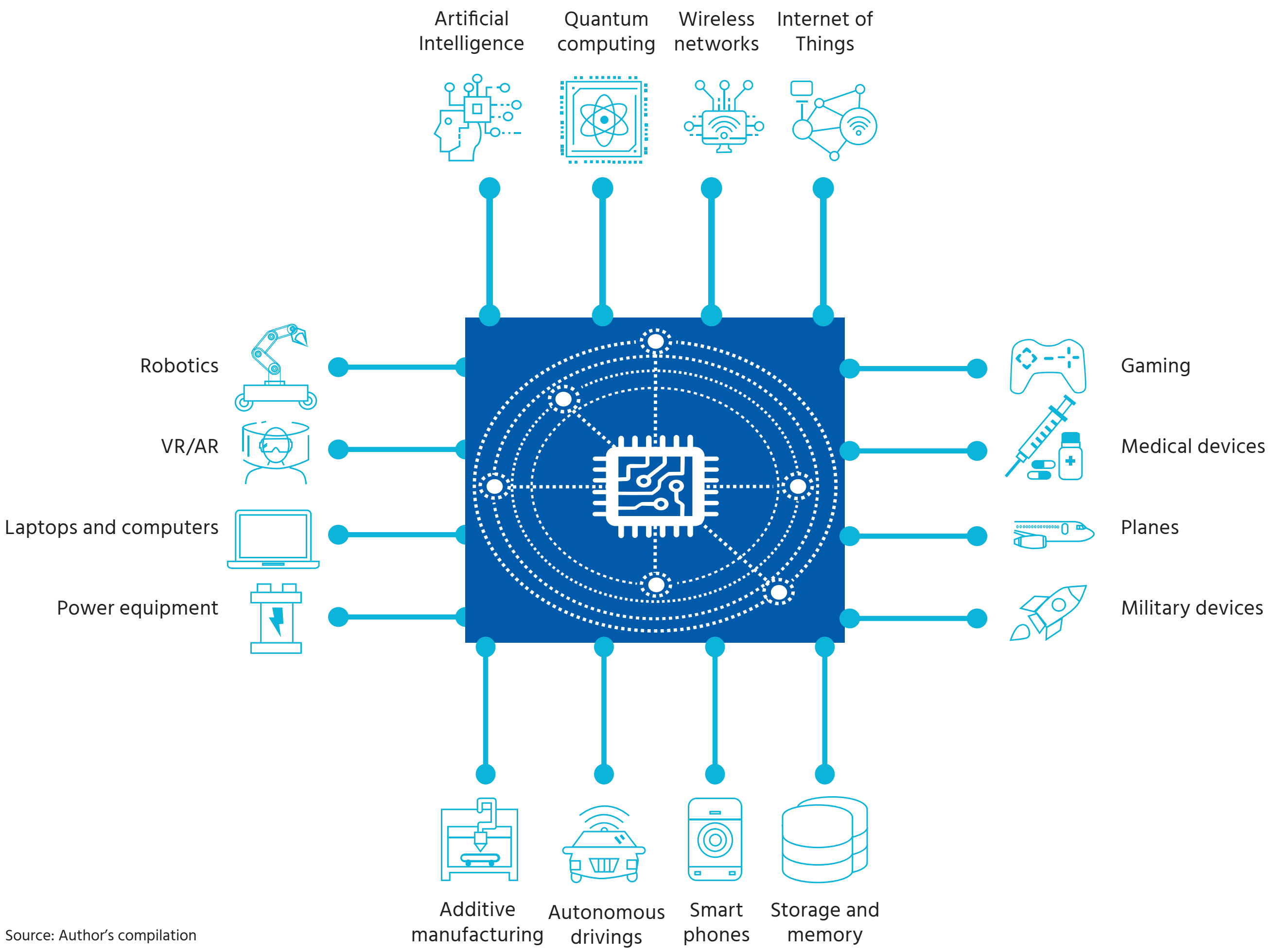
7. **Techno-nationalism and Industrial Policies**

8. **The Decoupling of US-China Semiconductor Value Chains**

The author's analysis and conclusions were drawn from a variety of research methodologies including review of salient literature and corporate publications, interviews with company management at various semiconductor companies, and from the dissemination of questionnaires to entities in the semiconductor ecosystem.

1. What are Semiconductors? Where are Semiconductors Manufactured?

Graph III: Semiconductors: At the Core of all Future Industries[14]



Source: Author's compilation

The fabrication of a state-of-the art microchip represents, perhaps, humankind's greatest technological achievement. The process of designing, creating and mass-producing, for example, a 7-nanometer integrated circuit, with virtually zero margin of error, is the result of one of the world's most complex, knowledge-intensive processes.

Only a small number of multinational companies can compete in this dynamic environment, where R&D costs run to the billions of dollars and represent more than 20 percent (and rising) of annual profits.[15]

The cost of building a highly automated, AI-enabled factory starts at $10 billion, and requires "clean-rooms" that are 100,000 times more sterile than the average hospital environment.[16]

What are Semiconductors?

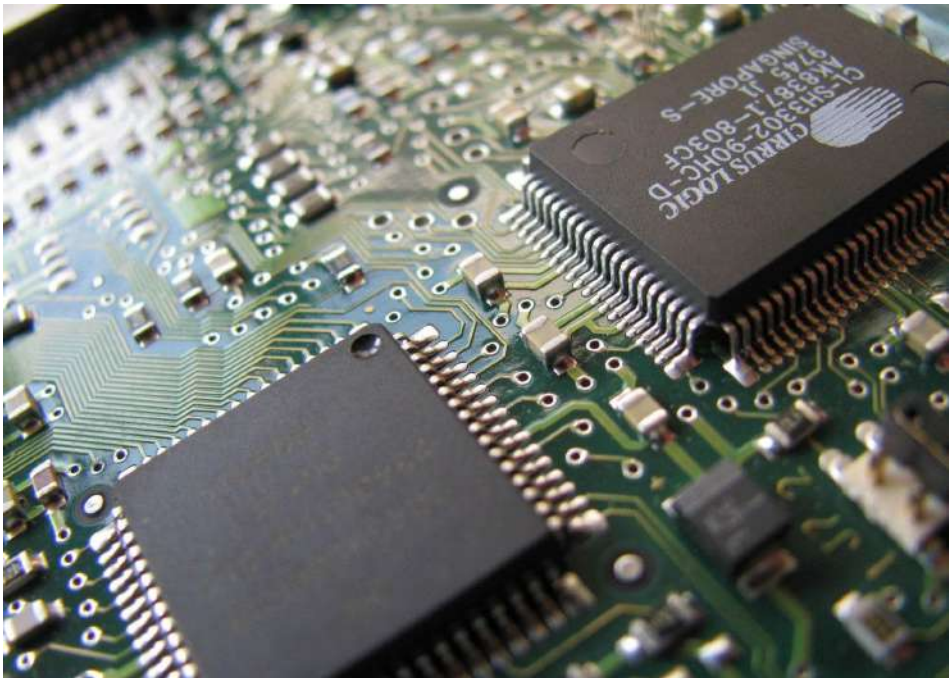
A semiconductor (also referred to as a "microchip") is a material that provides conductivity between an insulator and other materials.

There are three types of semiconductors:

- Discrete
- Integrated Circuits (IC's)
- Opto-electronics

Discrete semiconductors contain only one transistor. Integrated circuits contain multiple transistors, while optoelectronics detect and generate light pulses.

Integrated circuits are the most common microchips and are often the technology that is referred to as "semiconductors" in the press and academic journals. This paper will use "integrated circuits" and "semiconductors" interchangeably. What makes the science behind these microchips so impressive is the size at which these tiny devices perform their functions. A silicon atom is about half a nanometer in diameter and today's most advanced microchips are produced at commercial volumes that attain a size of 7 nanometers or smaller. (One nanometer is one billionth of a meter.[17])

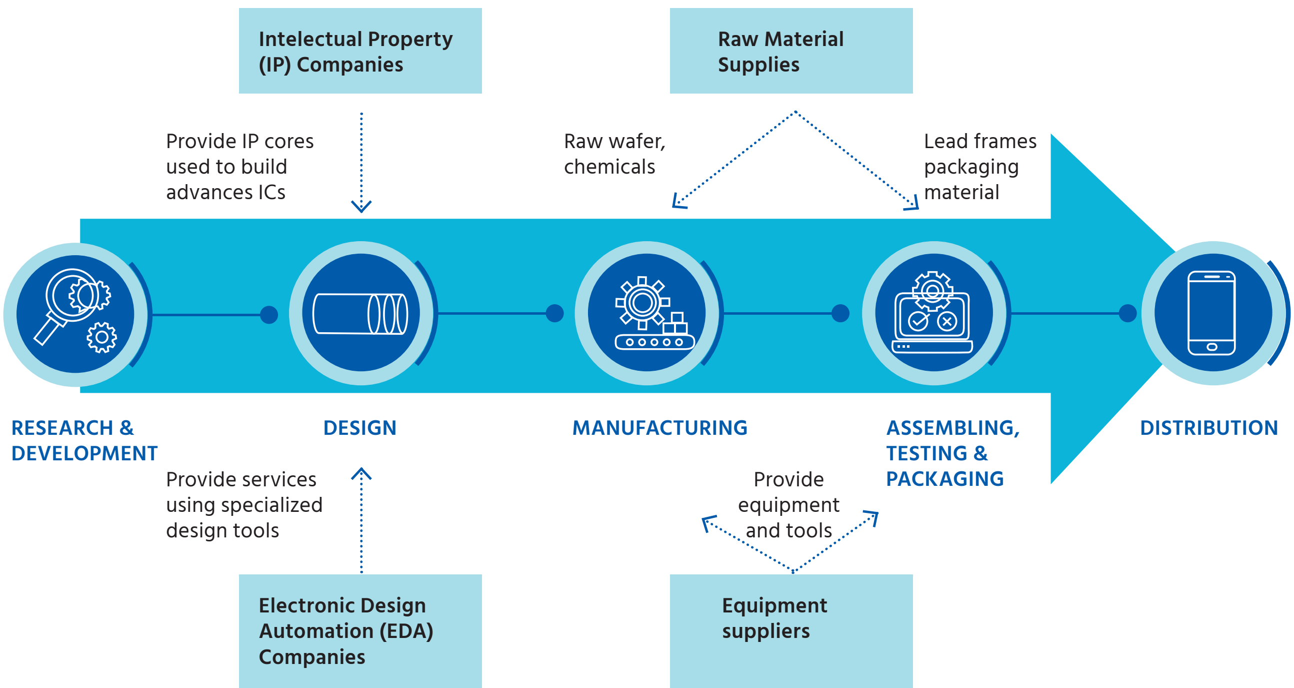


How are Semiconductors Manufactured?

Semiconductor value chains in the semiconductor industry have become hyper-specialized, with critical portions of the global value chain located throughout the world. Highly complex functions in the manufacture of these products are performed at virtually any location that can confer competitive or relative advantage, so long as risks can be managed. There are four basic stages in a semiconductor value chain:

1. **Research and Development**
2. **Design**
3. **Manufacturing**
4. **Assembly, Testing and Packaging (ATP)**, also called Outsourced, Assembly and Testing (OSAT)

Graph IV – The Semiconductor Ecosystem[18]



Source: SIA Beyond Borders

Semiconductor Value Chains Operating Models

Participants in the semiconductor industry fall into four categories:

IDM – A number of companies such as Intel, Samsung and Micron are vertically integrated, meaning that they can perform all phases in-house. These companies fall under the label of integrated device manufacturers (IDMs). For example, Samsung makes chips primarily for their own branded products and finished goods such as smart phones and TVs. Intel is also vertically integrated in that it makes chips for a whole range of its branded components and subcomponents, but it will also sell its chips to third parties.

Fabless – In a separate niche, "fabless" companies focus on the research and design of semiconductors, or, for example the electronic design and automation (EDA) software tools needed to design integrated circuits. These companies do not do any manufacturing.

Foundries - So-called "foundries" specialize solely in fabricating (hence they are also known as "fabs"). A manufacturing foundry's operating model depends on contracts with design firms to perform fabrication.

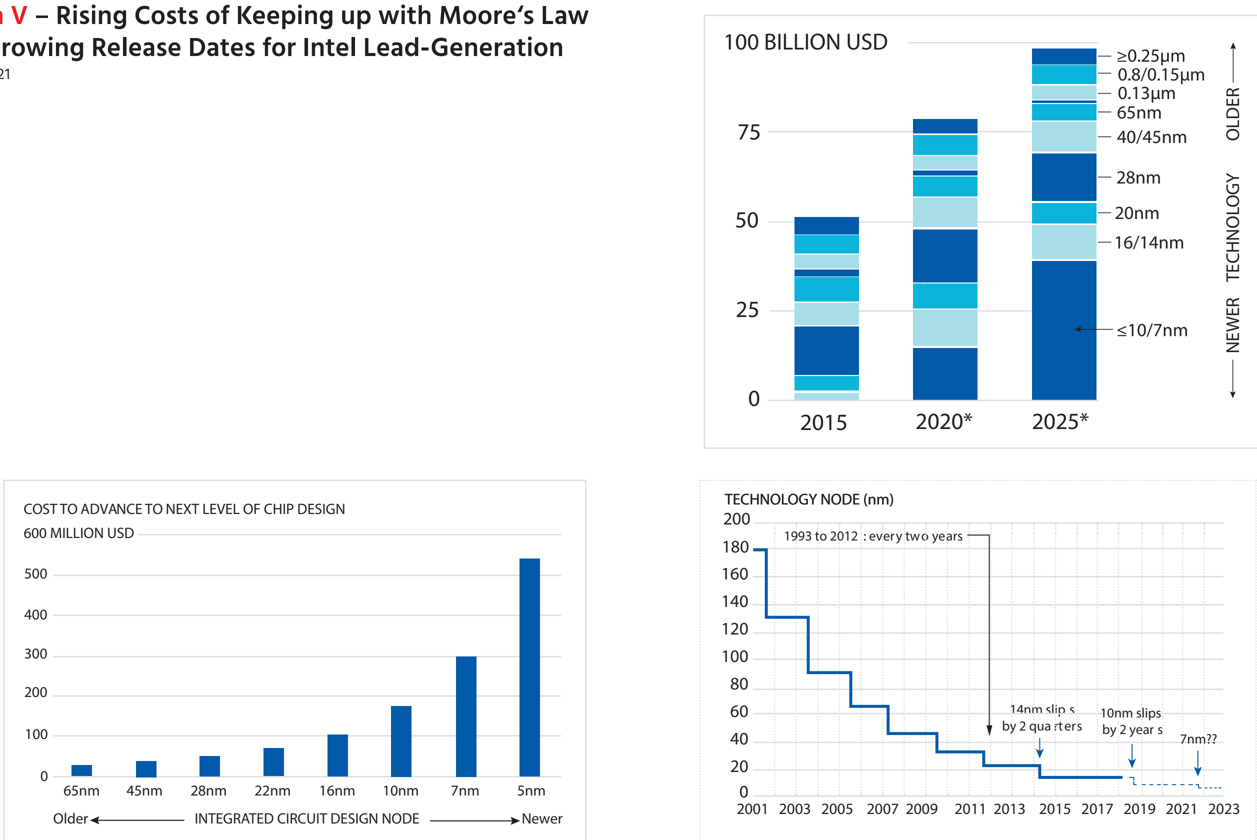
OEM/ODM – Finally, when a microchip completes its journey through the semiconductor global value chain, it will be delivered to an original equipment manufacturer (OEM) or original design manufacturer (ODM) such as Apple, Oracle, BMW or Airbus – where it is incorporated into everything from smart phones, IoT infrastructure, autonomous vehicles and aircraft navigation software. Often, original equipment manufacturers use contract manufacturers for the fabrication of their products, which adds more complexity and interconnectedness to the end of the value chain.

Table I – Operating Models: Semiconductor Industry[19]

<table>
<tr><td rowspan="4">Research & Development
CEA-Leti, IMEC, ITRI, SEMATECH, Semiconductor Research Cooperation</td><td colspan="3">Fabless-Foundry Model</td><td rowspan="4">Distribution (to OEMs/ ODMs)
Allied Electronics, Arrow Electronics, Avnet, Digi-Key, Mouser Electronics</td></tr>
<tr><td>Design (Fabless)
AMD, Broadcom, Media Tek, Spreadtrum, Qualcomm</td><td>Manufacturing (Foundries)
Global Foundries, HH Grace,SMIC, Tower Jazz, TSMC, UMC</td><td>Outsourced Assembly & Test (OSAT)
Amkor, ASE, ChipPAC, JCET, J-Devices, Powertech, SPIL</td></tr>
<tr><td colspan="3">IDM Model</td></tr>
<tr><td colspan="3">Integrated Device Manufacturer (IDM)
Infineon, Intel, Micron, Renesas, Samsung, Texas Instruments</td></tr>
</table>

Source: SIA Beyond Borders

Graph V – Rising Costs of Keeping up with Moore's Law and Growing Release Dates for Intel Lead-Generation Chips[21]



Source: https://worldview.stratford.com/article/us-china-tech-wars-rages-electronics-industry-braces-impact, SCMP Stratford 2019

Semiconductor Manufacturing Cost Breakdown

As Moore's Law[20] reaches its end, the costs of achieving the next breakthrough in a semiconductor have become increasingly expensive and complicated, thus the semiconductor value chain could become more unbundled as it migrates towards firms that not only can absorb escalating costs but also can hyper-specialize in unique areas of the integrated circuit value chain.

Having reached the boundaries of Moore's Law with the silicon-based chip, a race is on to develop the next generation of technologies, including gallium and nitrogen-based materials and quantum computing.

According to the Semiconductor Industry Association, about 90 percent of an IC's value is derived from the design and manufacturing phases of the global value chain.[22]

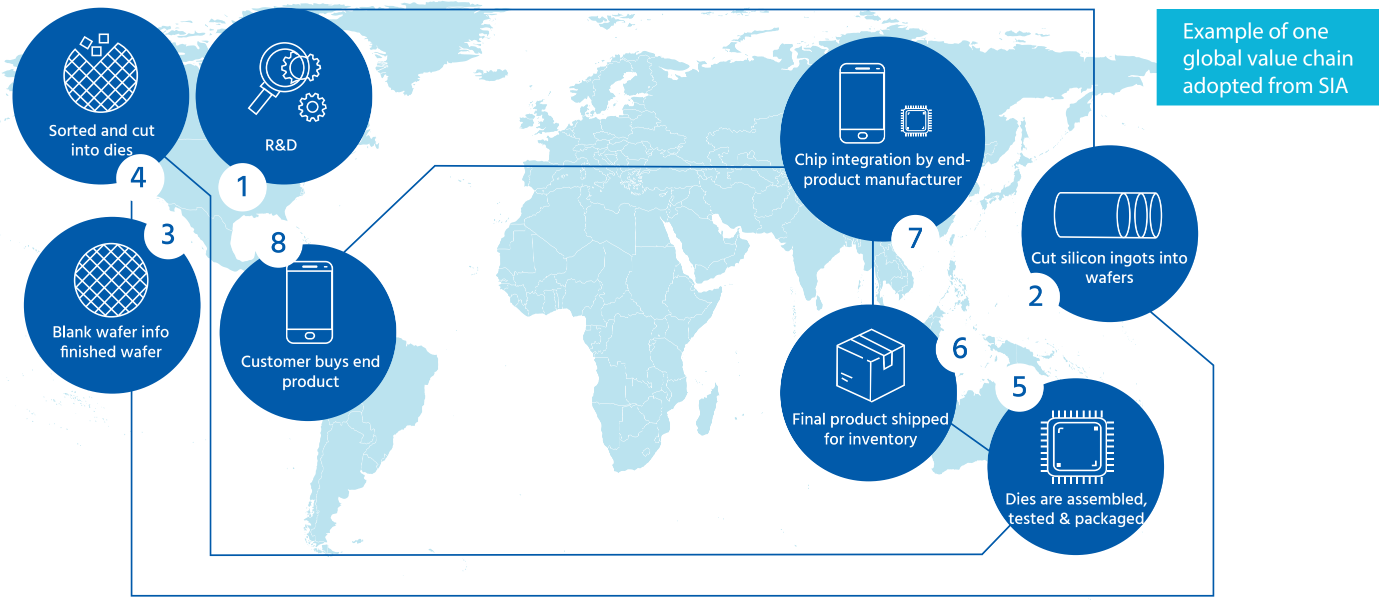
This is an important fact, as this has a direct bearing on the state of China's semiconductor industry, which has been heavily concentrated in the assembly, testing and packaging phase, at the low-value end of the semiconductor value chain — and many of these operations are performed by the subsidiaries of US companies.[23]

This will be discussed later, in more detail, in the context of the US-China tech war and what this could mean for international trade flows should heavy export controls and restrictions be imposed on semiconductors.

