

UBS Global I/O

Semiconductors

A fork in the road: China's pursuance of semiconductor independence

Is the globalisation trend for semiconductors about to reverse?

Semiconductor has been a global industry, but we think this is changing as mainland China attempts to insource chips. Investors are split on whether this is a temporary or long-lasting measure by China; we are firmly in the latter camp as we think: 1) US policies have changed markedly; 2) China-US trade tensions spurred the replacement with domestic suppliers, but once started, cost has become the bigger driver; 3) China's technology has improved through its internal efforts and M&A; and 4) having its own chips is now more important to China, given the demand shift to the cloud, industrials and automotive versus the focus on consumer devices. We see replacement prospects in radio frequency (RF), processors, high-performance analog, field programmable gate arrays (FPGAs) and packaging. Within memory, NAND flash has lower barriers to entry, in our view. We think graphic processors, dynamic RAM (DRAM), leading-edge foundries and semi-manufacturing equipment are harder to replace.

How will the US and other non-Chinese companies fare?

For non-Chinese companies that want to do business in China, many are scouring their intellectual property (IP) for US content that they can replace. Although this could be an easy exercise for some, we believe most will struggle. We identify two other ways for US companies to deal with trade restrictions: 1) move manufacturing outside the US; and 2) adopt new open source standards such as RISC-V.

What does it mean for other Chinese technology industries?

We lay out three scenarios in this report. We believe the most likely scenario involves investment restrictions targeting Chinese firms and end-user-based control rather than product-based control. This means control would not be on products but on specific companies. We assume Chinese internet companies will not be put on the US entity list, although areas such as data sharing with the Chinese government and surveillance could change this. Huawei is already on the entity list, and it has initiated the rapid replacement of its chips, according to our analysis.

Stock implications

In our global semiconductor coverage universe, gainers include TSMC, STMicro, Infineon, GUC, Silergy, Murata, Rohm, MediaTek and Huatian. Those who could be adversely affected are US RF companies, Broadcom, Qualcomm and global semi equipment. We find tail risks for Chinese internet companies as the availability of chips could become an issue in areas such as artificial Intelligence (AI) and surveillance.

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We would like to thank Rae Xu, our support service professional, for her assistance in preparing this research report.

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Summary

Semiconductor has been a global industry in the past 20-30 years. However, considering the China-US trade disputes and national security concerns, we believe China is incentivised to use more domestic vendors and to develop its own semiconductor-related technology. We think this is evident in the areas of semiconductor equipment, materials, memory, fabless design, foundry, packaging and design service, among others. Street expectations vary on China's bifurcation: some believe the bifurcation – namely China's move away from the globalisation trend towards insourcing and domestic replacement – is temporary and the industry will normalise if or when the trade disputes are resolved, while others believe this could continue regardless of how the trade war ends. We are firmly in the latter camp and we detail our reasoning in this report. With that said, we believe China's degree of success depends on specific areas within semiconductors and on multiple drivers: 1) the technology gap between China and the rest of the world; 2) the availability of replacements outside the US, such as in Europe, Japan, Korea and Taiwan; 3) dependence on US IP; and 4) governmental policy changes.

What this report addresses:

- **Why we think China bifurcates.** Even if the trade war ends right now, we believe China would continue insourcing. This is based on our reviews of China's policy change, our assessment of China's technology and feedback from our company visits.
- **Where could China find success?** We think China is investing in almost all facets of semiconductors, such as manufacturing (logic foundry, memory and assembly), IC design, IP, equipment and materials. In which areas is China ready to succeed and disrupt the global supply chain, and where is China more likely to face roadblocks?
- **Strategy for US companies?** For the US companies, we believe some will lose market share in China, while others may be able to maintain their shares. For those that can maintain share, we think part of this will be because China is not ready to replace US technology or insource, but we believe others will transfer their IP and move manufacturing outside the US. What does that mean for cost and IP protection in the longer term?
- **Implications for non-US, non-China suppliers:** Investors believe non-US suppliers, such as those in Europe, Japan, Korea and Taiwan, could benefit if US loses its market share. While we generally agree with that assumption, we take a look at the non-US companies that could have US IP and would need to comply with US regulations, and which are most ready to gain market shares. We consider this generally positive for the European Semiconductor sector (particularly for Infineon and STMicro, two companies that compete with their US counterparts) as we think China could shift to non-US sources. We identify some potential risks that competition in other markets (namely the US and Europe) increases as US competitors look to replace the business lost to China with either domestic or other non-US suppliers. However, on balance, we believe this is a net positive for EU supplies.
- **Implications beyond the semiconductor industry:** Huawei has started to replace US chips as it is on the entity list. We think the biggest potential change could be for Chinese internet companies. There are no export restrictions at

present, but as many Chinese internet companies are involved in sensitive areas such as artificial intelligence and surveillance, we reason this could change.