Over the past twenty years of globalization, semiconductor global value chains have evolved into the most internationally integrated of any industry. For example, when tracing the end-to-end value chain of a microchip, it may be exported and imported dozens of times, across multiple borders before finally being imbedded into a finished product. For example, consider the following scenario for a standard integrated circuit (see Graph VI Highly Integrated Semiconductor Value Chains):

1. R&D is performed in the US
2. Base silicon ingots are cut into wafers in Japan, Taiwan, Philippines or Korea
3. Ingots are shipped to the US and fabricated into blank wafers
4. The wafers are then sorted and cut into dies within the US
5. Dies are shipped to Indonesia to be tested and assembled
6. Product-ready microchip goes through a centralized distribution center and is shipped to China
7. Microchip is imbedded into end-products in China
8. Finalized products are shipped to customers around the world

Graph VI – Highly Integrated Semiconductor Value Chains[24]



Source: SIA (2019)

Graph VII – Geographic Dispersion: Semiconductor value chains[25]

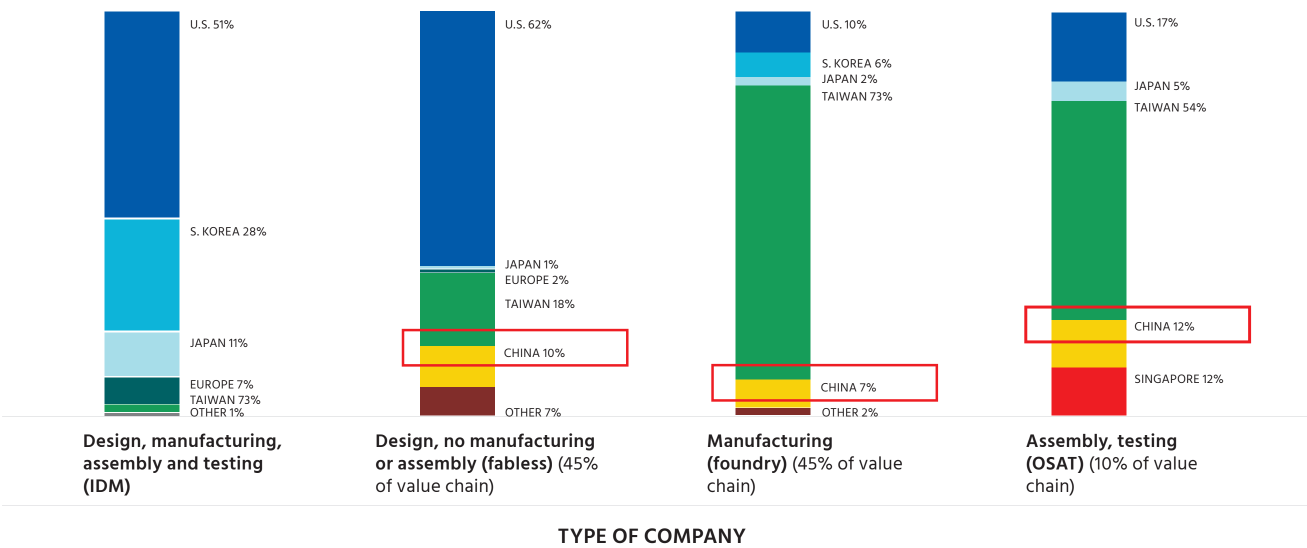
Source: SIA Beyond Borders

A closer look at where semiconductor companies perform their highest value-add activities (the R&D and critical manufacturing stages) reveals that they choose to ring-fence their most valuable intellectual property and keep these processes close to home, while performing the lower-end assembly, testing and packaging in other markets.

For example, Graph VII from the Semiconductor Industry Association (SIA) shows the geographical dispersion of key production activities for leading semiconductor companies Intel and Micron (US); Toshiba (Japan); Samsung (S. Korea); Infineon (Germany) and NXP (Netherlands).

Leading US, European, Japanese and South Korean semiconductor companies all show similar behavior regarding where they have placed strategic assets, formed partnerships and optimized their global value chains.

Graph VIII – Location of Semiconductor Companies, by step in production, in Global Value Chains[26]



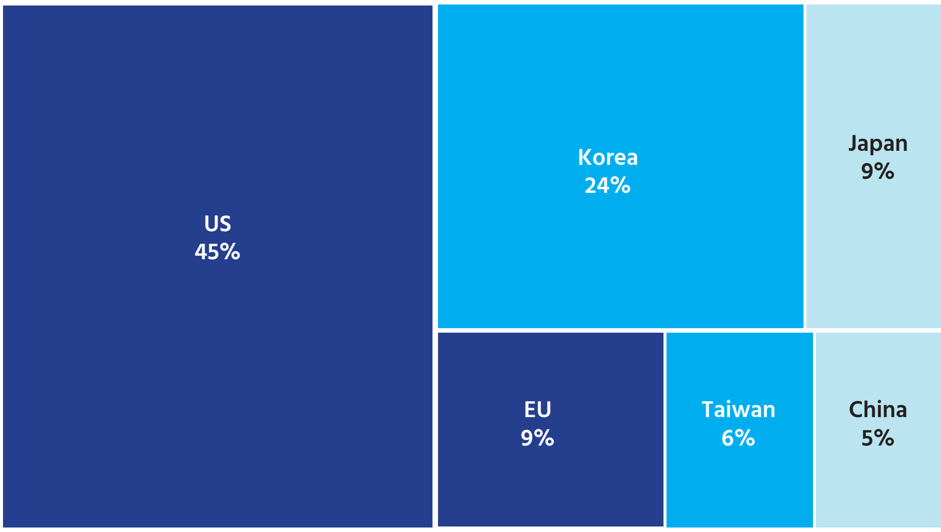
Source: https://worldview.stratford.com/article/us-china-tech-wars-rages-electronics-industry-braces-impact,SCMP Stratford 2019

2. Top Semiconductor Companies: Innovators and Market Leaders

Market share and innovation has been dominated by US and South Korean companies.

The semiconductor industry has been dominated by a small group of companies, comprised primarily of American semiconductor companies, which have been able to build upon first-mover advantage and create high barriers to entry. In the past two decades, however, a handful of Asian semiconductor companies including Toshiba (Japan), Samsung (South Korea) and TSMC (Taiwan), have managed to grow market share.

Graph IX – Global Market Share (Sales: Company Nationality by Market Share)[27]



Source: SIA, World Semiconductor Trade Statistics (WSTS), IHS, Global, PwC

The Asian late-comers benefited from a timely combination of government support, a narrow focus on specialization and innovation, and access to key foreign partnerships and foreign direct investment.[28] Ambitious industrial policies by the Japanese, South Korean and Taiwanese governments assisted these companies to achieve success.

China's semiconductor companies have less than 5% market share and are multiple generations behind in technology.

The Large Gap between China Semiconductor Companies and their Competitors

This begs the question of whether the Chinese government will be able to play catch-up and replicate these success models on a larger scale under its own ambitious Made in China 2025 industry policy objectives or whether the current state of geopolitics will prevent such an outcome.

Given the growing US-China tech rivalry (and the US's historic allies in Europe and Asia) as well as the overwhelming amount of influence that both American semiconductor companies and the US government wield in the semiconductor industry, the answer to this question is far from certain for China.

Graph X, below, provides a snapshot of the top semiconductor companies by revenue and how a select group of multinationals dominate global markets.

What is noteworthy is the conspicuous absence of China semiconductor companies, not only from global markets but also from the China market, which is almost entirely dependent on foreign firms for the microchips required for both its domestic and export markets.

According to the SIA, China's current national champion semiconductor companies supply less than 5 percent of the worldwide market and are at least two generations behind in their ability to produce microchips for consumer electronics.[29]

Graph X – Top Semiconductor Companies 2018[30]

COMPANY	HEADQUARTER LOCATION	OPERATING MODEL	2018 REVENUE (IN BILLION US$)
Samsung Electronics	South Korea	IDM	$65.90
Intel	United States	IDM	$61.70
TSMC	Taiwan	Foundry	$32.20
SK Hynix	South Korea	IDM	$26.70
Micron Technology	United States	IDM	$23.70
Broadcom	United States	Fabless	$17.80
Qualcomm	United States	Fabless	$17.00
Texas Instruments	United States	IDM	$13.90
Toshiba/Toshiaba Memory	Japan	IDM	$13.30
Nivida	United States	Fabless	$9.40
NXP Semiconductors	Europe	IDM	$9.30
ST Microelectronics	Europe	IDM	$830
Infineon	Europe	IDM	$8.10
Sony	Japan	IDM	$7.90
Western Digital	United States	IDM	$7.80

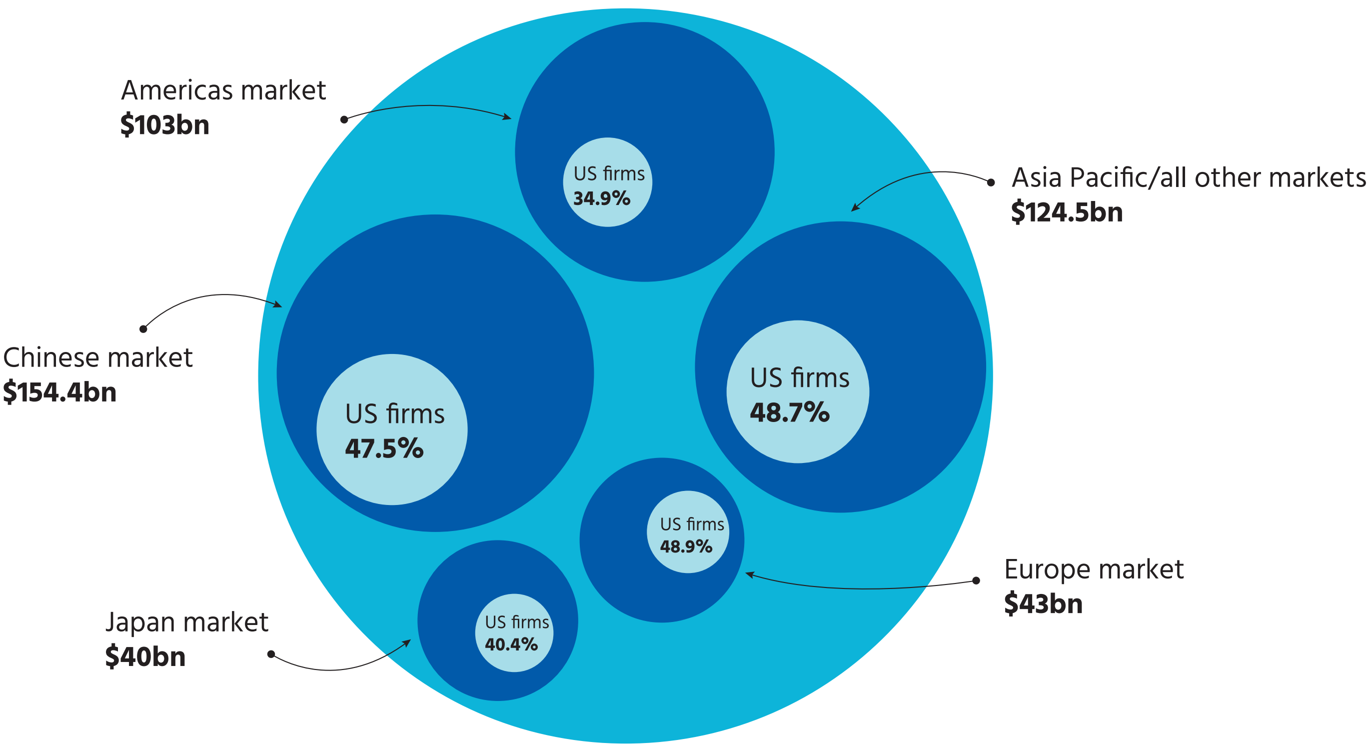
Source; IC Insights (2018)

Dominance of American Semiconductor Companies

American semiconductor companies enjoy a large footprint in all of the world's markets, another indication that should the US-China tech war morph into a full-scale neo-mercantilist rivalry across global markets, the US government and its allies in Europe and Asia could collectively weaponize a substantial installed base of American technology already imbedded in extensive supplier networks and industry.

This also means that should the US government choose to impose additional export controls on American technology there could be extensive collateral damage, impacting American multinational technology companies primarily, but extending well out into their first, second and third levels of suppliers and service providers.

Graph XI – Global Semiconductor Sales and American Semiconductor Companies by Market Share[31]



Source: https://worldview.stratford.com/article/us-china-tech-wars-rages-electronics-industry-braces-impact, SCMP Stratford 2019, Author's compilation

3. China's Semiconductor Industry

China is currently the largest consumer of integrated circuits in the world. In 2018 its imports of microchip technology were valued at $300 billion and exceeded even the cost of its imported oil.[32]

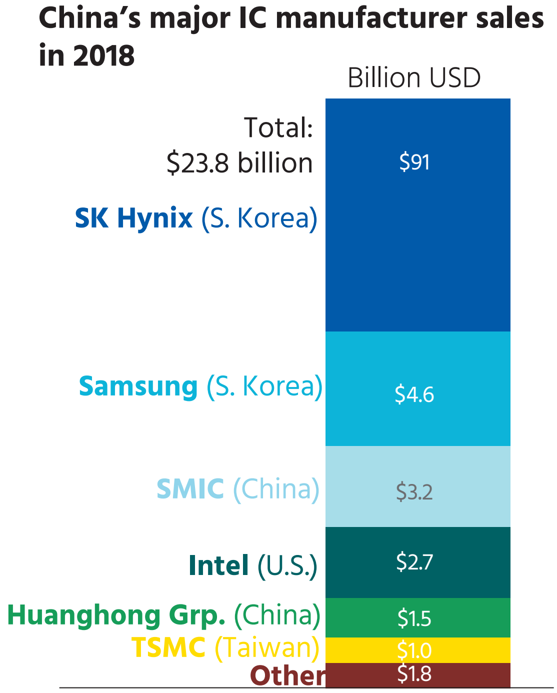
China's Technology Gaps in Semiconductors

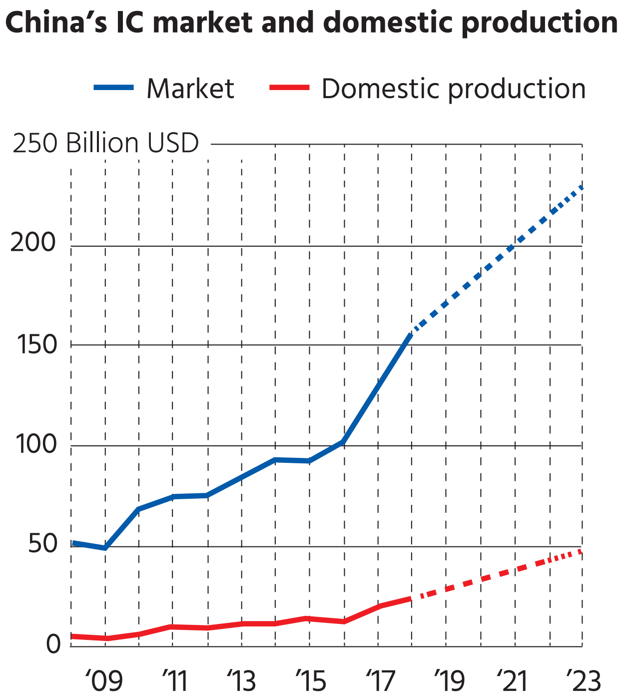
Semiconductor technology is vital to China's economy and its manufacturing base, particularly as it feeds the supply chains of China's top exports, including smartphones (90 percent of global production); personal computers (65 percent) and smart televisions (65 percent).[33]

At home, China's domestic production only accounts for 9 percent of consumption – leaving 91 percent of China's demand to be satisfied by imports, including 56.2 percent from the United States.[34]

Domestically, China produces 16 percent of its semiconductors – yet only half of this amount is manufactured by Chinese companies.[35]

Graph XII – **China's National Champions vs. Global Leaders**[36]





Source: https://worldview.stratford.com/article/us-china-tech-wars-rages-electronics-industry-braces-impact,SCMP Stratford 2019

Can China Produce Semiconductors?

The Chinese Communist Party's Made in China 2025 plan calls for Chinese semiconductor companies to produce 80 percent of chips domestically but this goal is far from being realized. Chinese semiconductor companies accounted for only $4.7 billion out of $23.8 billion worth of local production in 2018.

China's dependence on US and foreign semiconductor technology has been a catalyst for Beijing's doubling down on its Made in China 2025 industrial policies for the promotion of its own homegrown companies.

Chinese Fabless Companies: Slow but Steady Design Progress

In the fabless semiconductor space, for example, Chinese fabless companies have been making progress and have clawed their way to 11 percent of market share[37].

The area of fabless design has seen a surge in the numbers of mainland Chinese firms. According to PWC, between 2010 and 2015 alone, the number of Chinese IC design firms went from 485 to 715, with the largest 20 percent of these firms producing revenues of between $2.3 billion and $16 million.[39]

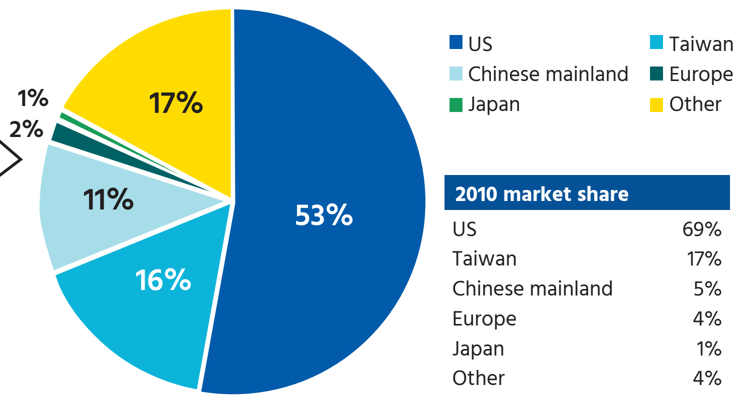
Graph XIII – Market Share of China's Semiconductor Firms[38]

MAKING PROGRESS China's semiconductor firms have slowly but steadily increased their market share

Top Chinese mainland fabless suppliers by revenue

Company	Background	Revenue
HiSilicon	Subsidiary of telecom giant Huawei	$3.87 billion
Tsinghua Unigroup	Government-backed group that acquired Spreadtrun and RDA	$1.86 billion
Omnivision	Founded in California and sold to Chinese Investors in 2015	$893 million
ZTE Micro-electronics	Subsidiary of leading telecom firm ZTE	$506 million
CEC Huada	Subsidiary of central government-controlled enterprise	$506 milliom
Nari Smart Chip	Main supplier to govern-ment-controlled utility firm State Grid	$478 million

Fabless semiconductor industry market share by sales, 2017



2010 market share

US	69%
Taiwan	17%
Chinese mainland	5%
Europe	4%
Japan	1%
Other	4%

Source: IC Insights, Electronic Design

Source: http://knowledge.ckgsb.edu.cnu/2018/11/29/technology/china-semiconductor-industry/

Table II – 2017 China's IC Design Industry's Top Ten Company Ranking

RANKING	COMPANY NAME	SALE (MILLION RMB)
1	HiSilicon	361
2	UNIS Spreadtrum	110
3	ZTE Microelectronics	76
4	Huada Semiconductor	52.1
5	IPCore Microelectronics	44.9
6	Goodix	38.9
7	Hangzhou Silan	31.8
8	Focaltech	28
9	Galaxycore	25.2
10	Vimicro	20.5

Source: PWC

These Chinese tech companies have been able to grow and innovate because of unfettered access to collaborative relationships and partnerships with foreign research and academic institutions, as well as access to foreign companies through acquisitions and other mergers.

The US China trade war and tech war has changed this, however, as will be discussed in the subsequent sections on US export controls and restrictions on acquisitions.

The HiSilicon scenario underscores China's dependence on foreign technology and has been a catalyst for Beijing's massive funding campaigns to produce Chinese technology around critical technologies of the future.

China's home-grown semiconductor industry relies heavily on TSMC, a Taiwanese firm, to meet demand for production of critical 7 nm and 5 nm microchips, and the next generation of integrated circuits, which are currently in the R&D phase. To meet growing demand, in October of 2019, TSMC announced additional capital expenditures of $4 billion to bolster the company's 2019 overall expenditures to between $14-$15 billion.[42]

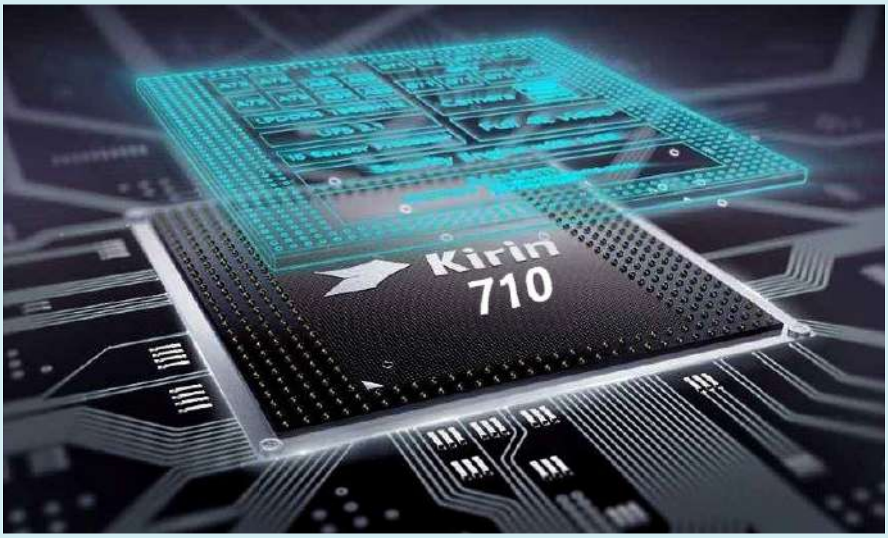
In the wider context of US-China tech war, Taiwan's relations with both the US and China could tilt the tech war significantly one way or the other. The geopolitical significance of Taiwan is discussed in section 8.

New Fab Projects in China

According to SEMI's World Fab Forecast Report, China has the most new fab projects – some 30 new facilities either under construction or in the planning stages — of any country in the world[43]. Of these projects, 13 are said to be fabs targeted at the foundry market.

SPOTLIGHT

Huawei's Latest Microchip Design Capabilities



One revealing insight into China's semiconductor design progress involves Huawei's fully owned subsidiary HiSilicon. The company, which is a fabless microchip maker, has developed an advanced smart phone integrated circuit, which is on par with those used by the iconic US brand Apple.[40]

HiSilicon's chips are vital for competing in the next phase of wireless broadband, 5G, which means it could compete head-to-head with American firm Qualcomm, the world leader in designing 5G compatible processors. HiSilicon's new microchip has a state-of-the art line width of 7 nanometers, which has been verified by Tokyo-based technology "tear-down" firm, TechanaLye.[41]

However, looking more closely at HiSilicon's latest accomplishment reveals a high level of dependence on foreign technology.

HiSilicon cannot design its microchips without licensing the intellectual property from UK-based chip designer Arm Holdings, which was recently bought by the investor group Softbank of Japan.

In addition to not owning vital design IP required to produce its chips, HiSilicon relies on Taiwan Semiconductor Manufacturing Company (TSMC) for its production. Huawei could be vulnerable to US technology controls, since TSMC may still rely on US manufacturing technology for its high-volume commercial production lines.

Thus, as the tech war intensifies, Washington could exert pressure on the Taiwan political establishment to restrict the sale of semiconductors to Chinese buyers, such as ZTE and Huawei.

Multinational semiconductor companies are involved in the most noteworthy projects:

- TSMC (Taiwan) plans to produce 16 nm FinFets44 at a new fab in Nanjing, in addition to the production of 200 nm integrated circuits that it has been producing in commercial quantities at its site in Shanghai. This is part of a phased plan to eventually migrate to a 12 nm integrated circuits. This is a significant development for China semiconductor production.

- Global Foundries (US) is building a 300mm wafer fab in Chengdu, and has announced that it intends to use the fab for production of the company's 22 nm chip, which is suited for 5G, IoT and specialized edge computing.[45]

- Foxconn (Taiwan) and Sharp (Japan) are said to be in talks to build fabs in Zhuhai that will produce specialized 300 nm chips.[46]

- UMC (Taiwan), which has been producing 300 nm integrated circuits in a fab in Xiamen, has been looking to raise funds to produce 40 nm and 28 nm chips. In order to finance capacity expansion, UMC has slated an initial public offering (IPO) of its Chinese unit, Hejian Technology (Suzhou) Co Ltd (although the IPO is on hold at time of writing).[47]

Meanwhile, as of 2019, there is significant overcapacity in the 28 nm niche of integrated circuits in China.[48] SMIC, China's most advanced domestic foundry, has been stuck at the 28 nm threshold as it continues to grapple to produce high yield commercial quantities. SMIC currently does not have the IP, processes or know-how to improve its yields.

By contrast, TSMC, Samsung, Global Foundries and UMC remain two or even three generations ahead of Chinese firms in the 28nm to 14nm range, and in the R&D phases of 12 nm and 7 nm. Within China, for example, Intel is increasing 14 nm production and is in the R&D stages of 10 nm microchip, which is well ahead of SMIC, China's national champion.

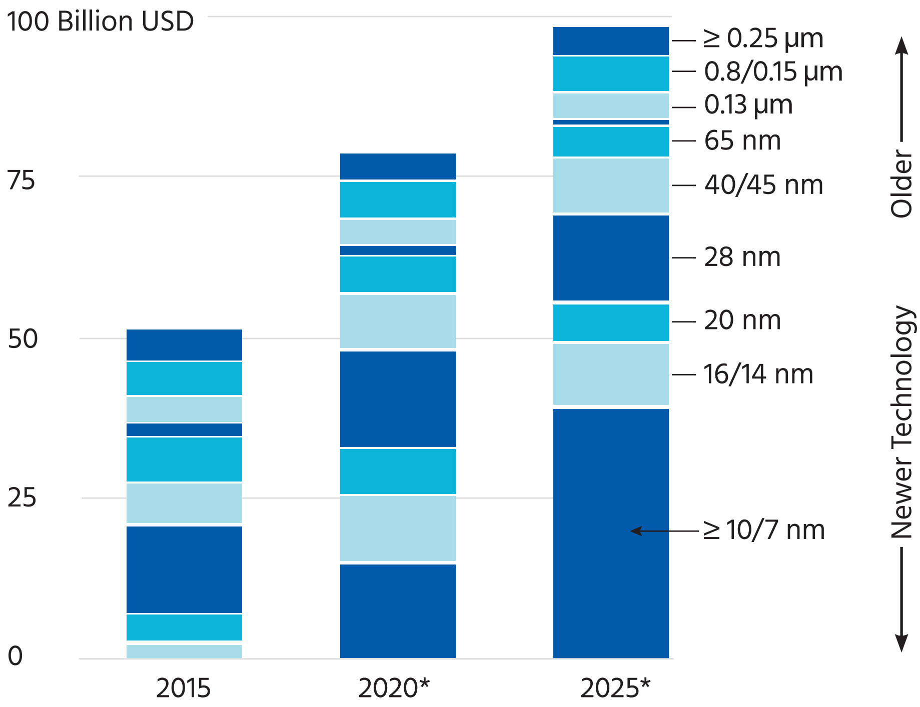
Overall, China's semiconductor companies still have a long way to go before they are able to capture significant domestic market share, particularly in the critical space of microchips below 14 nm.

Semiconductor Demand by Chip Size

Beyond the specialized and lucrative microchip niches below 14 nm, foreign firms still control a large swathe of the Chinese market in such niches as microchip packaging and testing, semiconductor equipment, memory and AI chips, as well as contract microchip making.

An analysis of China's semiconductor development capabilities in 2018 shows the degree of dominance by American semiconductor companies and other foreign firms, throughout all phases of the global value chain.

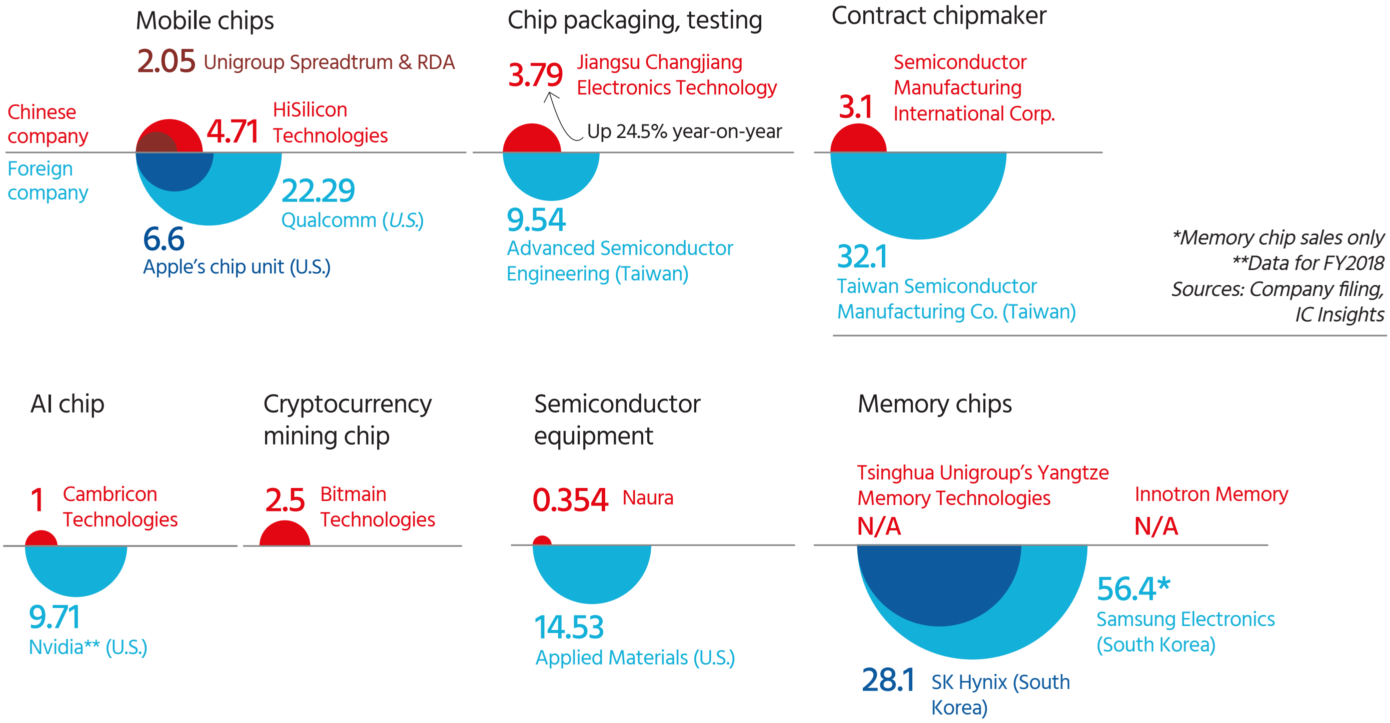
Graph XIV – Semiconductor Demand by Microchip Size



Source: Strat for 2019

Graph XV – Dominance of Foreign Firms in China's Semiconductor Market[49]

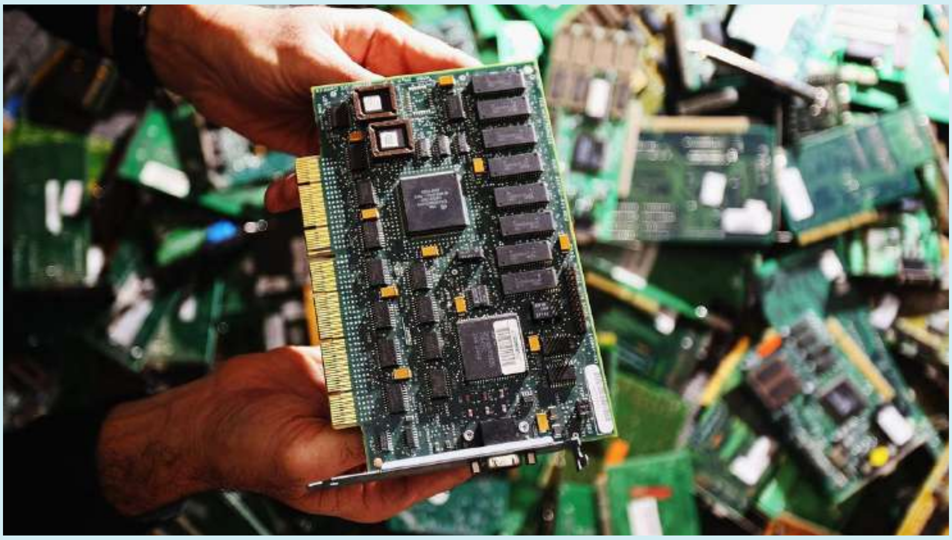
(by revenue, in billions of dollars)



Source: https://asia.nikkei.com/Business/China-tech/Chinese-companies-rush-to-make-own-chips-as-trade-war-bites/

SPOTLIGHT

China's State-backed Production of Memory Chips Could Lead to Overcapacity



For 2020, China's state-backed companies have announced major production increases in both NAND and DRAM — critical memory technology for a broad range of devices, from computers to smartphones.

Yangtze Memory Technologies Co. (which is owned by the state-backed Tsinghua Unigroup), expects to triple production to 60,000 wafers a month, or 5 percent of world output, by the end of 2020 at a new $24 billion plant in Wuhan.[50]

ChangXin Memory Technologies, another state-funded company, has announced that in 2020, it will quadruple production of DRAM chips to 40,000 wafers a month (or 3 percent of world DRAM output) at its $8 billion facility in Hefei.[51]

China's rapid progress in NAND and DRAM production is noteworthy. But it is the business model behind this expanding output that should be getting increased attention from the world's dominant manufacturers in this space.

Despite a steady accumulation of financial losses at Yangtze Memory Technologies, the state-backed company continues to operate normally, has not defaulted on its debts, and continues to receive large amounts of cash as well as the support of key shareholders.[52]

Losses at the group were reported to be $460 million in the first half of 2018.[53]

As China's memory chip production is based on government output targets and other strategic, non-market driven goals, then the possibility of an over-supply of NAND and DRAM chips would seem likely, at some point, which would drive down global market prices. None of this bodes well for the world's existing players in this space.

A recent OECD trade policy paper measured and highlighted the distortions caused by government activities in semiconductor value chains.[54]

4. China's Tech Funds, Government Subsidies and Industrial Policies

China's Made in China 2025 plan is not about market share. It's techno-nationalism at work.

China's dependence on US and foreign technology is not only an issue of national security, it poses a serious impediment to the Chinese Communist Party's geopolitical ambitions as a rising power, as virtually all hard and soft power will depend on achieving technology supremacy.

As such, a massive industrial policy initiative to develop, promote and protect its own China semiconductor industry is underway. This is technonationalism at work.

Made in China 2025

Beijing's Made in China 2025 plan aims to propel 10 key technology sectors to national champion (a.k.a. global leader) status. According to the US Chamber of Commerce, these key sectors comprise 40 percent of China's value-added manufacturing base.[55]

Some estimates put the Chinese Communist Party's funding commitment for Made in China 2025 at $300 billion over a ten-year period.[56] China's key technology sectors include: Next generation IT (AI, IoT), aerospace and aeronautical equipment, automated machine tools and robotics (AI and machine learning), new materials, maritime equipment and high-tech shipping, advanced railway equipment, power equipment, new energy vehicles, biopharma and advanced medical products, and agricultural equipment.

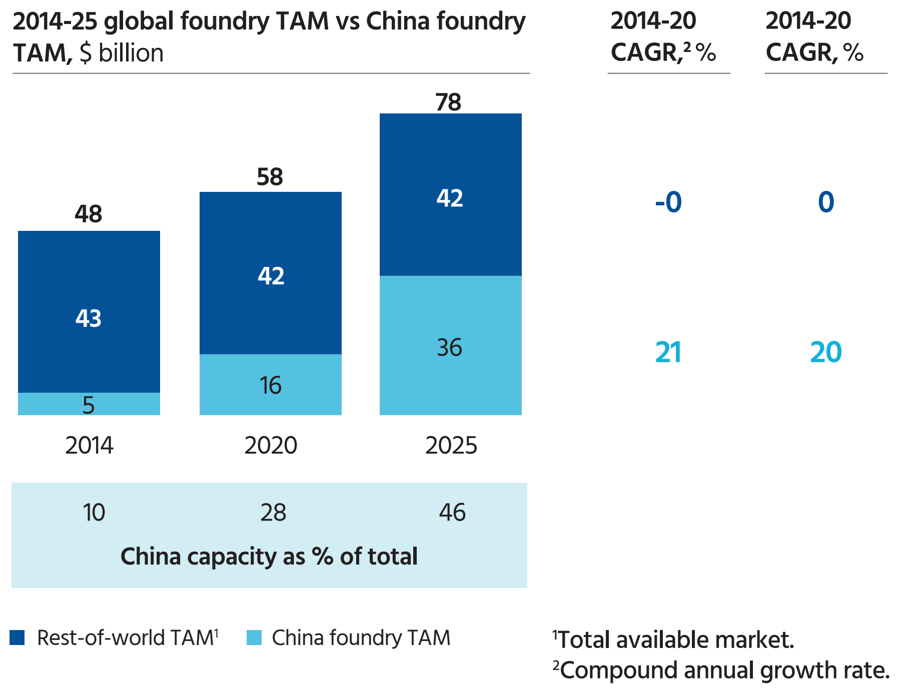
All of these key sectors depend on advanced semiconductors. In 2018, Chinese, Premier Li Keqiang named semiconductors as the top priority of the 10 industries of MIC 2025. As such, integrated circuits have been singled out for special attention and have been receiving funding through an assortment of other state-backed funds.

Beijing has set very aggressive goals for growing China's foundry capacity. According to recent analysis done by McKinsey, in order to meet Made in China 2025 growth targets for China's share of global foundry capacity, virtually all of the foundry capacity growth in the world would have to take place in China (see Graph XVI).[57]

The backlash against China's aggressive funding initiatives is driven by a growing consensus in Washington and other capitals that the Made in China 2025 plan is motivated by the Chinese Communist Party's ambitions for geopolitical power, and is not merely about capturing market share for Chinese state-owned enterprises. As such, it would differ considerably from other contentious industrial subsidy programs, such as the Airbus Consortium in Europe, which focuses solely on capturing market share and is not seen as a geopolitical or systemic threat by the EU's trading partners. This same logic, for example, applies to the ongoing Belt and Road Initiative (BRI)[58], which seeks to build a network of costly hard and soft infrastructure (roads, ports, wireless networks and railways etc.) through some of the world's least developed and more politically unstable countries. In the case of China's new silk road, its objectives are seen by many as purely techno-nationalist.