Figure 1: Stock implications

Company	Ticker	Rating	Price target (LCY)	Share price (LCY)	Market cap (US\$ m)	EPS growth		ROE (%)		PE (x)		P/BV (x)	
						2019E	2020E	2019E	2020E	2019E	2020E	2019E	2020E
Potential beneficiaries													
GUC	3443 TT	Buy	320.00	247.00	1,104	-54%	223%	10.7	31.2	72.9	22.6	8.0	6.3
Huatian Technology	002185 CS	Neutral	6.50	7.52	2,312	-48%	54%	3.5	5.2	78.8	51.3	2.7	2.6
Infineon	IFX GR	Buy	25.00	21.63	29,881	-11%	5%	13.4	23.7	20.3	23.5	2.6	2.9
MediaTek	2454 TT	Buy	455.00	437.00	22,923	10%	40%	7.8	9.9	29.9	21.4	2.2	2.1
Murata Mfg.	6981 JT	Buy	7,700.00	6,811.00	39,845	42%	-12%	13.5	11.0	17.3	23.9	2.2	2.5
Rohm	6963 JT	Buy	11,000.00	8,880.00	8,486	11%	-51%	6.5	3.3	18.2	38.1	1.2	1.3
Silergy	6415 TT	Buy	1,075.00	984.00	2,961	24%	26%	16.2	17.7	39.1	31.1	5.9	5.1
STMicroelectronics	STM FP	Neutral	23.00	25.20	24,876	-24%	24%	14.7	16.3	25.6	20.6	3.6	3.1
TSMC	2330 TT	Buy	335.00	337.50	292,108	-3%	24%	20.2	24.2	25.7	20.7	5.3	4.8
Potentially adversely affected													
Alibaba Group	BABA US	Buy	235	221.78	576,406	17%	20%	19.1	17.3	29.4	32.8	4.8	5.1
Applied Materials	AMAT US	Sell (CBE)	48	61.97	65,461	-32%	11%	38.3	38.1	13.8	18.1	4.8	6.9
Baidu	BIDU US	Neutral	135	140.86	49,174	-41%	15%	8.5	9.1	24.4	21.3	2.0	1.8
Broadcom	AVGO US	Buy	360	306.26	124,948	2%	16%	36.7	45.6	11.6	10.9	4.4	5.1
LAM Research	LRCX US	Sell	240	297.93	48,399	-19%	2%	41.2	46.2	11.0	19.3	5.4	8.8
Qualcomm Inc.	QCOM US	Neutral	87	89.91	132,887	-4%	15%	148.2	160.8	18.4	21.7	16.1	104.6
Tencent	700 HK	Buy	410	390	468,316	24%	19%	26.0	24.3	33.7	28.8	7.8	6.3

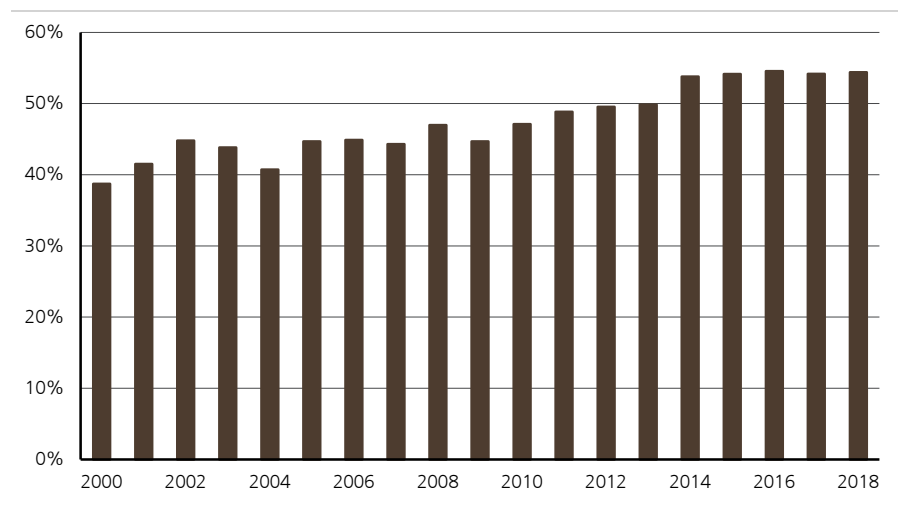
Note: Prices as of 9 January 2020; TSMC stands for Taiwan Semiconductor Manufacturing Company; CBE stand for Core Band Exception.
Source: Thomson Reuters, UBS estimates

Is the globalisation trend for semiconductors about to reverse, with China bifurcating from the rest of world?

The semiconductor value chain has become increasingly global in nature over the past 30 years. We believe this could reverse in parts of the supply chain, with China taking the lead.

Background: Specialisation and globalisation of the semiconductor supply chain has become more apparent over the past 20-30 years, in our view. Fabless and design has remained dominated by the US and Europe, but we think most of the manufacturing and assembly are now done in Asia. Most of the semiconductor equipment companies are US and Japanese, but ASML – a European company – supplies a critical technology (lithography) that is used globally. Figure 2 plots TSMC's foundry market share from 2000, which we use as a starting reference for the globalisation of this industry.