The China National IC Plan is to spend twice as much on R&D for integrated circuits as the rest of the world combined.

Graph XVI – Made in China 2025 Foundry Targets[59]



Source: McKinsey analysis
Note: For Beijing to reach its national IC plan targets for new foundries, virtually all the global growth in the semiconductor sector would have to occur to China.

China National Integrated Circuit Industry Investment Fund (China's Big Fund)

In June 2014, the Chinese government published "Guidelines to Promote National Integrated Circuit Industry" (the China National IC Plan). The China National IC Plan (also known as the "China Big Fund") called for $150 billion in funding, from both the central government as well as provincial and municipal governments.

Official government numbers claim that, as of 2019, some $29 billion of funding has been secured for the China National IC Plan.[60] As of 2017, the SIA has estimated that provincial and municipal integrated circuits-related funds have raised another $80 billion and are likely to reach the overall China National IC Plan goal of $150 billion.[61]

To put this in perspective, in terms of just R&D spending on semiconductors, SIA reports that US companies spent $32.7 billion in 2018, followed by EU Companies ($13.9 billion) and Taiwanese companies ($9.9 billion). Japanese companies and Korean companies were at $8.8 and $7.3 billion, respectively.[62]

Foreign companies remain drawn to China for its market size, role in GVCS and attractive government incentives.

In addition to the China National IC Plan, however, the Chinese Communist Party has been pumping large sums of money into Tsinghua Holdings[63], the tech investment fund of one of China's top state-led universities, which the Chinese Communist Party has charged with funding and advancing innovation in China's semiconductor industry.

To mobilize these subsidies, grants and other monetary assistance, Beijing is pursuing an overarching strategy that combines both domestic and international dimensions. The end game is to create the next generation of Chinese "national champions" within all the strategic sectors identified in both the National IC Plan and Made in China 2025.

Inward and Outward Investment Strategies

These policies are focused on two key objectives:

- Attracting specifically targeted foreign direct investment and technology into China; and
- Acquiring strategic technology abroad.

Yet, despite all of these requirements and China market access conditions, American semiconductor companies and other foreign players remain drawn to China, primarily because of the China market size and its growing importance in global value chains.

To support the Chinese Communist Party's efforts to attract strategic foreign direct investment, China's technology funds have been instructed to provide US and other foreign companies with generous Chinese R&D incentives to relocate research and processing activities to China.

For example, in the construction of new fabs, Samsung, Intel, TSMC, UMC, Global Foundries and others are availing themselves of Chinese government funding and incentives, including subsidized loans. Local governments including Shanghai (Pudong), Shenzhen and Wuxi are offering incentives to bring high tech manufacturing to those regions. This includes land for free and employee tax savings.

SPOTLIGHT

China's Inward and Outward Investment Strategies

Foreign Direct Investment: Attracting specialized foreign direct investment in semiconductors in exchange for China market access.

According to the Organization of Economic Cooperation and Development (OECD), China has the most restrictive inward foreign direct investment policies of all the G-20 countries.[64]

In 2017, a survey conducted within the semiconductor industry by the US Department of Commerce's Bureau of Industry and Security (BIS), found that 25 US companies – which accounted for more than $25 billion in annual sales — had been required to form JVs and/or transfer technology as a condition of market access.[65]

As recently as May, 2019, after more than a decade of dialogue between Washington and Beijing on matters involving IP protection and tech transfer, the US-China Economic and Security Review Commission, published a paper[66] which stated that, when applying for a license or a permit to operate in a China, foreign firms are still dealing with onerous conditions, including:

- Strict foreign equity caps
- Mandatory joint ventures with designated local entities
- An administrative approval process based on broader requirements, including agreeing to other specified investment parameters and government projects
- Licensing requirements contingent upon the transfer of blueprints, designs and technology
- Requirements that the foreign firms conduct R&D in China
- Concessions regarding the use of local content and export requirements

In October 2019, perhaps as a result of the on-going US-China trade talks, China announced that it would abolish its forced technology transfer requirements for foreign companies. The US-China Business Council – which represents over 200 companies – publicly stated that there was also a need for more transparency and consistent application of these rules, across China. In the past, Chinese government policies have not been implemented uniformly, if at all, across different provinces and municipalities.

SPOTLIGHT

The Impact of Foreign-Invested Enterprise's (FIE's) on China's GDP

Foreign invested enterprises (FIEs) have a hugely under-valued impact on China's semiconductor industry, and, more broadly, China's economy in general.

Simply measuring foreign direct investment in new fab sites or R&D centers, for example, does not accurately measure the on-going economic contribution of FIE's to China's GDP.

According to the China foreign direct investment research commissioned by the Hinrich Foundation to Enright, Scott & Associates, FIE's contribute more than 20 percent of sales, employment, and value added in China's industrial sector, and in some advanced areas – such as computers, autos, and chemicals – the percentages are substantially higher. Since the industrial sector accounts for roughly half of China's GDP, industrial foreign-invested enterprises contribute approximately 10 percent of China's GDP just through their own operations.

There is an FIE economic ripple effect that drives value chains and a multiplier effect from direct and indirect employer wages that can be traced back to foreign-invested enterprises' daily operations.

In China's computer sector, foreign-invested enterprises accounted for 59 percent of industry assets and 57 percent of industry profits in the manufacture of computers, in 2013.[68]

The number of joint ventures in China between American semiconductor companies and local partners — even without the transfer of technology – is benefiting China's economy immensely.

Therefore, should American and Chinese JVs be forced to de-couple, there will be collateral economic damage to the local economy as well as to JV partners and their respective value chain.

Graph XVII: US Semiconductor Firms Joint Ventures in China, 2014-2018[69]

ANNOUNCED DATE	NON-CHINESE COMPANY	CHINESE COMPANY
Jan-14	IBM	Suzhou PowerCore
Mar-14	IBM	Teamsun
Sep-14	Intel	Tsinghua Unigroup
Nov-14	Texas Instruments	Existing Texas Instruments facility expansion
Dec-14	Micron	PowerTech (Taiwan)
Jan-15	Qualcomm-IMEC	SMIC, Taiwan
May-15	Hewlett-Packard	Tsinghua Holdings (Unisplendour)
Jun-15	Broadcom	H3C Technologies Co.
Sep-15	Ciscc Systems	Inspur Group
Dec-15	Qualcomm	SJ Semi (SMIC & Jiangsu Changjiang Electronics Technology JV)
Jan-16	Qualcomm*	Guizhou Province (Huanxintong)
Jan-16	Intel	Tshinghua University and Montage Technology Global Holdings
Apr-16	AMD	Tianjin Haiguang Advanced Technology Investment Company
May-16	Brocade	Guizhou High-Tech Industrial Investment Group
May-16	Dell	Guizhou YottaCloud Technologies
May-16	VMWare	Sugon Information
Sep-16	Western Digital	Tsinghua Unigroup (Unisplendour)
Feb-17	GlobalFoundries	Chengdu Municipality
Mar-17	IBM	Wanda Internet Technology Group
Jul-17	Nivida	Baidu
Feb-18	Intel	Tsinghua Unigroup (Spreadtrum & RDA)
May-18	Qualcomm	Datang Telecom Technology Co.
Note:* = Since dissolved.		

Source: US International Trade Commission, Journal of International Commerce and Economics

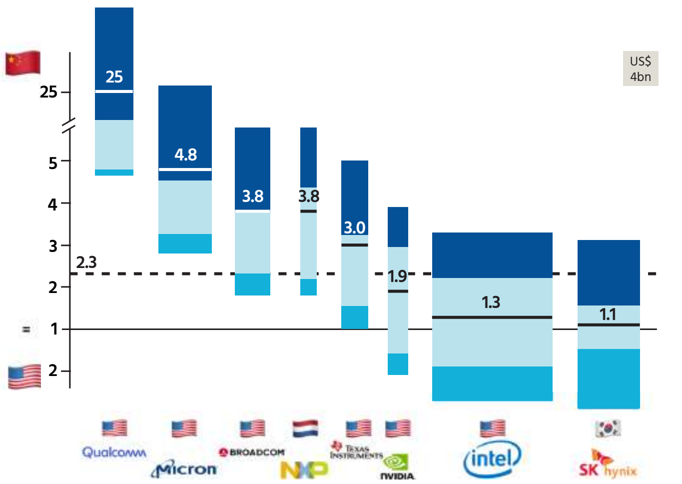
Global Semiconductor Sales: China versus other Markets

American firms have been transforming China's semiconductor industry for years. This has occurred primarily through joint ventures. However, these same American semiconductor companies have been instrumental in driving the transfer of human capital via US universities and R&D institutions and industry associations, which have benefited China greatly.

As the below graph shows, for most foreign and American semiconductor companies and specialized equipment makers, growing portions of their revenue are directly attributable to China, which is the world's largest consumer of integrated circuits.

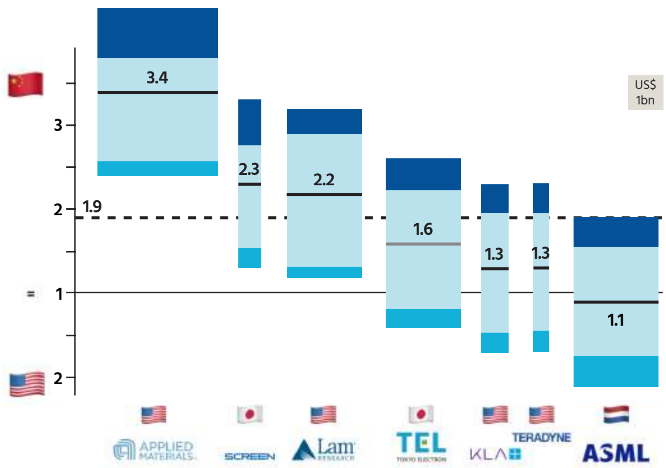
Graph XVIII: Global Semiconductor and Specialty Equipment Sales: China versus USA Sales: American & Foreign Firms[70]

Semiconductor suppliers



Sales	Qualcomm 22.7		Micron 30.4		Broadcom 20.8		NXP 9.4		Texas Instr 15.8		Nvidia 11.7		Intel 70.8		SK Hynix 36.2		Total 217.8	
(bn US$)	US$	%	US$	%	US$	%	US$	%	US$	%	US$	%	US$	%	US$	%	US$	%
China	15.1	67	17.4	57	10.3	49	3.4	36	7.0	44	2.8 24		18.8	27	14.1	39	88.9	41
US	0.60	3	3.6	12	2.7	13	0.9	10	2.3	14	1.5	13	14.3	20	12.8	35	38.7	18

Semiconductor equipment



Sales	Applied Materials 17.2		Dainippon Screen 3.3		Lam Research 11.1		Tokyo Electron 10.5		KLA 4.0		Teradyne 2.1		ASML 12.5		Total 60.7	
(bn US$)	US$	%	US$	%	US$	%	US$	%	US$	%	US$	%	US$	%	US$	%
China	5.1	30	0.9	27	1.8	16	1.9	18	0.6	16	0.4	17	2.1	17	12.8	21
US	1.5	9	0.4	12	0.8	7	1.2	11	0.5	12	0.3	13	2.2	18	6.9	11

Source: Bart van Hezewijk, Holland Innovation Network China

The US China Decoupling of Semiconductor Companies

Given the degree of penetration into the China semiconductor industry as well as integration within global value chains, decoupling of American semiconductor companies from the China market and relevant industry would have a traumatic impact on the entire technology industry, and alter the global economic landscape.

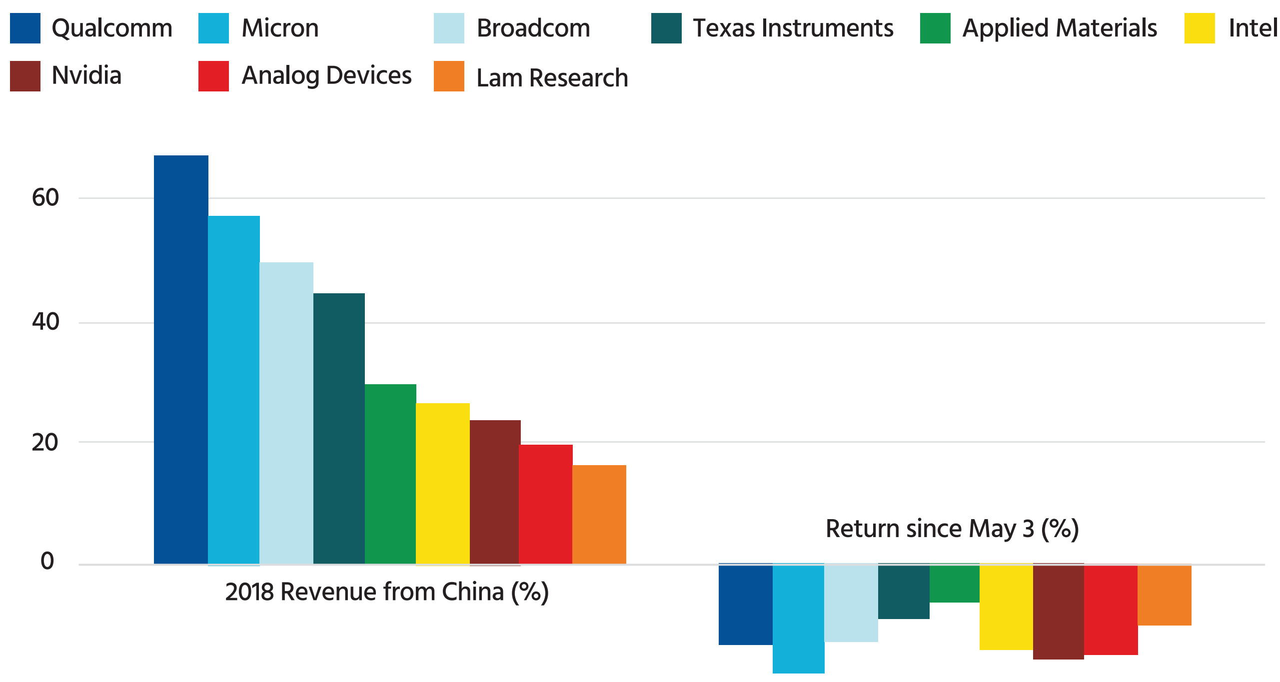
Because key technology sectors require a steady supply of leading-edge integrated circuits, a sudden ban or severe reduction of these integrated circuits would result in manufacturing slow down and unfulfilled demand across a broad spectrum.

To put this into perspective, more than 60 percent of Qualcomm's revenue came from China in the first 4 months of 2018 (see below chart); for Micron, over 50 percent; for Broadcom about 45 percent.[71]

In the case of Broadcom, the Huawei ban and overall market uncertainty from the US-China tech war has prompted the company to revise its 2019 revenue estimate down by $2 billion.[72]

All other semiconductor companies have seen a similar decline in their 2018 business.

Graph XIX – **US Semiconductor Company Revenue from China Sales (2018)**[73]



Source: Ned Davis Research

Chinese acquisitions of US technology companies have been substantial and often state-funded.

Technology Acquisitions by Chinese State-funded Actors

Chinese investors have taken advantage of generous government funding for technology acquisition to attempt to invest in large projects with key niche players in the semiconductor industry, primarily in the US.

By providing state funds for acquisitions of foreign technology companies, the Chinese government has been able to stay directly involved in orchestrating its broader objectives of the China National IC Plan and Made in China 2025.

Acquisition of American technology and businesses peaked in 2015, when Chinese entities were involved in 34 announced mergers and acquisitions with American companies, valued at $8.1 billion.[74]

Digital Horizon Capital, a Chinese technology fund, has been used extensively by the Chinese government to invest in strategic overseas targets. The fund has invested in 113 US companies which the Chinese Communist Party has identified as strategic priorities.[75]

Digital Horizon Capital's focus has been on an across-the-spectrum approach to acquiring critical technologies, including:

- Micro-electronic mechanical devices (MEMs)
- Memory chips
- Advanced microchip making materials

China's state-backed venture capital firms have been active in Silicon Valley in targeting start-ups working on innovations that can be incorporated into semiconductor niches along global value chains.

Westlake Ventures is a Silicon Valley-based entity that receives funding from the Chinese City of Hangzhou.[76] Another Silicon Valley-based VC fund is ZGC Capital Connection, which lists itself as a subsidiary of a state-owned enterprise funded by the Chinese government.[77]

A start-up tech company could make the argument that any money is better than no money, even if it comes from a Chinese state-backed company. Ultimately new capital can propel a company to create new innovations and economic opportunities that benefit the entire industry. The challenge arises when previously silent investors gain enough control over a start-up company to steer its strategic decision making and facilitate intellectual property theft.

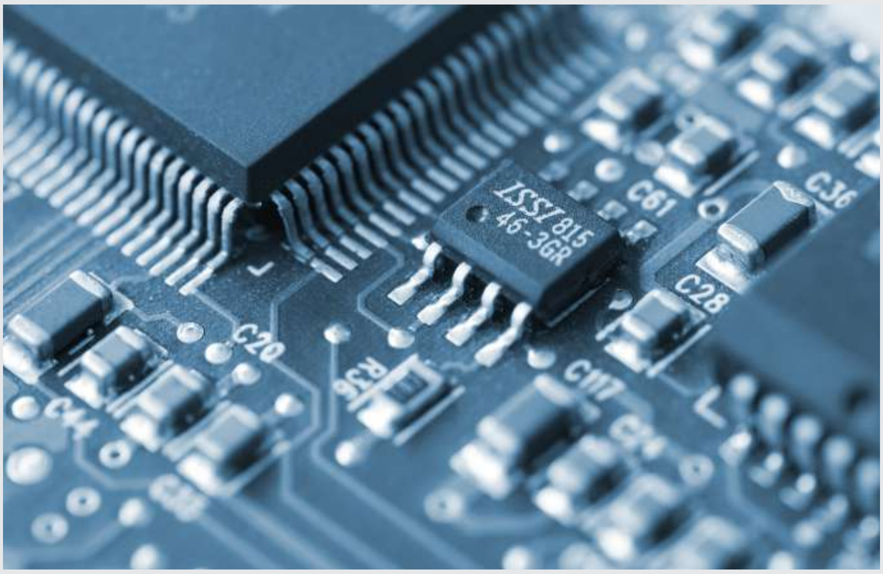
Dealing with Chinese entities that have (or could have) linkages to the Chinese government, has added huge risks and complexities for technology firms as they face the dangers of intellectual property theft or having their Chinese partners turn up on the BIS entity list or another Restricted Entity List.

The purchase of Atop Tech went ahead despite concerns, but it soon attracted the attention of US agencies doing national security reviews and even beyond, in the EU.

The Atop Tech acquisition went on to become a catalyst for the revamping of The Committee on Foreign Investment in the United States (CFIUS), the US government committee assigned with reviewing mergers and acquisitions of US companies and "dual use technologies" or other strategic assets.

CASE STUDY

California Chip-Designer Atop Tech and a Mysterious Chinese Buyer



In early 2011, California-based microchip designer Atop Tech, a company with a $1 billion market share in electronic-design automation (specialized software) and integrated circuits markets, filed for bankruptcy in a Delaware court.

A Hong Kong listed company, Avatar Integrated Systems (which had been set up at the same time that Atop was filing for bankruptcy) moved to buy Atop. Avatar had a sole director listed in its incorporation papers.

The individual listed was a Chinese steel magnate, who also controlled another Hong Kong-based company that was the major shareholder in Avatar.[78]

For observers within the semiconductor industry this was a text-book example of the Chinese government working with a proxy for strategic technology acquisition.