Figure 2: TSMC's historical share in the foundry market



Source: Gartner

The reason for globalisation is simple: in our view, specialisation and global partnerships have the potential to improve: 1) efficiencies; 2) economies of scale on manufacturing; 3) R&D and SG&A; 4) pricing power; and 5) inventory levels globally.

Although China has become one of the key consumers of semiconductors and a key country within global technology, its semiconductor design and manufacturing have lagged consumption. We believe China is manufacturing less than 20% of the logic chips that it consumes, none at the leading edge, and less than 10% of the memory chips. We think there are several reasons for the shortfall:

- Semiconductor is driven by Moore's Law, which means the leading-edge technology is constantly advancing. China was late to the semiconductor industry, and it struggled to catch up with the head start that the likes of Europe, the US, Japan, Korea and Taiwan had.

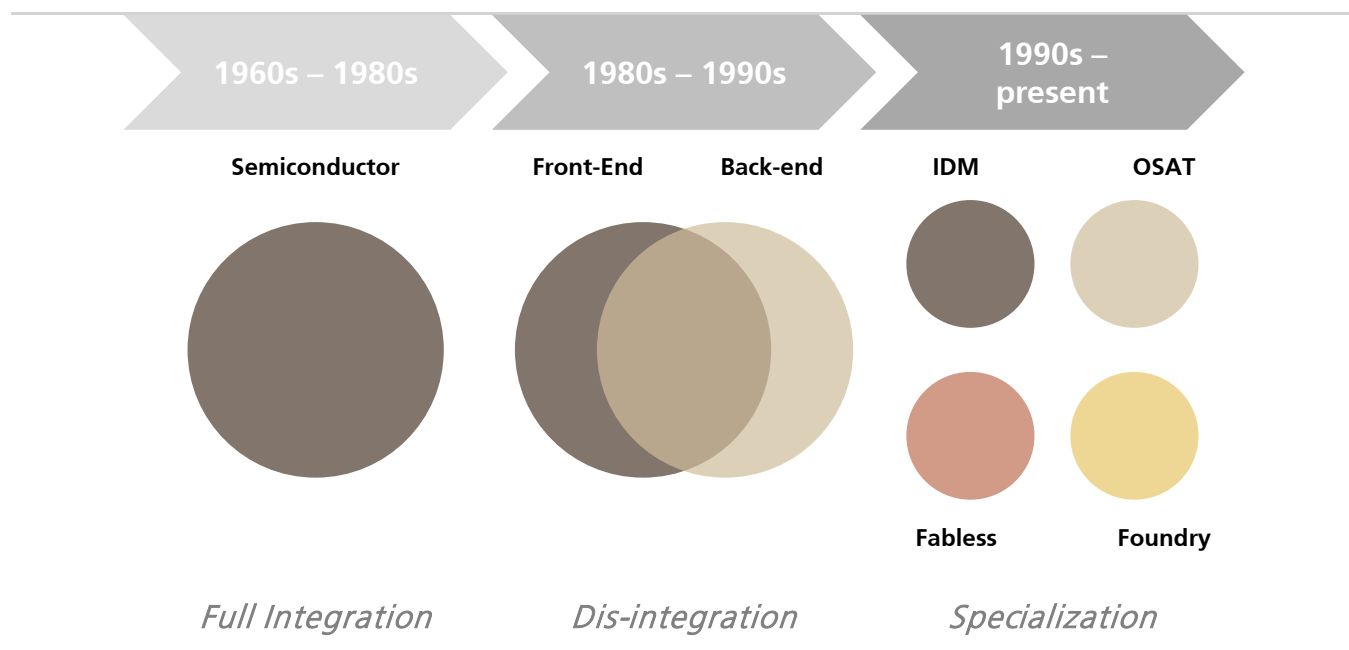
- Semiconductor manufacturing is capital-intensive. We find Semiconductor Manufacturing International Corporation (SMIC), China's largest IC foundry, spends roughly US\$2.1bn in capex a year compared with TSMC's US\$14-15bn. SMIC's R&D budget in 2019E is about US\$700m whereas TSMC's is US\$3bn and Intel's is US\$13bn.
- No cost advantage. Unlike downstream tech manufacturing where China's labour advantage over the last 15 years led to significant market share gains, in semiconductor manufacturing, labour costs typically account for a low-single-digit percentage of COGS. For the Chinese fabless companies, if they use foundries such as TSMC and GlobalFoundries, the cost is similar to global peers, but they are at a cost disadvantage when compared with US integrated device manufacturers (IDM). Chinese fabless companies could use domestic foundries, but historically that meant using technology that is one or two generations behind global peers.
- Strong IP protection. In many of the key areas of semiconductors, the incumbents own significant IP portfolios.

We believe China's position in the semiconductor industry could start to change in the next decade:

- US regulations on trade had not been changed in decades. However, in 2018, the US Congress passed the Foreign Investment Risk Review Modernization Act (FIRRMA) and the accompanying Export Control Reform Act of 2018 (ECRA). We provide details later in the report.
- The trade war and Chinese companies' presence on the US entity list is a concern for China.
- Demand is shifting from consumer products such as smartphones and TVs to enterprise solutions in the cloud, surveillance, AI, etc. Arguably, security and having domestic solutions are more important now than they were in the past.