5. US Export Controls and the BIS Entity Lists

The tech war is driven by national security concerns in both the US and China.

The Trump Government and the security establishment in Washington claim to have implemented what they consider to be necessary protectionist policies and counter-measures to China's long-standing "predatory" industrial policies.[79]

Washington's countermeasures aim to impede the Chinese Communist Party's ability to promote technology transfer and IP transfer to Chinese entities — either by stopping sales of technology, stopping investment flows into China's semiconductor industry or blocking the acquisition of strategic assets from US and foreign companies by Chinese state-backed entities.

The protectionist policies used by the US security establishment to achieve this goal include:

- Export controls and export licensing of "dual use technologies"
- Restricted entities/parties such as the BIS Entity List
- Blocking of mergers and acquisitions by the Committee on Foreign Investment in the United States (CFIUS)

All of these "non-tariff measures" have a disruptive effect on global value chains in the semiconductor industry, with far-reaching implications for second, third and fourth-tier suppliers.

Export Controls of "Dual Use Technologies"

The Bureau of Industry and Security (BIS) of the US Department of Commerce enforces export controls on all items on the Commerce Control List (CCL). The Commerce Control List covers information, goods and technology, and places special restrictions on exports.

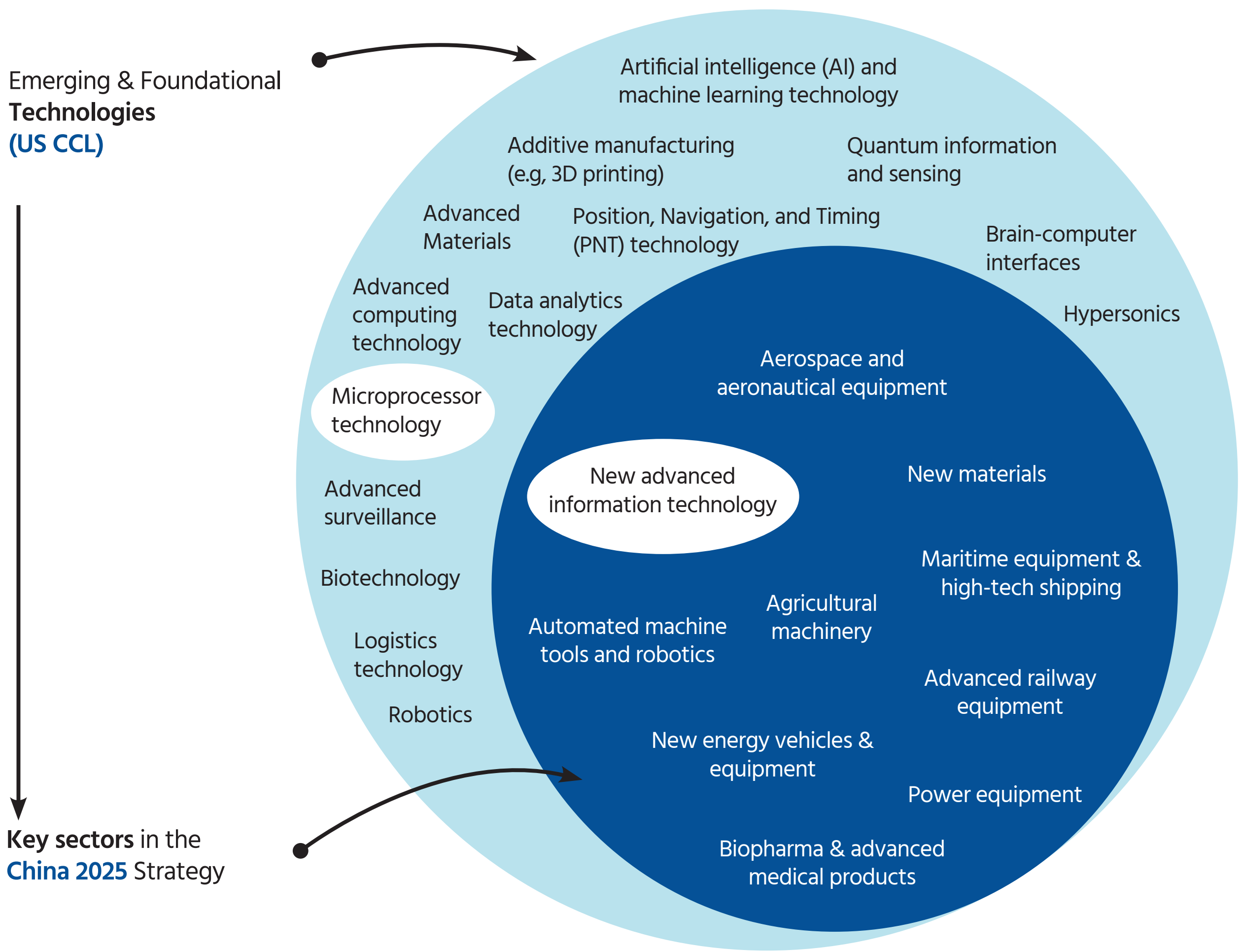
A core feature of the Commerce Control List is the concept of "dual use technology" which applies to any commercial information, goods or technology which could be converted or used for military purposes.
It is necessary to obtain a license before exporting, re-exporting or transferring a controlled technology or item, depending on its destination (which country), the identity of the actual buyer and the intended use of the item.

In 2018, the US passed the Export Control Reform Act (ECRA)[80], which was largely a result of the US-China trade war and broader narrative shift around the link between technology and national security.

Under ECRA, the BIS is reviewing the addition of newly "emerging" and "foundational" technologies[81] to the US Department of Commerce's Controlled Commodity List.[82] The importance of emerging and foundational technologies was acknowledged as early as 2012 by the US government, but there had not been significant follow-up on the issue until the roll out of the ECRA.

All 10 categories targeted by Beijing for development under Made in China 2025 are either already classified as dual use technologies or will likely end up on the Commerce Control List, as such.

Graph XX – **Made in China 2025 & US "Dual Use" Commerce Control List**[83]



Source: Federal Register/Vol 83, No. 223/Monday, November 19, 2018; Bertelsmann Foundation China 2025, Author's compilation

As graph XX, shows, virtually all industries of the future could be designated dual-use technologies and subject to licensing or restricted entity laws, including every category of goods in Made in China 2025.

China's Military-Civil Fusion Initiative

In addition to committing funding for the Made in China 2025 plan and the various large funds for the semiconductor industry, Beijing has appropriated special technology funding to promote what the Chinese Communist Party calls "military-civil fusion".

The Chinese government has launched a series of state-backed venture capital technology funds that are designed to bring together tech startups and other private companies with the People's Liberation Army (PLA). In 2017, for example, the Foshan Military-Civil Innovation Industries Fund was launched to the tune of $28.75 billion[86].

China's military-civil fusion funding campaign virtually ensures that innovations and technologies (not just in semiconductors) pertaining to the industries of the future will be considered dual use technologies, and therefore, end up on the US Commerce Control List.

Wassenaar and the International Application of Export Controls

The US is pushing for ECRA approach to be adopted under the multilateral framework of the Wassenaar Arrangement , with the aim of preventing Chinese tech companies from replacing US semiconductor technology with identical (if it is available) technology from other countries.

Key countries in semiconductor GVCs such as Taiwan and Singapore are not members of the Wassenaar but generally follow its rules and application of standards. A key question, therefore, is whether Taiwan, for example, would enforce new, more stringent rules on semiconductors intended to block China's access to key technology.

Source: Dji/Amazon

The European Union recently described China as a "systemic rival", thus despite the fact that the Wassenaar Arrangement is a voluntary rules-framework, the EU appears willing to align with the US on matters regarding EU technology and national security.

This scenario is already playing out: after facing pressure from the US, Dutch authorities have delayed the issuance of an export license to ASML (Europe's largest maker of highly specialized chip making machines) for technology sales to SMIC, China's semiconductor national champion.[88]

ASML makes extreme ultraviolet lithography chip tools (EUVs), which are required by foundries to produce state-of–the-art integrated circuits in commercial volumes. Each EUV machine is valued at approximately $150 million. Should SMIC be blocked from acquiring this technology, its ambitions of achieving domestically produced, leading edge microchips will be thwarted.

The BIS appears willing to draft unilateral semiconductor agreements with specific countries such as the Netherlands. Just as an increase in bilateral trade agreements between two countries could undermine the spirit of multilateralism and the WTO, an increase in bilateral export control agreements could undermine the Wassenaar Arrangement. This is yet another example of how techno-nationalism could fracture the global trade landscape.

Export Control Classification Numbers (ECCNs) and Supply Chain Traceability

Under the US Export Administration regulations (EAR), the BIS assigns 5-character alphanumeric ECCNs to goods, software and technology. Most ECCNs are harmonized across multilateral regimes such as the Wassenaar, thus, enable international application of export controls among different countries.

An ECCN determines whether an export control license is needed by an exporter (depending on destination and buyer). As controlled goods, software or technology that moves through semiconductor global value chain companies must be closely tracked and traced using ECCN.

From a supply chain perspective, tech firms must commit time and resources to track and trace ECCNs in order to manage:

- **The de minimis rule** – Applies to US controlled content that is incorporated into foreign made products. If an item contains more than a certain percentage of US origin by value it requires an export license. This is important as even goods made outside of the US with American technology could be subject to export controls and cannot be sold to restricted parties.

  The de minimis rule will be discussed later, in Section 7, as a reason why semiconductor companies may look to restructuring value chains to circumvent export controls in order to maintain a profitable business – while still complying with all relevant export control laws.

- **End-use of the technology** - Exporters must ensure that the ECCN is used for the purposes described in the export license application, thus they must put in place processes to verify who the end user of the technology is and how it will actually be used.

Tracing ECCN's in the Semiconductor Value Chain

As was described earlier, semiconductor value chains are highly complex, with niche players operating hyper-specialized functions and operations throughout.

In the below example, ECCN's apply to the design, materials, production testing and end-use of the semiconductor value chain. As materials, parts, components, sub-components, software and equipment move around the world, companies must track and trace everything, obtain licenses or refrain from transacting business with restricted entities and customers in certain countries.

Failure to manage this process results in fines, penalties, loss of export privileges and criminal prosecution.

Graph XXI – Export Control Classification Numbers (ECCNs) along a semiconductor global value chain[88]

	Design	Materials	Production	Testing	Incorporation & End-use
ECCN	Semiconductor design/ development technology **ECCN: 3E003.b.**	Hydrogen fluoride **ECCN: 1C350d.1** Fluorinated polyimide **ECCN: 1C009.b** Photoresists **ECCN: 3C002.a**	*Semiconductor production technology* **ECCN: 3E003.d** *Semiconductor manufaturing equipment* **ECCN: 3D991 or 3D001** *Semiconductor production and manufacturing equipment* **ECCN 3B001**	Testing equipment for semicondutors **ECCN: 3B002.b / 3B992.b**	**End-use determination** mass market products vs. non-civilian purposes **De minimis consideration**
Software	Computer aided design software for semiconductor design **ECCN: 3D003**		Software for the production of semiconductors **ECCN: 3D001**	Software "specially designed" for the "use" of equipment controlled by 3B001.a to .f, or 3B002. **ECCN: 3D002**	Mass market software **ECCN: 5D992.c** Software "specially designed" for the "development," "production," operation, or maintenance of military aircraft **ECCN: 9D610**

Source: Author's Compilation

Export controls force manufacturers to replace component suppliers across their global value chains.

Blacklisted Entities/Parties, Specially Designated Nationals (SDNs)

A denied or restricted party is any entity with which a US company or individual is forbidden to do business. In May of 2019, the US government famously placed Huawei, China's telecommunications giant (and 68 of its non-US affiliates in other countries), on a so-called restricted entities or "US blacklist", which effectively banned the sale of American technology to Huawei. In this scenario, the application for an export license would be presumed denied.

Semiconductor Value Chains Are Deeply Entangled

According to Ken Hu, one of Huawei's rotating chairmen, the company has more than 13,000 suppliers globally, and it purchased some $70 billion in components and parts in 2018. These technology industries include suppliers from across the globe and in the US, including Intel, Qualcomm, Broadcom and Xilinx Inc.[89]

In the same timeframe, Huawei bought approximately $11 billion worth of microchips from American technology companies alone.

Fully executing a technology ban on Huawei, therefore could have a disruptive impact on a tectonic scale, not just on US companies, but on the semiconductor industry as a whole, as an entire industry comprised of supplier networks, service provider relationships and manufacturing operations are forced to adjust.

Take for example, the US companies that, until recently, suppled microchips, design software and operating systems for Huawei's P30 Smart Phone, below.

As a result of its designation as a restricted entity, however, Huawei claims to have replaced all US technology from the P30 Smart Phone. As such, the US companies previously in the P30 global value chain provide compelling examples of the collateral damage inflicted by export controls. Once a company is decoupled from a customer relationship under an export controls scenario, it is unlikely that it will ever recapture that business.

Restricted entities in the semiconductor space are not limited to technology companies. Take an example where an exporter wishes to sell or transfer a semiconductor material used in the fab process called photoresists (ECCN 3C002) to a foreign entity – assuming, in this scenario, that this foreign buyer was a named restricted entity. See Graph XXI.

This example shows the wide range of different kinds of entities that could be subject to restrictions if they are named as restricted entities or specifically designated nationals (SDNs). These could include:

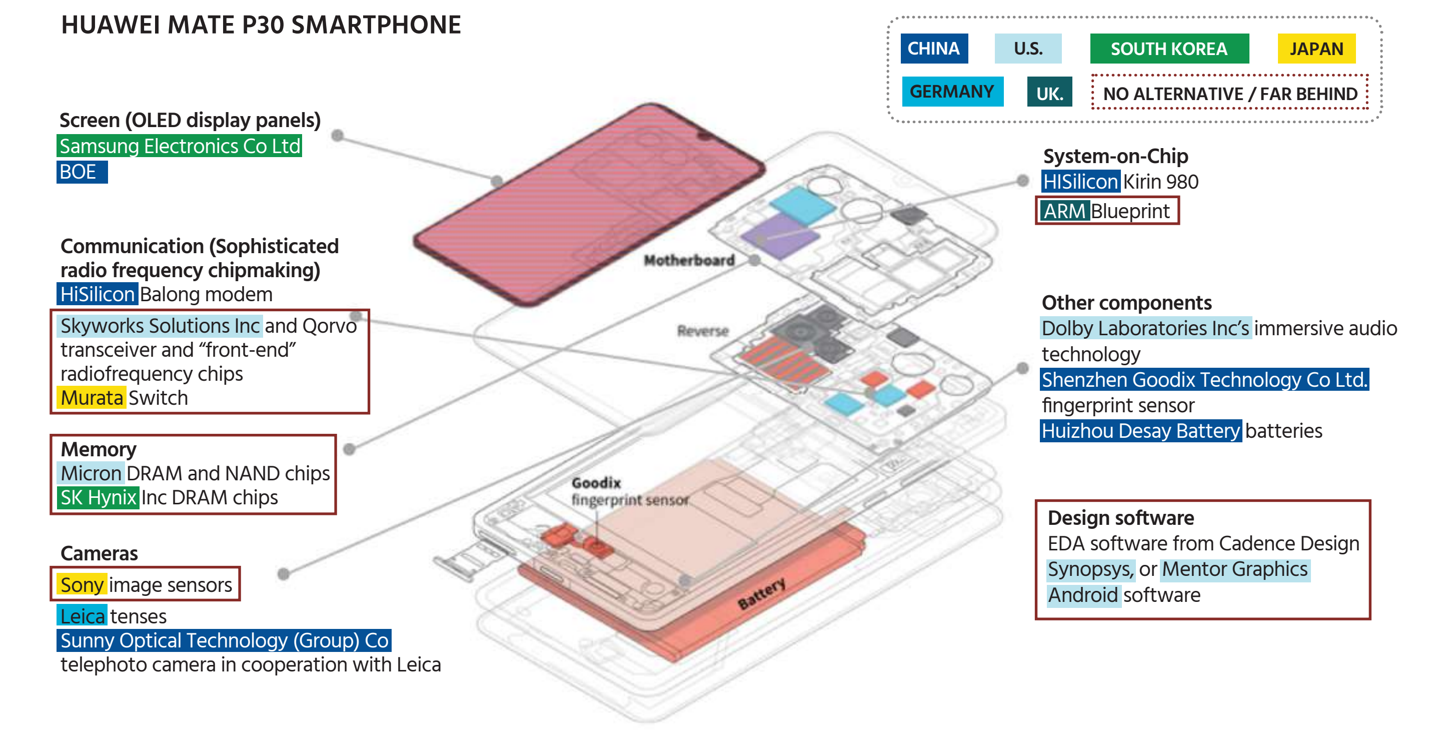
- Individual end-users (persons), who may be denied access to the end product (even an email or a text message to a restricted foreign national on the SDN list is considered a deemed export, and, therefore, illegal).
- Financial institutions, who may be banned from processing transactions for a buyer or supplier named on an OFAC SDN list
- Academic and research institutions, who may be prevented from using the component in their research
- Professionals, academics, subject matter exports, consultants that have been placed on Restricted Entity Lists or are subject to restrictions
- Manufacturers and assemblers, other technology companies that have been placed on Restricted Entity Lists or are subject to restrictions.

American Technology (Previously) inside Huawei's P30 Smart Phone

Table III – Huawei Smartphone US Technology Providers[90]

COMPANY	FEATURE	COUNTRY	NEW STATUS
Skyworks Solutions	Radio Frequency Chips	United States	Replaced/Changed
Qorvd	Radio Frequency Chips	United States	Replaced/Changed
Micron	DRAM and NAND Chips	United States	Replaced/Changed
Mentor Graphics	Design software	United States	Replaced/Changed
Cadence Design	Design Software	United States	Replaced/Changed
Synopsis	Design Software	United States	Replaced/Changed
Google Android	Android Operating System	United States	Replaced/Changed

Source: US Department of the Treasury



Source: Reuters China's Chip Challenge

Graph XXII – **Export Control Classification Number 3C002.a - Selected List of Chinese Restricted Entities 9/2019**[91]

PHOTORESISTS
ECCN 3C002.a
A light sensitive polymer used in semiconductor fabrication

ACADEMIC INSTITUTIONS
- Changchum Institute of Applied Chemistry, Chinese Academy of Sciences
- Guangdong University of Technology
- Nanchang University
- Beijing University of Aeronautics (BUAA)
- Renmin University

BANKS / FINANCIAL INSTITUTIONS*
- Ryugyong Commercial Bank
- DCB Finance Limited
- Hana Banking Corporation Ltd.

LOGISTICS / TRADING COMPANIES**
- Dalian Sun Moon Star International Logistics Trading Co., Ltd.
- Golden Start Trading & International Freight
- Guangzhou Syriss Logistics & Services

VARIOUS INDIVIDUAL END-USERS
- Yan, Xiaobing
- ZHANG, Keping
- SUN, Sidong
- LI, Fangwei
- Etc ...

CORPORATE END-USERS
- Hebei Fas East Communication System Engineering
- North Huawei *** Technology Co., Ltd.,
- Shijiangzhuang Communication and Control Technology Institute

TECHNOLOGY COMPANIES
- Beijing Opto-Electronics Technology Company
- Shanghai Haisi Technology Co., Ltd
- Sino Superconductor Technology Company
- Zongyi Superconductor Technology Co., Ltd.

MANUFACTURERS/ ASSEMBLERS
- Xi'an Micromach Photon Manufacture Technology
- Hebei Seminconductor
- Xian Semi Electronic Co., Ltd

**Most are actually North Korean banks with China branches*
***Many China 3PLs are linked with or also function as trading companies*
****For Huawei Companies, there is currently a 90 day reprieve for licensing requirements expiring on 19 November*

CFIUS appears poised to block virtually any mergers and acquisitions in the semiconductor industry involving American and Chinese semiconductor companies.