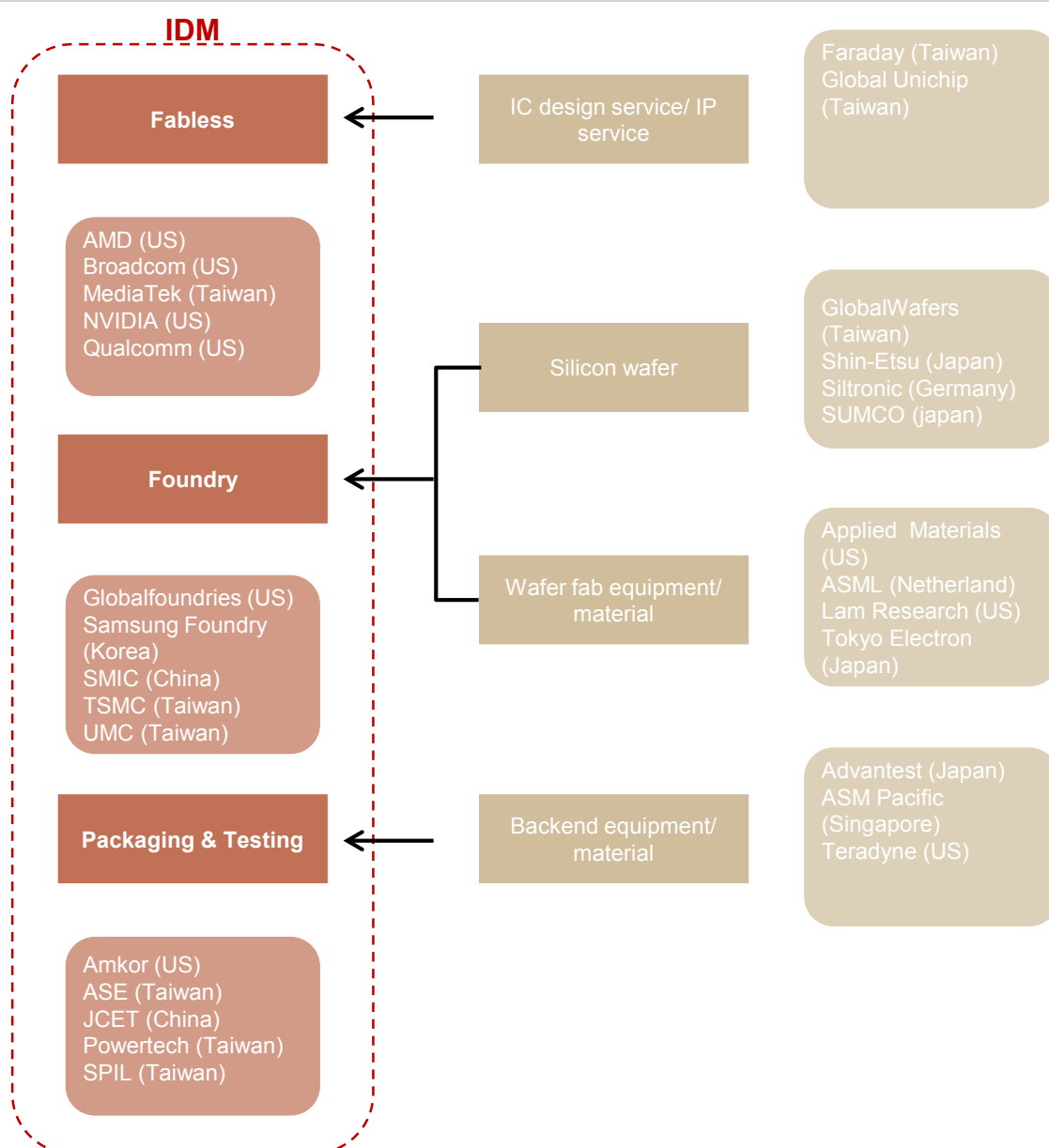
We think the Chinese government and privately owned Chinese investment firms are increasing investments in all areas of semiconductors. On top of this, we believe Chinese customers are more willing to test and use Chinese designed and manufactured chips. We acknowledge that this change could take time, and we believe success depends on the particular segments of the semiconductor industry. That said, we aim to break down the scenarios and examine which companies could benefit or hurt by at China's insourcing.

Figure 3: Transition of semiconductor industry



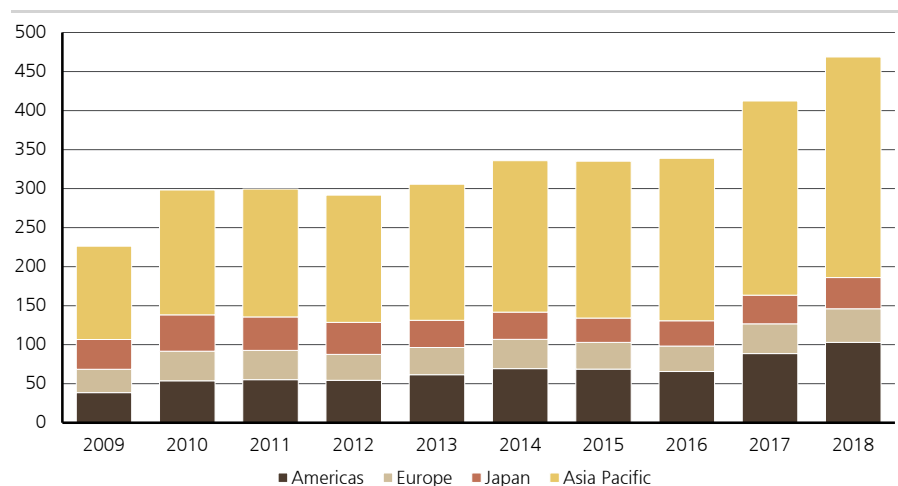
Note: OSAT stands for outsourced semiconductor assembly and test.
Source: UBS

Figure 4: Overview of semiconductor industry's major companies



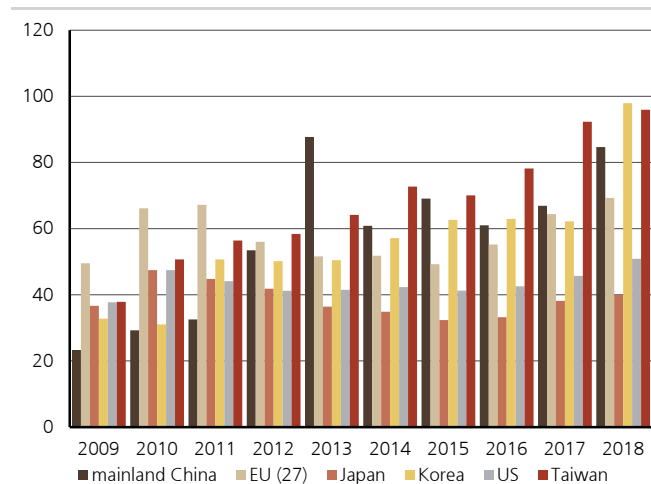
Note: Full company names: Advanced Micro Devices (AMD), United Microelectronics Corporation (UMC), Advanced Semiconductor Engineering (ASE), Jiangsu Changjiang Electronics Technology (JCET), Siliconware Precision Industries (SPIL).
Source: UBS

Figure 5: Worldwide semiconductor revenue by region (US\$bn)



Source: World Semiconductor Trade Statistics

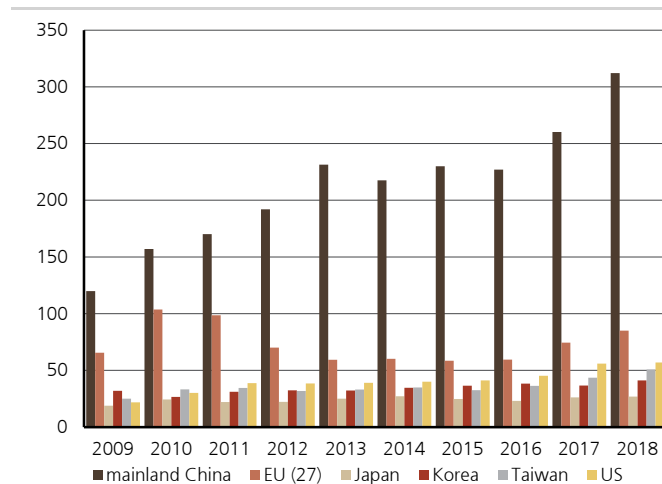
Figure 6: Semiconductor-related export by region (US\$bn)



Note: Including re-export after assembly.

Source: General Administration of Customs (China), Korea International Trade Association, Ministry of Finance (Taiwan), World Trade Organization (WTO)

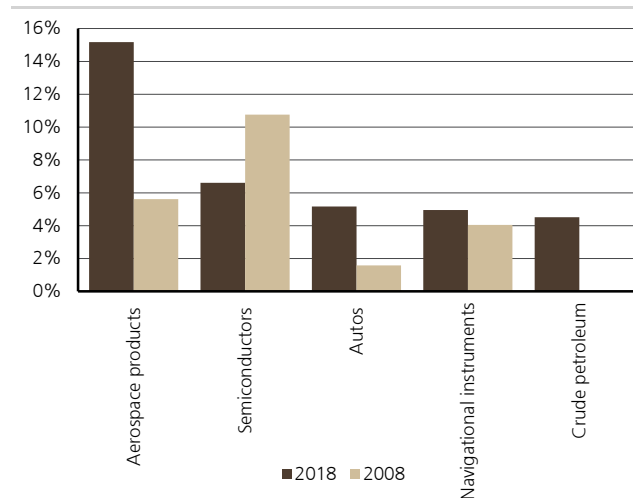
Figure 7: Semiconductor-related import by region (US\$bn)



Note: Including goods and components imported for assembly.