Chinese Acquisitions of US Companies

The purchase of California-based chip designer Atop Tech by Avatar, the Hong Kong listed company, played an instrumental role in the recent enlargement and enhancement of powers granted CFIUS.

But the semiconductor industry had already been undergoing a gradual ratcheting up of controls and blocked deals involving Chinese entities. Since Beijing's roll out of Made in China 2025, the China National Integrated Circuit Fund and its Foshan Civil-Military Innovation Industries Fund, CFIUS appears poised to block virtually any mergers and acquisitions in the semiconductor industry involving American and Chinese semiconductor companies. Below are a few examples of early activity in this area.

Blocked Chinese Technology Acquisition Deals

Aixtron (2016) – US President Obama blocks the Chinese firm Fujian Grand Chip Investment Fund from acquiring Aixtron, a German-based semiconductor firm with US assets because the acquisition would have also included the company's US subsidiary and assets in California.[94]

GSR Ventures (2016) – CFIUS advises blocking a deal between GSR Ventures and Nanchang Industry, a subsidiary of Royal Dutch Philips Electronics Ltd

SPOTLIGHT

Mergers & Acquisitions in the Semiconductor Industry

The US-China Tech war has sparked a surge in new regulations and enforcement actions surrounding technology mergers and acquisitions in the semiconductor industry.

In America, the Committee on Foreign Investment in the United States (CFIUS) is responsible for reviewing all mergers and acquisitions involving American technology companies and foreign entities. CFIUS, an inter-agency committee, scrutinizes proposed and pending deals with the aim of preventing strategic dual-use technology from being purchased (or obtained via any other financial means) by foreign actors.

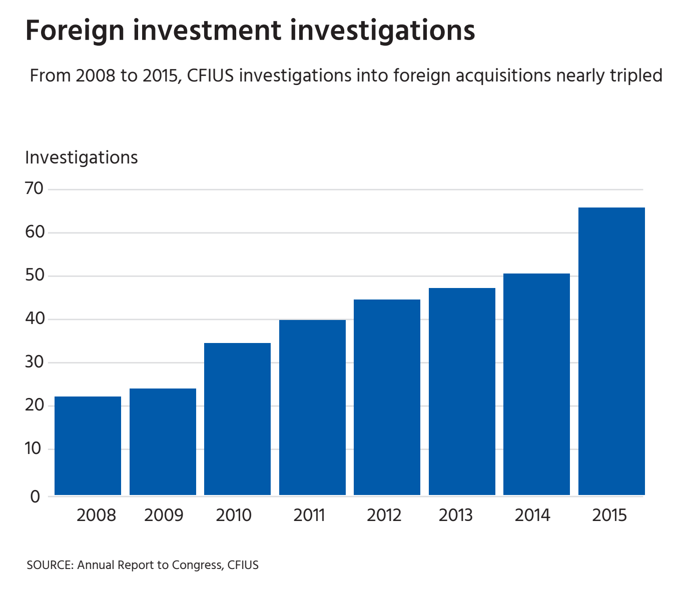
Overall, there has been a steady increase in the number of cases reviewed by CFIUS as well as a dramatic increase in the committee's recommendations to block or prohibit deals, particularly involving technology acquisition by Chinese buyers.

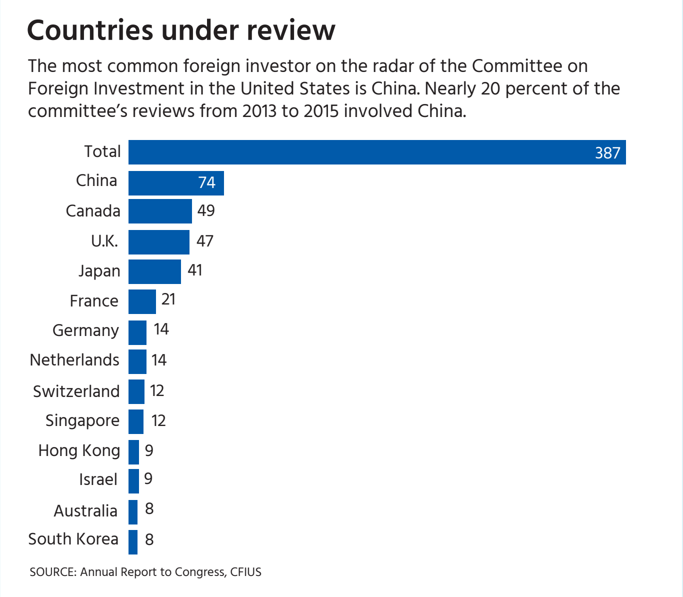
In 2018, with the US-China trade war providing impetus, the US Congress expanded the scope, reach and overall remit of CFIUS, with the passage of the Foreign Investment Risk Review Modernization Act (FIRRMA).[92]

Among other things, FIRRMA gave CFIUS the authority to review all scenarios that might involve acquisition of US technology by Chinese state-backed entities, no matter how small, and across a broad range of sectors.

This means that even partial or "beneficial ownership" scenarios (compared with full legal ownership), where individuals have any kind of access to intellectual property or technology, can be blocked.

Graph XXIII – CFIUS Reviews of Proposed Acquisitions and Mergers[93]





The EU Parliament has approved bloc-wide rules to increase scrutiny of foreign investment and acquisitions that could result in threats to national security.

that manufactures LED, which includes semiconductors.

Fairchild Semiconductor International (2016) – Because of CFIUS concerns, Fairchild rejects China Resources Microelectronics and CRE's $2.49 billion acquisition bid.[95]

Lattice Semiconductor (2017) – US President Donald Trump blocks Chinese-backed private equity firm, Canyon Bridge Capital Partners, from the $1.3 billion acquisition of Lattice Semiconductor.[96]

Qualcomm (2018) – President Trump blocks a $117 billion acquisition offer for semiconductor chip maker by Singapore-based Broadcom.[97]

Meanwhile, after it officially labelled China as a "systemic rival", the EU Parliament has approved bloc-wide rules to increase scrutiny of foreign investment and acquisitions that could result in threats to national security.[98]

These latest technology acquisition efforts were triggered, in part, when China's Midea Group acquired an 81 percent stake in German industrial robotics company Kuka AG, in 2016, which sparked a public outcry among policy makers in the EU.[99]

Since then, the current trade landscape in the EU, as in the US, is shifting towards more protectionist policies and non-tariff measures.

Germany recently blocked another attempt by a Chinese company, the Yantai Taihai Group, to buy Leifeld Metal Spinning AG, a high-tech machine tool company.[100]

Export controls and investment restrictions are having a profound impact on semiconductor value chains. The added risks and uncertainties mean that businesses must fundamentally rethink their strategic and operational plans, going forward.

The next section of this report will focus on the major risk mitigation strategies that semiconductor companies are currently exploring, as they seek to protect market share and sustainable trade flows, while also adhering to relevant laws and requirements.

Source: Wolfgang Rattay/Reuters

6. Strategies to Manage Tech Controls and Global Value Chains

National security issues and semiconductors will remain inextricably linked, well into the foreseeable future.

This evolving trade landscape will inevitably lead to the reconfiguration of global value chains and will necessitate corporate strategies that could involve the shifting of manufacturing and other critical operations to new locations.

The world's top semiconductor companies cannot ignore the importance of China's market, and, as businesses that must compete in an extremely challenging and complex environment, this will require a host of new approaches for risk mitigation.

Going forward, semiconductor companies will grapple with the many or all of the below challenges:

- The "De-Americanization" of global value chains
- Circumvention of "de minimis" value thresholds on foreign made goods
- "Reshoring" of certain value-add operations
- "In-China-For-China" localization strategies
- Lobbying of government agencies to obtain exclusions and waivers on export bans and export controls
- Decoupling entirely from entities on the US blacklist.

The "De-Americanization" of Global Value Chains

In 2018, when Huawei was placed on the US government's Restricted Entities List, effectively cutting it off from critical US inputs for its products, it immediately sought other non-American sources for its estimated $11 billion worth of technology needs.

However, this most important China tech company remains highly dependent on a broad range of American technology companies for its products.[101]

As such, Huawei's legal team began an analysis to determine if the company could legally circumvent US export controls by instructing its suppliers to reduce the overall value of American technology in its value chain.

SPOTLIGHT

De Minimis Example

For eligible items, there are two de minimis threshold levels that apply to inputs of US origin content which is designated US controlled technology: 10 percent and 25 percent of a non-US made product's overall fair market value.

In order to meet de minimis exclusion, either of the below outcomes must be achieved:

1) reduce the value of the US content; or

2) increase the value of the non-US made product.

This can be done by sourcing technology elsewhere or adding more non-US value to the finished item. For example, to manipulate the value of non-US inputs, companies can increase the costs of foreign labor, overhead, IP license fees and the costs of materials.

Conversely, the US can arbitrarily lower a de minimis threshold (from 25% to 10% or below, for example), making it more difficult for items further down a supply chain to escape the constraints of export controls.

Take, for example, an integrated circuit that is of US origin (controlled under ECCN 3A001.a.7), which is bundled together with a non-US made underwater device known as a "towed acoustic hydrophonic array".

An initial calculation shows that the total US content is at 26.3 percent which exceeds the de minimis level, which means the product requires a license if it is to be shipped to, in this case, Russia.

Graph XXIV – De Minimis Rule Example 1

Product: Field programmable gate array integrated circuit
Origin: US
ECCN: 3A001.a.7

Fair market value: $250

Product: Towed acoustic hydrophonic array

Origin: UK

Fair market value: $950

US origin calculation:

US$ (250/950) X 100= 26.3%

2 destinations
• Australia
• Russia

Australia: No license required because ECCN 3A001.a.7 is granted a license exception

Russia: License required because the controlled US content exceeds the de minimis threshold of 25%

Can the license be avoided? (See example 2)

A second illustration shows how changes in the prices lead to a reduction of the US content to 20%, which makes the product eligible for the de minimis exclusion.

Graph XXV – De Minimis Rule Example 2

Product: Field programmable gate array integrated circuit

Origin: US

ECCN: 3A001.a.7

Fair market value: $200

Adjust the values?

- Reduce price of US integrated circuit
- Increase price of hydrophonic array

Product: Towed acoustic hydrophonic array

Origin: UK

Fair market value: $1,000

US origin calculation:

US$ (200/1,000) X 100= 20%

2 destinations

- Australia
- Russia

Australia: No license required because ECCN 3A001.a.7 is granted a license exception

Russia: No license required because the controlled US content is within the de minimis threshold of 25%

CASE STUDY

International Traffic in Arms Regulations (ITAR regulations)

Source: Fabrizio Gandolfo/Jetphotos

Military items listed under the International Traffic in Arms Regulations (ITAR) regulations have a 0 percentage de minimis threshold. This means that they cannot be sold to a restricted entity regardless of value.

ITAR covers the manufacture, sale and distributions of military, space and defense related articles.

Under the so-called "see-through rule", if a part or component is subject to ITAR regulations and incorporated into a larger system, the entire larger system becomes subject to ITAR regulations.

Consider the example of the sale of a Boeing 737 civil aircraft with GPS technology embedded in the cockpit valued at $1000. Because the GPS technology was on the ITAR list, the entire civil aircraft becomes subject to ITAR regulations, despite the technology in question representing a tiny fraction of the aircraft's value.

Thus, if no special permission were obtained from the US State Department, the sale of the aircraft would constitute a violation subject to criminal and monetary penalties.

The Second Incorporation Rule

Another way for companies to legally circumvent US licensing controls is for suppliers to use the second incorporation rule. In the case of Huawei, the Chinese tech company performed a second incorporation analysis of all its supply chains and has instructed suppliers to utilize this loophole.

This rule applies where controls on American technology imbedded into a non-US second product (known as a "discrete product") would no longer be subject to export licensing if the second product is incorporated into a third non-US product (i.e., second incorporation).

Here, for example, a US made microprocessor chip classified under Export Control Classification Number 3A001.a.3 (a controlled commodity) is first incorporated into a non-US CPU board classified under Export Control Classification Number 4A003.c (also controlled because of the American technology imbedded in it). The CPU board is then incorporated (i.e., a second time) into a non-US laptop computer. The second incorporation rule releases the non-US laptop computer from licensing controls.

The second incorporation rule is part of an interpretive guidance document issued by the BIS and is not part of the existing export control regulations. The BIS is concerned about the fact that Huawei issued directions to its suppliers to use the second incorporation rule, thus, it is possible that this rule could be rescinded or changed significantly.

Graph XXVI – Second Incorporation Rule

SECOND INCORPORATION RULE

Product: microprocessor chip
Origin: US
ECCN: 3A001.a.3

(1ST INCORPORATION)

Product: incorporated into non-US-origin CPU board (aka discrete product)
ECCN: 4A003.c

Prior to 2nd incorporation the CPU board will still be subject to de minimis calculations and licensing

(2ND INCORPORATION)

2nd incorporation rule releases the laptop from EAR license control

No license required in most destinations*

*Note however that strict conditions have to be met before this is accepted (e.g., the discrete product after first incorpation must be a standalone/mass market product, and should not be bespoke to the buyer), not to mention the conditions stated in the previous slide.

Moving More Value-added Operations out of the United States

Even under normal circumstances, semiconductor companies must struggle to manage highly complex, competitive and demanding global value chains. As the US Restricted Entities List expands and the US-China trade war escalates, many companies are looking into these de minimis exclusions as a means to help mitigate risk and maintain their businesses. The US-China tech war is adding costs to semiconductor companies in the following ways:

- Lost sales to restricted entities (which often awards the market to competitors)

Circumventing export controls is adding costs to semiconductor products.

- Increased supply chain traceability costs (to track ECCN's through global value chains)
- Risks of monetary and civil penalties and revoked export privileges for non-compliance
- Legal and professional services costs.

Therefore, unless foreign and American semiconductor companies can convince US officials to walk-back or remove export controls and export restrictions on a growing list of emerging and foundational technologies (see Graph XX, Made in China 2025 and US Export Controls), efforts to circumvent US export controls will increase.

Redesigning a supply chain around de minimis thresholds and the second incorporation rule are perfectly legitimate strategies available to companies looking to maintain their businesses, so long as they maintain compliance with relevant laws.

At the moment, however, the semiconductor industry is taking a wait-and-see posture regarding large-scale reshoring operations, as companies continue to gauge the likelihood of the rolling back of US export restrictions or a future US China trade deal that would address both sides' concerns regarding technology.

Ring-fencing and Off-Shoring Operations – China and Beyond

In the avoidance of export controls, there is historical precedent with another American technology sector: the US communications satellite industry which, in the 1980s and 1990s, responded to increasing US export controls and restrictions by offshoring key parts of global value chains.

Because of China's high demand for semiconductors, the business case for adopting an in-China-for-China supply chain remains strong for US and other foreign companies.

Localizing and ring-fencing semiconductor operations in a controlled, secure environment in China, however, is still very hard to do, as detailed earlier under China's investment and local business requirements for foreign firms.

Vertically Integrated Semiconductor Value Chains

One way to reduce the inherent risks of doing business in China is to diversify operations and activities to multiple markets in Asia, such as Taiwan, Singapore or Vietnam, to achieve a so-called "China-plus 1-2-3" strategy.

However, with the huge investments associated with both fabless and foundry-related activities, it is difficult to move facilities and operations or replicate them. As such, there may be a need for consolidations and mergers within the industry to form more IDM semiconductor business models.

An IDM (Integrated Device Manufacturing) model is essentially a vertically integrated semiconductor value chain and is employed by Intel and Samsung.

Exclusions and Waivers on Export Controls

The best hope for the semiconductor industry (in the near term) may be to redouble its efforts to lobby the US government to roll back export restrictions on certain items, rather than try to restructure global value chains around the de minimis exclusion.[105] Here, associations like the Semiconductor Industry Association (SIA) would be well placed to facilitate and provide reliable information to all parties.

The outcome of the ZTE case, in 2018, may serve as an encouraging precedent for future efforts by the industry to work with and consult with the US government regarding its export control enforcement activities.

SPOTLIGHT

Increased Cyber-Security Threats

Cyber security experts have noted that since imposition of export restrictions on Chinese tech firms such as Huawei, Hikvision, SenseTime and others, there has been an escalation of cyber security threats (attacks and attempted cyber-intrusions) at American technology companies.[104] According to CrowdStrike, the cyber-security firm, this uptick in activity coincides with both the US-China trade war and the roll out of Made in China 2025.

American semiconductor companies operating in China or planning new operations are faced with a conundrum: how to tap into China's huge market, while at the same time, protect intellectual property and sensitive technology.

The US technology industry regularly lobbies the US government to ease restrictions on the basis of unreasonable harm.

When the US government threatened ZTE, the Chinese telecoms company, with a 7-year ban on sourcing US tech, a well-organized group of American companies such as Qualcomm, Qorvo, Google, Intel and Microsoft were successful in getting the US government to back off its threats.[106]

When seeking an exclusion to an export restriction or license, companies often argue successfully that the item in question meets one of the below circumstances:

- The restricted item is made elsewhere and readily available – and therefore, a prevention of the export, re-export or transfer of said technology would harm the company requesting the exclusion
- The item in question can be labelled as "general merchandise", meaning it poses no national security threat.

Many of these same companies again played a key role in quietly convincing the US Commerce Department to delay a ban (for a second time) on technology sales to Huawei, which would have gone into effect on November 19, 2019.

Federal Register Notices

In the US, one of the most important public-private communication mechanisms that has been used for public-private cooperation is the US Government's Federal Register Notice.[107] Before arbitrarily enacting a law or new enforcement mechanism, US officials have used the Federal Register to canvas the business sector for feedback, which gives companies and organizations the opportunity to comment on proposed actions and denials.

A Federal Register Notice on a proposed action gives the public the opportunity to:

- Disagree with the proposal
- Suggest alternatives courses of action
- Respond to specific questions in the Federal Register
- Estimate potential losses and other burdens.

The importance of maintaining transparent and open public-private communications through a process such as the Federal Register Notice cannot be overstated. In the realm of export controls and dual-use technologies, special working groups and public-private groups representing the semiconductor and other sectors have been successful in influencing policy making in Washington.

One such group is the Information Systems Technical Advisory Committee (ISTAC), which operates under the auspices of the Department of Commerce's BIS.[108] Members of the ISTAC committee are deep subject matter experts from the semiconductor and other tech sectors and have been instrumental in informing and guiding policy making.

However, there is a high level of anxiety in the semiconductor industry because, since 2017, there has not been an effective public-private dialogue about the impact of export controls, BIS entity lists and other enforcement mechanisms.

The public-private communication process around semiconductor-related policy making in Washington has been largely abandoned in the early stages of the US-China tech war.

The general concern is that there has been little or no consideration given to the long-term outcome of technology bans and restrictions on US companies, and how this impairs their ability to compete and fully participate in global value chains. Key concerns are:

- Restricting US firms from doing business in key global value chains effectively cedes market share to Chinese and other foreign firms.
- Restricting sales to Chinese global value chain partners cuts off funding for much-needed R&D.
- Collaborative innovation across specialized clusters and between human capital networks cannot occur in fragmented global value chains.

The public-private communication process around semiconductor-related policy making in Washington has been largely abandoned in the early stages of the US-China tech war.

In addition to trying to compete in an already highly competitive global market, American semiconductor companies are increasingly having to react to what they considered short-sighted and seemingly irrational policy making – with no over-arching strategic vision on how to best position US entities over the long-term.

Decoupling Due to Excessive Regulations

Assuming they are unable to obtain official exemptions or waivers from the relevant US government bodies, semiconductor companies also must prepare for scenarios involving a process of decoupling from their Chinese buyers, R&D partners, suppliers and other partners.

Specially Designated and Blocked Persons List (SDN)

In what is often referred to as the "nuclear option" of export controls, when an entity is placed on the SDN list by the US Office of Foreign Assets Controls (OFAC), then even simple financial transactions with named entities become prohibited for US companies and persons.