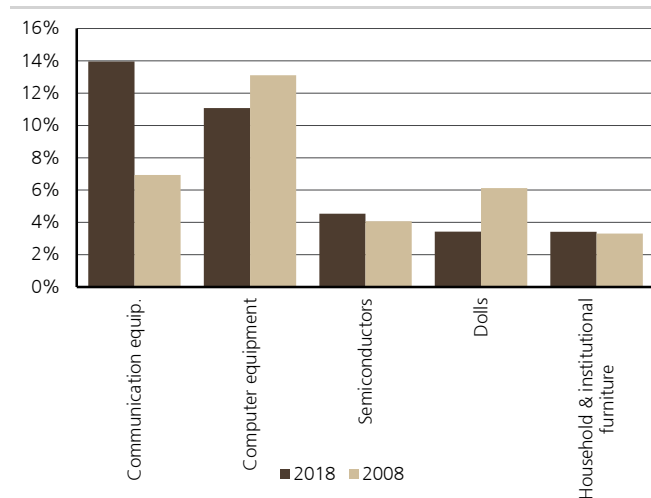
Source: General Administration of Customs (China), Korea International Trade Association, Ministry of Finance (Taiwan), WTO

Figure 8: Top five categories of US export to China (% of total)



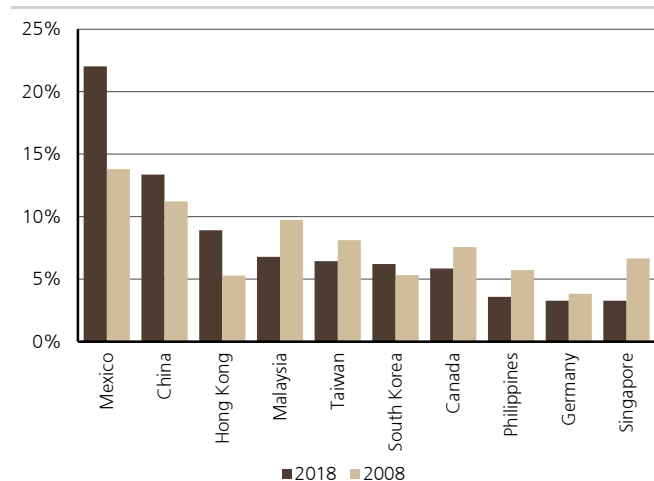
Source: Foreign Trade Division, US Census Bureau

Figure 9: Top five categories of US import from China (% of total)



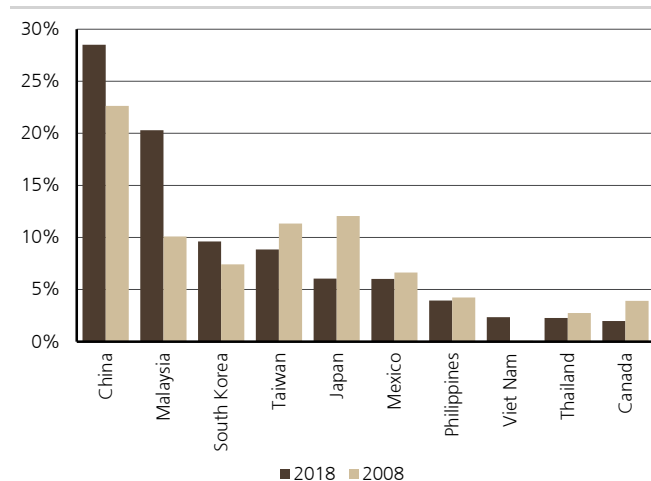
Source: Foreign Trade Division, US Census Bureau

Figure 10: Top partner of US semiconductor export (% of total)



Source: Foreign Trade Division, US Census Bureau

Figure 11: Top partner of US semiconductor import (% of total)



Source: Foreign Trade Division, US Census Bureau

What can US semiconductor companies ship to China today?

Over the past two years, there has been significant debate on what US companies can and cannot ship to China. Before we get into how things are likely to change, we summarise the status today.

First of all, it is important to differentiate Chinese companies that are on the entity list (and the list has expanded) from those that are not on the entity list.

Entity list: This is a US list of entities that are ineligible to receive any item subject to the Export Administration without a licence, as specified in Supplement No. 4 to Part 744 of the Export Administration Regulations.

Huawei's inclusion on the entity list was a significant event for the technology industry, but the list now includes 14 Chinese companies, as outlined in the table below.

Figure 12: Relevant Chinese companies on the entity list

Chengdu Haiguang Integrated Circuit
Chengdu Haiguang Microelectronics Technology
Dahua Technology
Hikvision
Huawei Technologies Co., Ltd. and affiliates
Hygon (JV between AMD and THATIC)
Iflytek
Megvii Technology
SenseTime
Sugon
Wuxi Jiangnan Institute of Computing Technology
Xiamen Meiya Pico Information
Yitu Technologies
Yixin Science and Technology

Source: Bureau of Industry and Security, US Department of Commerce

For Huawei and others on the entity list, the transfer of US technology will require a licence issued by the Bureau of Industry and Security (BIS).