Assuming it is not possible to obtain an exemption, this is the ultimate deal-killer and even a company-killer: such an outcome would result in a full decoupling with affected parties.
At the time of publication of this report, 168 Chinese individuals and entities (representing a wide swathe of industries) were on the SDN list.[109]

These restrictions are enforced by more than a dozen different US government agencies and, can be implemented without warning and cause massive collateral damage. From a government perspective, such actions should not be undertaken without careful consideration about the long-term consequences.

Therefore, even if businesses manage to legally circumvent export licensing on dual-use goods by off-shoring operations and driving US origin values below de minimis thresholds, newly imposed SDN prohibitions could halt any dealings, whatsoever, with restricted entities.

7. Techno-Nationalism & Industrial Policies

Techno-nationalism is a set of mercantilist-like policies that link tech innovation and enterprise directly to the national security policies, economic prosperity and social stability of a nation.

The US-China trade war is but one symptom of an emerging systemic rivalry between the world's two superpowers. This competition covers the entire geopolitical spectrum and encompasses all aspects of hard and soft power — with fundamental ideological differences between the two systems beginning to spill over beyond China and US trade-related matters.

One could say that over the past thirty years, despite the systemic differences between the US and China, a kind of de facto strategic relationship has developed through an intertwined network of global value chains. However, after decades of globalization, where offshore production became the norm, the trade landscape has been shifting towards a more fragmented and localized trade model, which the author calls "techno-nationalism".

Techno-nationalism is a set of mercantilist-like policies that link tech innovation and enterprise directly to the national security policies, economic prosperity and social stability of a nation. In this regard, it considers government interventions in markets as a form of protection against what it considers opportunistic or hostile foreign actors (both state and non-state) and to develop, enhance and promote its own national champions' chances for success.

Many would challenge the underlying rationale behind this new way of thinking — which will be discussed later. But, regarding semiconductor value chains, this new mindset seems likely to become further entrenched, not only in the US, but in the EU and beyond.

Increased Government Intervention

Under the banner of techno-nationalism, US government intervention is increasing. For instance, it is exploring ways to funnel money to European telecommunications companies Nokia and Ericsson, in an attempt to counter the dominance of Huawei in the next generation of wireless technology[110].

This kind of techno-nationalist rationale is new to Washington. A palpable sense of urgency to find a competitor to Huawei reveals the degree to which techno-nationalist thinking is gaining traction.

Funding Nokia and Ericsson is Washington's attempt to counter the generous multi-billion credit lines and other financial assistance that Huawei has been receiving from the Chinese government via state-owned enterprises and banks. Government assistance has allowed Huawei to offer cheaper prices for high quality equipment when bidding for contracts around the world, and has pumped up Huawei's R&D war chest.

Also on the international front, the US plans to counter China's Belt and Road Initiative by approving a huge expansion of the Overseas Private Investment Corporation (OPIC) into a new agency, the International Finance Development Corporation (IDFC), that can co-invest some US$60 billion with non-US and private-sector American

A palpable sense of urgency to find a competitor to Huawei reveals the degree to which techno-nationalist thinking is gaining traction in the US.

technology companies in the same markets targeted by China's Belt and Road Initiative.[111] The focus is on developing telecoms that provide alternatives to China's state-backed companies Huawei and ZTE.

In the 5G space, the US has also been seeking to push Oracle and Cisco, two American technology companies, to enter the radio transmission market niche as manufacturers, despite objections from both firms on the grounds that Huawei's first mover advantage is too great.
Finally, also in the 5G space, the Trump Government has been looking to use government funding for the homegrown development of software and technology that would allow separate pieces of 5G equipment from different companies to communicate with each other — which would neutralize Huawei's end-to-end domination of 5G network equipment.[112] This approach will require the successful implementation of universally accepted standards, but it is not clear yet which country or conglomeration of countries will win the contest to set the standards — assuming that there will not be multiple 5G standards that emerge.

Source: John Thys/AFP

The EU intends to join forces with the US to counter China's attempts to dominate next-gen technologies.

Trans-Atlantic Technology Alliance

The EU is also turning to techno-nationalism. Brussels recently issued a report that emphasized the importance of working closely with America to create an economic model that would compete directly with Beijing, particularly with the intent of blocking the Chinese Communist Party's attempts to influence global standards in 5G and other next-gen technologies.[113]

The report called for EU-US strategic cooperation and the need to join forces to counter efforts by Chinese Government backed companies to influence the International Telecommunications Union and the International Organization for Standardization.

This strong shift in both America and the EU to resort to a kind of techno-mercantilist alliance, after three decades of relatively open

Policy makers on both sides of the Atlantic appear to be comfortable to embrace increasingly mercantilist and nationalist strategies.

globalization and unrestricted trade, represents a key moment for the semiconductor industry and global trade, in general.

This is not a temporary phenomenon that will recede with the election of a new American president in 2020. Policy makers on both sides of the Atlantic appear to be comfortable to embrace increasingly mercantilist and nationalist strategies.

This mindset was showcased in a long-running debate among the EU anti-trust authorities on whether to allow two of Europe's dominant manufacturers of high-speed trains (France's Alstom AG and Germany's Siemens AG) to merge. Coloring the debate were memories of tech transfer agreements dating back to the early 2000's when Alstom and Siemens agreed to hand over some of their most precious Intellectual property to their Chinese joint venture partners.[114]

Alstom's and Siemens' Chinese joint venture partners have since merged to become CRRC Corp, the world's largest maker of trains, and are now bidding for contracts around the world in competition with Alstom and Siemens.

Ultimately, the idea of creating a European "national champion", however, was rejected and the Alstom-Siemens merger was blocked on anti-trust grounds, but not without significant backlash in political circles.

Semiconductors and Techno-Nationalism

As was described earlier, semiconductor global value chains are highly rationalized with key sustainable value creation undertaken around the world, virtually anywhere that relevant competitive strategies can be leveraged. It has taken more than three decades for global value chains to migrate and agglomerate into key global industries and networks.

Semiconductor value chains are agnostic. They exploit competitive advantage strategies found within different countries in order to achieve:

- Maximum efficiency & productivity
- Access to the best innovation & human capital
- Access to new markets
- Movement up the value chain (when possible).

Trying to nationalize or ring-fence today's hyper-complex semiconductor global value chains within an artificial, political-designated geographical area will prove to be a difficult task.

Even in industries with less complexity, lower costs and lower barriers to entry, government-controlled champion building is generally seen to have a dubious track record. The reasons for the failings are well documented: failure to allocate funds efficiently, systemic corruption and rent-seeking behavior, and failure to punish subpar performance. And, of course, state-driven growth targets encourage over-capacity and can distort markets, as seen in the steel industry and other industries involving commodities.

Beijing, however, has been steadily expanding its state centric model and has continued to bolster Chinese capabilities in the tech industry.

The Evolution of China's Techno-nationalism and Techno-mercantilism

Dating back to the 1960's and the establishment of the Huajing Group's Wuxi Factory No. 742, which trained the first generation of China's chip industry engineers, China has been riding industrial policy toward the creation of a domestic semiconductor industry.[115]

From 1978, Deng Xiaopeng's "opening" of China put the country on the trajectory that got it to where it is today. By the early 1980's, China's sixth Five Year Plan (1981-85) created a "Computer and Large Scale IC Lead Group" which was tasked with modernizing China's semiconductors.[116] Already in the 1980's the Chinese government had recognized the advantages of shifting toward the hybrid industrial policy model that is evident today: joint ventures and technology transfer.

In the 1980's and early 1990's, under the so-called Project 908, Chinese companies attracted joint ventures that included Canada's Nortel, Holland's Philips, Japan's NEC, Belgium's ITT and Lucent laboratories from the US.[117]

By the Chinese Communist Party's ninth Five Year Plan (1996-2000) and under the so-called Project 909, industrial policy had successfully lured Japan's NEC, whose engineers transferred technology and trained local Chinese engineers for what would become China's first domestic production capabilities for Dynamic Random Access Memory (DRAM).[118]

Over the years, China's industrial planners have oriented their focus to emulate the so-called "fast-follower" approach, described below, that worked so well in the 1970s, 1980s and 1990s for tech companies in Japan, South Korea and Taiwan.

Should the West Emulate China's Industrial Policies?

The Made in China 2025 Plan and the National Integrated Circuit Plan Fund, among others, are the result of a long series of initiatives focused on semiconductors and related tech. Yet, as earlier sections of this study have described, China continues to struggle to make substantive progress when it comes to reducing its dependence on foreign technology and foreign entities.

The IDAR Methodology

China's semiconductor industrial policy has increasingly emphasized the core principles of technology transfer, joint ventures and strategic partnerships, with the development and acquisition of human capital, at scale.

In March of 2018, during the early days of the US-China trade dispute, the United States Trade Representative (USTR), published the findings of its "Section 301" investigation into China's practices regarding innovation, tech transfer and IP protection. The report concluded China's successful industrial policies could be attributed to an acronym: IDAR.

IDAR stands for "Introducing-Digesting-Absorbing-Re-innovating".

It is an IDAR methodology that has enabled Beijing to leverage newly obtained IP and technology as part of a "catch-up" strategy.

The US-China tech war has witnessed a tilt by the United States, the EU and others towards techno-nationalism. Why is there an emerging narrative that government intervention in markets and trade protectionism are needed to succeed in a tech war with China?

Whatever short comings state capitalist economies embody, there is increasing acknowledgement that Beijing's methods have, in fact, been succeeding in some technology sectors.[119]

Thus, if Beijing's financial support and strategic funding of key tech sectors have been successful, logic would dictate that the US and its allies should consider borrowing from China's playbook, and adopt some of its methods.

SPOTLIGHT

Milestones of Chinese Techno-nationalism

China's success in telecoms, satellite navigation and high speed rail has reinforced the attractiveness of industrial policy as a tool for economic growth.

Examples of the successes of China's industrial policies in the modern era:

Huawei – Huawei has become the largest telecommunications equipment manufacturer in the world. Its dominance of 5G end-to-end wireless technologies and infrastructure is well documented.

Huawei's success is not linked exclusively to Beijing industrial strategies, but, without access to the broad range of government resources and financial assistance (including compensation for price reductions and discounts on the bidding of international contracts) the company would not have risen to its current status. Huawei's access to new technology and IP through state-funded acquisitions and state-orchestrated technology transfer programs have paid off.

The fact that the present US government is adopting techno-nationalist policies and has made it a foreign policy priority to block the installation of Huawei's networks around the world and limit its access to American tech is testimony that China's industrial policies are working.

Beidou Navigation Satellite System – China built its own independent global satellite system as an alternative to the United States' Global Positioning System, the EU's Galileo system and Russia's GLONASS. Beidou is said to be the most accurate of the world's navigation systems and in just over 15 years was designed, implemented and successfully deployed through China's space and military programs.

High Speed Rail – In roughly the same timespan that it developed the Beidou Satellite system (15 years), China rolled out the world's longest and most extensively used public rail system, with trains attaining speeds of 250-350 kilometers per hour.

Huawei and 5G, navigation satellites and high-speed rail networks all were brought to fruition through an underlying, disciplined application of industrial policy, emphasizing the core objectives:

- Technology transfer
- Acquisition of IP
- R&D funding (ever-increasing)
- Development and acquisition of human capital
- Execution of IDAR methodologies (Introducing - Digesting - Absorbing - Re-Promoting)

As industrial policies become acutely focused on the industries of the future, as described earlier, emerging and foundational technologies will garner ever more attention from public-private working groups.

There are calls in the US for a more overt industrial policy approach to counter China's advanced in the tech sector.

Even within the US tech sector, there is acceptance that a techno-nationalist agenda must emerge, with government initiatives that create the right foundation for national innovation — which must spill over into "main street" and create jobs and economic benefits for the middle class. This cannot happen without sound, well executed industrial policy.

This nationalist mindset is shared by executives from Apple, Google, Facebook, Intel, Microsoft and a host of other big tech firms, some of which participated in a national committee that drafted a report on the topic, published by the Council on Foreign Relations. The publication was aptly named "The Innovation and National Security Task Force Report".[120]

The Scale of China's Technology Laboratory

The scale of China's technology landscape and its growing number of innovators and public-private industry partnerships is only just beginning to be put in proper perspective.

Regarding Huawei and the advantage of scale, consider the following: When Washington announced that Huawei would be placed on the Department of Commerce Restricted Entity List (which, among other things, restricted its access to Google's Android operating system), management tapped 10,000 Huawei engineers — requiring them to work continuously in three shifts over 24 hours — to tackle the problem. Engineers were tasked with the re-writing of code and redesigning specifications in order that Huawei might minimize the damage of US export controls.[121]

Regarding the replacement of the Android operating system (and, allegedly, the replacement of virtually all US parts and components from Huawei's smart phone) the engineers' efforts appear to have paid off. In October of 2019 Huawei paid its employees some $285 million in bonuses for "successfully coping with US sanctions".[122]

The ability of a Chinese company like Huawei to leverage high quality human

US businesses would embrace government funding for R&D, education and even more civil-military technology development projects, provided that the money did not come with excessive constraints and conditions that would hobble participation in global value chains.

capital, at such a large scale, has not gone unnoticed amongst businesses outside of China.

As such, the question being asked is: would more government "support" in the form of new industrial policies be welcomed by the semiconductor industry, particularly in the US?

If so, what would effective public-private initiatives look like? In the past, Japan, South Korea and most notably, Taiwan, have benefited immensely from semiconductor industrial policies, but could similar practices work in the US and Europe?

The Proverbial Horse Race

If the US-China Tech war was described as a horse race, should the participants devote their efforts towards trying to slow down their opponent's horse, or focus on making their own horse run as fast as possible?

The consensus among the world's semiconductor companies is the latter. As one Silicon Valley executive told the author: "We need to hire the best and brightest and run as fast as we can, especially while we still lead the race".

In terms of embracing new industrial policies, the most oft-cited request from today's tech sector involves two areas: more general R&D funding and development of human capital — primarily through education.

The author spoke with representatives from numerous semiconductor companies in Silicon Valley and the emerging narrative, in general, is that US businesses would embrace government funding for R&D, education and even more civil-military technology development projects, provided that the money did not come with excessive constraints and conditions that would hobble participation in global value chains.

There is widespread agreement in the US semiconductor space that export controls can inflict long-term collateral damage, often resulting in the ceding of market share to competitors and the erosion of revenue bases that are vital for generating R&D activities. Furthermore, escalating compliance costs resulting from supply chain traceability requirements are also a negative factor.

But the days of laissez-faire government approaches toward the digital economy and technology are coming to an end, which means that the semiconductor industry will have to learn to adjust.

Industry thought-leaders recognize an acute need to develop human capital and the necessary skill sets for the industries of the future. This comes down to the education of a new generation of professionals in the science, technology, engineering and mathematics (STEM) areas, beginning in primary and secondary schools and then blossoming in the university environment.

However, in the US, public funding for the technology sector has been steadily declining, particularly at universities, which are at the center of collaborative networks and are increasingly the catalysts of innovation, tech-startups and new jobs.[123]

According to the OECD, the US has slid to 28th out of 39 nations in government funding for university research as a share of GDP, with the 12 leading governments investing more than double the US's investment.[124]

To continue to be competitive, US universities would need a minimum of $45 billion per year for public-private research.

However, in terms of overall R&D spending on semiconductors, U.S companies spent far more than any other country, at $32.7 billion in 2018, followed by the EU ($13.9 billion) and Taiwan ($9.9 billion).[125] Therefore, as industrial policy in the US and EU reorients toward new milestones and public-private partnerships, human capital development and other educational milestones should be achievable.

The Information Technology and Innovation Foundation (ITIF), a US-based foundation, estimates that US universities should receive a minimum of $45 billion per year, to promote public-private research.

As *Moore's Law* reaches its end, the need to achieve the next level of innovation in the semiconductor industry has reached an historic milestone – one that could very well catapult the next innovators to an insurmountable lead over the competition. Therefore, the entities that can develop and leverage the smartest people, at scale, will likely win the race.

This will require smart industrial policy that enhances innovation, but, at the same time, does not create new distortions in the market that ultimately harm key stakeholders.

In the US, the Defense Advanced Research Projects Agency (DARPA) has been increasing its focus and funding on semiconductors. In 2018, the US Department of Defense announced its first chip innovation center, with the aim of targeting more secure chip design.[126] Of particular interest to the US military is the development of trusted sources of 14 nm process technology and 2.5D chip packaging.[127]

Another DARPA program, the Electronics Resurgence Initiative (ERI) was announced to the tune of $1.5 billion over 5 years, to explore among other things:

- Traceability of electronic components from design to end-use in a real supply chain
- IC technologies that can enforce security and privacy protections
- Secure and leading-edge infrastructure systems around emerging and new foundational technologies.

Also under DARPA is the Joint University Micro-electronics Program (JUMP), which in 2018 committed to semiconductor R&D in the following areas:

- Materials & Integration
- Architecture
- Design.

The scale of US and European spending appears to be far less than what China has been spending on its civil-military fusion initiatives.

Military Involvement in Semiconductor Research

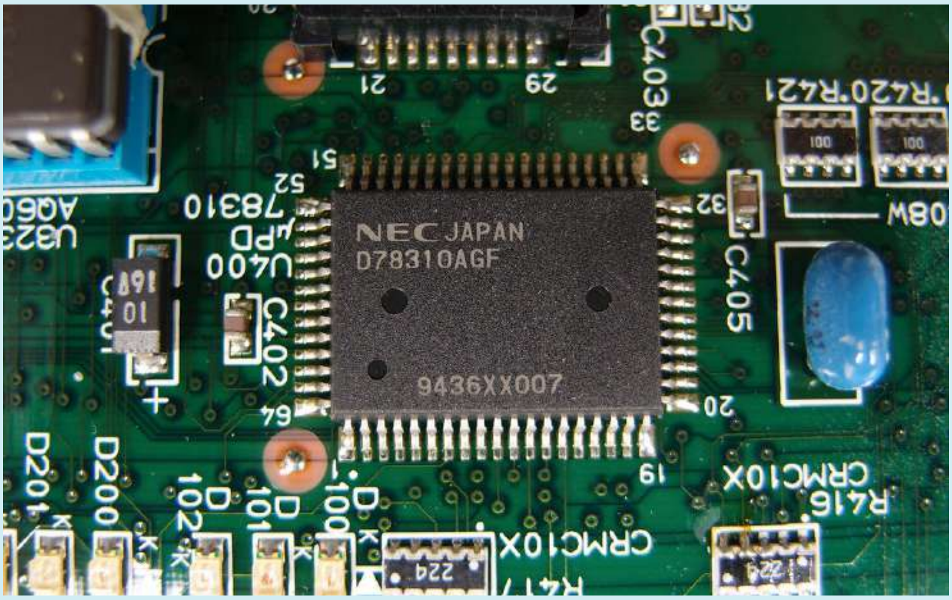
Military organizations will play an increasingly active role in public-private partnerships and government funded programs in the development of leading-edge technology for semiconductors.

It is difficult to measure the true scale of US defense R&D spending, as other programs may not be made public. For publicly known programs, however, the scale of US and European spending appears to be far less than what China has been spending on its civil-military fusion initiatives.[128]

SPOTLIGHT

The Galapagos Syndrome

Techno-nationalism has risks. Companies that dominate their protected domestic market under domestic standards may not be capable of competing globally.



One of the risks of techno-nationalism is that a ring-fenced, insulated market can put local firms at a competitive disadvantage on the world stage.

Techno-nationalist policies can lead to the emergence of local companies that dominate the domestic market, but because they evolve in isolation from global industry (and operate on different standards) they are unable to compete globally. This is known as the Galapagos syndrome.[129]

A classic example of the Galapagos syndrome involves Japan's NEC, which for decades dominated Japan's mobile phone market but ended up crashing out of the industry in 2013. Because the company had been wedded to local phone standards, it lacked the scale to compete in bigger international markets. At the same time, foreign companies adopting international standards such as Google's Android operating system continue to expand into Japan's market – as an invasive species, capable of out-competing the vulnerable and un-adapted indigenous ecosystem.