Who has been granted export licences?

At the end of November 2019, the US Department of Commerce announced that it has begun issuing licences for some companies to sell goods to Huawei. Currently, only Microsoft and Micron have announced that they have been granted export licences, but US officials have said that they have processed roughly half of the 300 or so licence requests received, according to Thomson Reuters. They added that roughly half of the processed requests were approved, while the rest were denied. Despite this, we think other companies with requests approved appear to have been granted licences by the end of November 2019.

The temporary general licence

While Huawei and other Chinese companies have been put on the entity list barring them from shipping goods to China without a licence, Huawei has also received a temporary licence. The licence was originally for a period of 90 day (expiring on 18 November 2019), but was extended until 16 February 2020. The

temporary licence does not apply to Huawei's subsequent sales, but it allows for maintenance and software updates of existing systems.

The current temporary general licence allows:

- Continued operation of existing networks and equipment
- Support to existing handsets
- Cybersecurity research and vulnerability disclosure
- Engagement as necessary for development of 5G standards by a duly recognised standards body

What else can the US companies do?

Some US companies have continued selling to Huawei even after the company was added to the entity list, using the so-called De Minimis provision. This exemption applies if companies can prove that at least 25% of the value-add is from the US and both IP and manufacturing are examined to meet the requirements. However, the 25% threshold could change.

- IP test. We understand that the IP requirement does not apply to the entire company as a whole but is tested on a product-by-product basis. The test is on the percentage of R&D spending that is non-US based. Many of the US-domiciled companies have engineering centres overseas, or they have made significant acquisitions overseas.
- Manufacturing test. On manufacturing, the content is defined as a portion of the manufacturing COGS. Given that most of the US companies outsource to Asian foundries, such as TSMC, and assembly houses, such as ASE, for manufacturing, this potentially applies to many of the US fabless companies. We find that companies such as Texas Instruments and Intel do most of their own manufacturing, though certain products are still outsourced.

Shipments are allowed for older contracts signed before Huawei was added to the entity list, if the term has not ended. As an example, Xilinx has said publicly that its older, 28 nanometre (nm) chips under existing contracts can still be shipped to Huawei without an export licence.

What about non-US companies?

As reported by several news sources such as the Financial Times and Thomson Reuters, the US Commerce Department and its sister agencies are also attempting to influence non-US companies. Again, this is known as the De Minimis Rule, but is applied to non-US companies. It dictates whether US content in a foreign-made product gives the US government authority to block an export. We believe this is a similar clause to the one mentioned above, namely that companies are bound by export controls if any non-US products have more than 25% of its IP or manufacturing content based in the US.

As an example, Arm continued to ship to Huawei in October 2019, after its legal team ruled that its chip technology (Armv8-A architecture) is of UK origin and would not breach US restrictions, after the supply halted in May 2019. The company evaluated its IP on a product-by-product basis and most products passed the test.

In another example, the Financial Times reported that the US government had asked TSMC to comply with the export restrictions, but TSMC continues to ship to Huawei and other Chinese customers on the entity list.

What is the current financial implication?

If we summarise all companies that are on the entity list, we estimate that they account for 5% of global semiconductor demand in 2018.

Figure 13: Exposure of US-origin product for non-US semiconductor companies selected

Company	Listed country/ region	Domiciled country/ region	Key US acquisitions	For Non-US companies
				Key products with >25% of IP from the US, and % contribution to sales
MediaTek	Taiwan	Taiwan	ADI's wireless business	Wireline communications (<5%)
TSMC	Taiwan	Taiwan	10-20%	25-35%
GlobalWafers	Taiwan	Taiwan	SunEdison Semi, GlobiTech	SOI (<5%)
Silergy Corporation	Taiwan	Mainland China	Maxim's smart meter unit	Smart meter (15%)
Hua Hong Semiconductor	Hong Kong	Mainland China	NA	0%
Chipbond Technology	Taiwan	Taiwan	NA	0%
Samsung (Semis)	Korea	Korea		0%
SK Hynix	Korea	Korea		0%
Renesas Electronics	Japan	Japan	Intersil IDTI	40% of sales are to China
Tokyo Electron	Japan	Japan	none	0%
SCREEN Holdings	Japan	Japan	none	0%
Ibiden	Japan	Japan	0%	0%
NGK Spark Plug	Japan	Japan		0%
MinebeaMitsumi	Japan	Japan		0%
Mabuchi Motor	Japan	Japan		0%
Nidec Corporation	Japan	Japan	Emerson's motor business	<5%
TDK Electronics	Japan	Japan	InvenSense	0%
AlpsAlpine	Japan	Japan		0%
Hirose Electric	Japan	Japan		0%
Rohm Semiconductor	Japan	Japan		0%
Kyocera Group	Japan	Japan	AVX	<5%
Taiyo Yuden	Japan	Japan		0%
Murata Manufacturing	Japan	Japan	Perigrine	<3%

Source: Company data, UBS estimates

Recent changes in US policy

Restrictions on China and the sale of technology came to the forefront in 2018, when ZTE faced a temporary ban and Huawei was subsequently added to the entity list. In our view, these policy changes were probably overdue.