Techno-nationalist industrial policy must strike a balance between helping the proverbial horse run faster, while also avoiding short-sighted actions that lead to the horse falling over farther down the track. National policies around R&D funding, human capital development and defending against unfair practices, therefore, must be balanced with intelligent trade facilitation efforts. As with any government intervention, these are significant challenges and prone to political and vested interest manipulation.

8. The Decoupling of US-China Semiconductor Value Chains

US export controls and other restrictions have already damaged Chinese companies. But "de-coupling" has far-reaching effects beyond just Chinese and US companies.

In the semiconductor industry, the decoupling of certain US-China value chains has become inevitable. Even if the two super-powers are able to repair ongoing trade tensions and hammer out a series of "trade deals", there will be no turning back from the pervasive effects of techno-nationalist policies and the salient connection between semiconductors and national security.

Given its heavy dependence on US tech, China has no choice but to double down on its efforts to "de-Americanize" its supply chains, which, as was discussed earlier, will continue to be a catalyst for the restructuring of operations and supply chains by both US and other foreign companies.

The placement of Huawei on the US Commerce Department's restricted list marks a watershed in US-China bilateral relations and represents the beginning of an increasingly fragmented and uncertain trade landscape.

Non-tariff measures in the form of export controls and all-out technology restrictions have already done extensive damage to Chinese companies, including state-owned Fujian Jinhua Integrated Circuit Co., which had to shut down chip production in March of 2019, as its access to critical materials and technology were blocked.[130]

These same painful lessons were learned by China's Hikvison, the world's largest manufacturer of facial recognition and CCTV cameras, which depends on US chip makers Intel and Nvidia.[131] And of course, Huawei has become a microcosm of the greater decoupling narrative.

By definition, decoupling involves the divorcing or separation of previously joined, embedded, intertwined value chains. Although the name implies that just two primary parties are involved, many more entities and stakeholders are affected in semiconductor ecosystem, including:

- Primary and secondary suppliers up and down the value chain
- Designated Individuals
- Companies
- Academic institutions and think tanks
- Government entities.

The recent addition of Huawei to the US Restricted Entity List provides a window into this new reality.

The funding and staffing for programs of academic institutions around the world are now under intense scrutiny.

The Decoupling of Talent

Shortly after being put on the Restricted Entity List, Huawei laid off 70 percent of its staff at its Silicon Valley-based R&D facility, Futurewei, fearing theft of IP.[132] According to the Nikkei Asian Review, Huawei has also been redeploying its senior research scientists and executives with US links for fear they may be co-opted by American espionage agencies and facilitate technology transfer.

The deterioration in trust in US-China relations has pervaded the entire Huawei value chain, affecting the entire industry and will be felt around the world, as Chinese firms look for new sources of talent.

Ren Zhengfei, the CEO of Huawei, held a press conference in September of 2019 and announced that Huawei would be looking towards Russia to find mathematicians and towards Europe to find scientists.[133]

US academic institutions and research organizations will feel the effects of decoupling as they come under scrutiny for transferring, exporting or sharing controlled technology, software and IP with restricted entities — which includes individuals as well as companies or governments.

This scenario played out recently when US prosecutors indicted a University of Kansas professor, Franklin Tao, on the grounds that the Chinese academic failed to disclose his ties to Fuzhou University in China, which funds research under various government civil-military fusion initiatives. China already has the most academic institutions on the US Restricted Entities List.[134]

Already, a number of the world's leading universities have elected to stop receiving research funding from China, including Oxford and Cambridge in the UK and MIT, Stanford and UC Berkeley in the US.[135]

This decoupling of human resources from global value chains will present a challenge for the semiconductor industry. This also presents a paradox for techno-nationalism, as the attempt to promote local champions will likely result in cutting them off from international talent, especially smaller companies and start-ups. At the very least, the world's leading semiconductor companies will have to increasingly funnel resources into localized R&D efforts in key markets around the world.

As trade tensions escalate, it is becoming evident how deeply American technology is embedded throughout global value chains and how far the long arm of US laws extends into the semiconductor industry.

De-Americanization of Value Chains by Chinese Companies

As was discussed previously, Chinese companies have committed to looking for alternative sources to American technology and aim to bring entire value chains into closed, domestic loops within China.

As the Huawei case demonstrates, American and other foreign firms are deeply imbedded in these supply chains and are suffering collateral damage from export controls and restrictions on Chinese companies. As such, US and other international entities are actively looking for the legal means to circumvent these controls, including moving operations out of the US and changing the source and percentage of inputs to defeat de minimis value thresholds.

But the risks of facing more draconian US extraterritorial laws, including those that fall under the Office of Foreign Assets Control (OFAC) – especially as the US dollar remains the predominant international currency – means that even a simple financial transaction with a restricted entity could be prohibited, thereby killing the business relationship entirely.

As such, Huawei and other Chinese tech companies are looking to decouple entirely (or bide their time until it is possible) from US-influenced supply chains. To do this, Chinese firms must form alliances with non-American technology companies.

For this strategy to succeed, however, the Chinese technology establishment will need to differentiate US techno-national interests from those of its historic allies in the EU, Taiwan, South Korea and Japan. Ideally, this means figuring out how to engage the likes of ASML, TSMC, Samsung and others, without putting them in a position where they have to "choose sides".

As trade tensions escalate, it is becoming evident how deeply American technology is embedded throughout global value chains and how far the long arm of US laws extends into the semiconductor industry, even when Chinese companies purchase finished product from other foreign firms such as TSMC.

The European Union and China

In 2019, the European Commission published a policy paper calling China a "systemic rival". Beyond this, the EU has been promoting a more robust trans-Atlantic alliance with the US and Canada to counter China's technological ambitions and growing influence at international standards organizations, as described earlier.

If the Sino-US Tech war is polarizing the global landscape, then the EU is tilting decidedly towards the US, despite having to endure historically low levels of trust with the Trump Government.

The window appears be closing for Chinese state-backed strategic acquisitions of European tech companies, as evidenced by the rejection of both the Aixtron attempted acquisition by Fujian Grand Chip Investment Group and the more recent blocking of the acquisition of Germany's Leifeld Metal Spinning AG by another China state-backed entity, the Yantai Taihai Group.

The shift in EU-China relations has seen EU members states voluntarily enforcing export controls.

EU member countries have been willing to voluntarily enforce export controls as members of the Wassenaar Arrangement.[136] One key indicator involves the withholding of an export license by the Dutch authorities for the sale of state-of-the-art ultraviolet lithography equipment made by ASML, to China's Semiconductor Manufacturing Int'l Corp (SMIC). Without this sophisticated technology from ASML, SMIC's efforts to produce high quality commercial quantities of chips will continue to be hampered.

All of these developments reflect a broader shift in relations between the EU and China. The days of check-book diplomacy — where large delegations of Chinese party members and state-owned enterprise representatives toured Europe on well-publicized company visits – are over.

Japan in the Semiconductor Landscape

Japanese semiconductor companies have remained, for the most part, hyper-specialized in the R&D and materials niches within global value chains. In general, Japanese semiconductor companies have focused on Japan's domestic market and have been active mostly within the value chains of Japanese Keiretsu structures.

Japanese companies are reducing their footprint in China. It is foreseeable the US will pressure Japan to halt sales to Chinese companies on the US's restricted Entity list.

As such, Japanese companies have not scaled out internationally in ways that, for example, American companies have. The growth of China's semiconductor sector has shifted attention to Japanese expertise in specialized materials, with the likes of Huawei, SMIC and other Chinese firms looking to build stronger ties with Japanese companies.

This runs contrary to a general trend for Japanese companies relocating their assembly and manufacturing operations out of China: according to the Nikkei Asian Review, one quarter of Japanese companies in China are reducing their footprint, and more than half of these companies believe that US-China tensions will last for at least 10 years.[137]

The Japanese semiconductor industry will, however, also remain attractive to Chinese and other firms as a source of talent, as was evidenced by ex-Elpida CEO and Japanese semiconductor heavyweight, Yukio Sakamoto, being recruited by Tsinghua Unigroup, one of China's leading chipmakers.[138]

Japan and China's uneasy history, however, will continue to hang over the bilateral relationship, creating opportunities for Washington – still a strong and vital ally of Tokyo – to exert its will when it comes to enforcing export controls and restrictions on the transfer of American technology to Chinese firms. In an extreme scenario, this could involve putting pressure on the Japanese government to halt sales of Japanese technology to Chinese companies on the US's Restricted Entity List.

Thus, as Beijing looks to de-Americanize its semiconductor global value chains, it will find Japanese entities to be less than ideal partners. At the time of this publication, Japan had already blocked Huawei 5G technology from its domestic wireless networks.

Samsung benefited from the US's ban on Huawei, but realizes it has to diversify away from its dependence on China.

South Korea

For Samsung and SK Hynix, two of South Korea's largest chip makers, China accounted for a substantial portion the company's sales in 2018: 38 percent of Samsung's and 41 percent of SK Hynix's. This makes China a vital market for South Korean companies and gives Beijing some leverage in bilateral discussions. The scale of China's market will continue to be a strong attraction and desired destination.

As US export restrictions were placed on some $12 billion worth of chips from American companies, Samsung increased its sales of chips to Huawei and other Chinese firms.

In 2019, American export controls were timely for Samsung, as it had just closed it last smart phone factory in China due to declining sales and fierce competition from local brands such as Vivo, Xiaomi and Oppo.[140] Thus, the sales boost from Huawei's dilemma was welcomed.

However, the US-China tech war also sparked forward-looking strategy at Samsung to not only reduce its dependency on the Chinese market, but also to position the company internationally, across a broad swathe of 5G markets. As such, Samsung entered into an alliance with Qualcomm, the American chipmaker and wireless telecommunications company.

The Qualcomm-Samsung Axis alliance will promote 5G interoperability, avoiding single player dominance.

Qualcomm-Samsung 5G Axis

In the context of the US-China tech rivalry, this Qualcomm-Samsung Axis alliance is important for a variety of reasons:

- The alliance was announced at the time that Huawei was struggling with a pending ban (currently delayed) on its use of Google's Android operating system for Huawei smart phones, thus positioning Samsung and other international brands not only to win market share but to influence standards, in the future.

- Qualcomm's chips have been designed for a large, diverse 5G ecosystem that will work on a number of Samsung devices, including mid- and low-priced models, which will appeal to customers in both emerging and developed markets.

- Qualcomm's chips are also designed to operate across a full spectrum of 5G frequencies, which encourages connectivity with a broad range of different devices, made by different manufacturers, once again making it less likely that one dominant player will control the technology for an end-to-end 5G value chain.

SPOTLIGHT

Taiwan: A Strategic Semiconductor Hotbed

TSMC may be caught in the crossfire as a leading innovator and critical supplier to both US and Chinese companies.

Taiwan is a global hotbed of semiconductor innovation and production. It is strategically important to both China and the US on a number of levels, all of them fraught with geopolitical consequences.

Source: Chien-Ying Chiu

TSMC

Taiwan is home to Taiwan Semiconductor Manufacturing Company (TSMC), the world's largest semiconductor foundry, which produces more made-to-order chips than other company. In 2018, TSMC manufactured 10,436 different products using 261 distinct technologies for 481 different customers.[141]

In addition to being the world's largest pure-play foundry, TSMC is also a leading innovator: it has crossed the 7 nm threshold for microchips and is producing them in commercial quantities, most notably for Huawei's wholly owned subsidiary, HiSilicon.

China's Growing Market Demand

Huawei accounted for 11 percent of TSMC's total sales in 2018. China's microchip market is growing, as has been detailed, and will continue to create demand for TSMC and Taiwan's other semiconductor companies, such as United Microelectronics Corporation (UMC).

However, as TSMC, UMC and other Taiwanese firms increase their dealings with Chinese buyers, they find themselves caught in the middle of the US-China tech war. For example, as sales to China increase, the Chinese government is pressing TSMC to move key manufacturing operations from Taiwan to China – something which could incite countermeasures from the US, which will be discussed, below.

Simultaneously, proponents of the US techno-nationalist view are keen for TSMC to stop providing leading edge technology to Huawei. This rationale is based on the following assumptions:

Both the US and Chinese government have asked TSMC to move its operations to their jurisdictions.

1) Cutting off sales to Huawei would slow down the transfer of technology and flow of human capital and resources to state-backed Chinese entities.

2) A significant scaling back of commercial ties would mitigate the risks of Chinese actors infiltrating TSMC's manufacturing operations in Taiwan, which supply virtually all of the major US semiconductor companies and a large number of original equipment manufacturers.

Therefore, severing ties with Huawei, according to its proponents, would reduce the risks of espionage and the embedding of malicious technology in US-bound integrated circuits.

US Leverage Over TSMC
US pressure on TSMC is likely to increase, however, as more than 60 percent of its revenue still comes from American companies such as Apple, Qualcomm, Broadcom, and Nvidia — all of which are buying the Taiwanese company's most advanced microchips.[142]

For decades, US firms have considered Taiwan to be an IP safe-haven, a place to keep operations and technologies safely out of the reach of Chinese state-backed actors. This perception is now changing, as Huawei and other Chinese firms pursue deeper ties with Taiwanese firms.

Consequently, TSMC is being asked by the US government to move key manufacturing activities to the US, in an attempt to ring-fence these operations locally — even as China is also urging TSMC and UMC to move high-end operations into China.

Taiwan and US Export Controls
Currently, from a US export controls perspective, Taiwan is a "Group B" country. As such, in the semiconductor space, most non-military items on the Commerce Control List are permitted to be exported to Taiwan under a license exception. This has been very good for TSMC and its customers, everywhere.

The license exception has been especially beneficial to TSMC regarding the import of semiconductor manufacturing equipment from Applied Materials and Lam Research, both American companies, on which it relies for this critical technology – along with highly sophisticated inspection equipment.

Similarly, for much of its business, TSMC receives chip designs from its US customers and some of those designs are also on the Commerce Control List, but enjoy export license exemptions.

What would happen, however, if the US government were to remove Taiwan's "Group B" designation and deny export licenses for these components?

Apart from constituting a major policy change in US-Taiwan relations, there would be immediate consequences. In the short term, TSMC's ability to produce and sell its microchips to Huawei, for example, could be substantially impaired.

Although not openly discussed, US national security experts have drawn up scenarios that include China's acquisition of all of Taiwan's local semiconductor assets, through "forced unification". A scenario of this sort would represent the most extreme outcome of a techno-nationalist policy.

There would also be collateral damage. American fabless semiconductor companies, for example, that have relied on TSMC for the supply of finished wafers, would lose a vital supplier. This, in turn, would send shock waves rippling throughout entire global value chains and industries, disrupting business for suppliers, service providers and original equipment manufacturers.

Given the negative consequences of such actions, removing Taiwan from Group B status would most likely be a decision to be avoided by the US, or only undertaken in unusual or extreme circumstances.

Instead, US policy makers will likely be tempted to increase pressure on Taiwan's political apparatus to restrict sales to Huawei.

US-Taiwan History and Military Ties

The US has maintained strong relations with Taiwan since 1979. At the same time as US President Jimmy Carter unilaterally severed diplomatic relations with the island and formally recognized the People's Republic of China (i.e. Communist China), the US Congress passed the Taiwan Relations Act[143], a document that was intentionally ambiguous but allowed the US to provide Taiwan with "military arms of a defensive character". This recently played out in the sale of $8 billion worth of military technology, including F-16 jets and advanced radar systems, in 2019.[144]

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As such, the US-Taiwan special relationship makes matters even more complicated when it comes to Taiwan's semiconductor companies, given the precarious balancing act that all parties must maintain to avoid decidedly bad outcomes.

Conclusion

The US-China tech war has led to a trade landscape that is increasingly impacted by techno-nationalism. After decades of globalization, this emergent state-centric model is fundamentally changing value chains in the semiconductor industry — and beyond.

How can semiconductor value chains continue to benefit from access to China's market, while simultaneously mitigating the escalating risks associated with techno-nationalism?

After assessing the evolution of the global semiconductor industry, this report has explored the extent to which China's ongoing government intervention in the semiconductor space has been countered by US policies such as export controls, technology controls and other non-tariff measures.

The report posed questions about the ascendance of techno-nationalism's industrial policies – specifically whether the US, the EU and others would adopt their own industrial policies similar to those embraced by China, and what those new policies might look like. The report then examined the fragmentation, restructuring and decoupling of global value chains, and how these trends are impacting the world's far-flung, highly complex semiconductor global value chains – as well as how companies are deploying new risk mitigation strategies.

American and foreign firms are grappling with the collateral damage created by US technology controls and they are looking to minimize that damage. The report explored the legal ways to circumvent export controls, including the seeking of licensing waivers from the US government and the "de-Americanization" of supply chains.

Finally, the report examined geopolitics and possible US-China decoupling scenarios where other strategic semiconductor economies such as the EU, Japan, South Korea and Taiwan were involved.

The China Conundrum

China's market and trade opportunities remain hugely attractive to foreign multinational companies. China and the US have systemic differences, but after decades of cross-border flows of products, investment, ideas and human capital, the countries have become unwitting strategic partners.

This produces a conundrum for the semiconductor industry. Specifically, how can semiconductor value chains continue to benefit from access to China's market, while simultaneously mitigating the escalating risks associated with techno-nationalism? Going forward, for the US, EU and others, determining the right balance between techno-nationalist objectives and an environment that allows a small group of powerful non-state actors to remain profitable and independent will

In-China-For-China ring-fencing strategies will be expensive, because they cannot fully capitalize on global innovations and economies of scale.

be a contentious topic – perhaps even more so in an era of rising populism and nationalism, where the technology industry is increasingly viewed (at least in the West) as elitist and detached from main street.

Despite the fact that techno-nationalist policies can end up hurting the very entities they aim to protect, semiconductor companies will learn to deal with the challenges of the China conundrum.

Under the uncertainties of techno-nationalism, living dangerously will become the new normal for US and foreign semiconductor companies – and all tech-related businesses in general.

Looking for ways to legally circumvent export controls will become an accepted way of doing business. In general, foreign firms that continue to do business in China must accept the risks involved.

The Ring-fencing Strategy

The world's leading semiconductor companies have managed to stay ahead in the race and keep their most valuable IP and technology safely ring-fenced and out of the reach of malevolent actors. This approach has worked so far, not only for the semiconductor industry, but also for the automotive sector.
Meanwhile, the lessons of Siemens and Alstom, the high-speed rail companies that freely signed away their most precious IP for market access in China, will not soon be forgotten. Doing business in China is always going to be a Faustian bargain.

An "In-China-For-China" strategy, therefore, will be expensive, as it cannot capitalize on global economies of scale while local operations have to be ring-fenced. There is also the possibility that techno-nationalism will lead to various "Galapagos Syndromes" in a world where global value chains have fragmented and regionalized. Different technical standards may emerge for different markets.

This outcome certainly diminishes the benefits of a fully connected and collaborative global commons, where semiconductor companies can operate with fully rationalized global value chains, and will affect both US and Chinese firms.

All of these issues represent a new techno-nationalist reality. The US-China tech war will influence semiconductor global value chains, and the global technology sector in general, for many years to come.

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He advises governments and businesses on matters involving "upskilling" and developing human capital. Some areas of focus include mobile financial services, peer-to-peer lending scenarios, AI and e-commerce strategies.

Alex has been a panelist and workshop leader for the World Economic Forum. He writes a column for Forbes Asia, the Nikkei Asian Review and other publications and is a frequent guest on global television and radio networks. He holds a M.Sc. from the London School of Economics, in International Political Economy. He holds a B.Sc. in International Relations, from the University of Southern California.

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