Changes in US policy were probably overdue

While the bans and entity list are what investors focused on, we find the broad US policies on trade and technology have been revised since 2018. Studying the revisions, it seems clear that the changes are not only trade related but are made in the hope of providing more protection for US technology.

The fundamental policies were quite outdated, in our view. In the US, fundamental policies were established in 1985: NSDD-189, the National Policy on the Transfer of Scientific, Technical and Engineering Information.

The purpose of NSDD-189 was to establish a national policy for controlling the flow of science, technology, and engineering information produced in federally funded fundamental research at colleges, universities, and laboratories.

In addition to NSDD-189, CFIUS (Committee on Foreign Investment in the United States) was created in 1988 to review acquisitions of US companies by foreign entities, especially for any potential national security implications.

These rules govern technology transfers and foreign investments, but do not explicitly control export.

Protection of national security and expansion of policies becoming more critical; in 2018, Congress passed FIRRMA and the accompanying ECRA

FIRRMA expanded the jurisdiction of CFIUS to address growing national security concerns over foreign exploitation of certain investment structures, which have traditionally fallen outside of CFIUS's jurisdiction. Additionally, FIRRMA modernises CFIUS's processes to better enable timely and effective reviews of covered transactions.

ECRA authorises the US President to control the export, re-export and transfer of commodities, software and technology to protect national security and to promote US foreign policy. Although the types of emerging and foundational technology to be identified are not yet publicly known, it encompasses 14 – potentially broad – categories such as biotech, AI, quantum compute and 3D printing). The new ECRA in 2018 stipulates that anyone involved in emerging and foundational technology areas, such as AI, driverless vehicle technology, advanced computing, additive manufacturing or microelectronics, should begin preparing comments on possible new controls in line with the standards in the new law.

Trade deal is a separate issue

We think investors tend to associate the China-US trade deal with export restrictions. Our view is trade and tariffs are separate from the stricter export laws. Regardless of when and how the two sides strike a potential trade deal, we think the fundamental laws we outlined above are changing and they are designed to address mounting national security concerns.

Europe likely going down a similar – albeit less drastic – path

Besides the US, we also witness other countries changing their stance towards China.

Europe dramatically sharpened its political stance on China in March 2019 by claiming that Beijing is a "systemic rival" for the first time, in the European Commission's "EU-China – A strategic outlook" report.

In a strategic communication mapping out 10 proposals for dealing with Beijing, the European Commission also reprimanded countries such as Italy for aligning too closely with China's landmark One Belt, One Road programme, which promotes Chinese trade via infrastructure running across Asia into Europe.

In a departure from its usual approach towards Beijing, the EU called China "an economic competitor in pursuit of technological leadership and a systemic rival promoting alternative models of governance."

Perhaps the changes in Europe are not as drastic or as clear cut as in the US, but we expect more restrictions ahead, especially in areas such as semiconductors.

What are the potential implications if China semiconductors bifurcate, and which companies are impacted?

We expect policies relating to China will become stricter, and therefore China will likely need to look for more internal supply for different semiconductor parts. The next question is in which area China might find success.

Can China replace US-designed chips, materials and equipment?

From the US side, our base-case assumption is a ban on specific companies, but potentially emerging and fundamental technology could face broader restrictions. From China's perspective, we believe companies on the entity list would be forced to use more domestic suppliers. We estimate companies on the entity list currently account for 15% of China's total semiconductor demand in 2018. However, as the domestic supply chain ramps up, the difference in cost relative to non-Chinese suppliers likely will fuel further adoption, even for non-entity list companies.

Is China ready to replace non-Chinese chips and equipment? Our view is it varies significantly across sub-segments, but we find the most upside for Chinese suppliers in power management, packaging, high-performance analog and equipment.

Replacement readiness, what changed?

China had wanted to replace non-Chinese chips ten or even five years ago, but its technological progress was not where it is today. We identify several changes:

Change in end markets and the need for IP protection

China's technology has historically focused on consumer products: DVD players, MP3 players, TVs, feature phones and then smart phones. Today, we think the consumer market is still key, but there are additional markets such as video surveillance (where Chinese companies, Hikvision and Dahua, are global leaders), data centres and AI, where IP protection is arguably more important.

Cost

The trade war prompted the insourcing trend but once it started, cost has become the sustaining factor. We think insourcing would continue even if the trade war ends. We look at power integrated circuit (IC) as an example.

Power ICs have historically been dominated by American and European suppliers. It was difficult for Chinese companies to penetrate this market. This was mainly because prices were low but the requirements for reliability and performance were high, and Chinese companies could therefore not gain market share merely by lowering price. However, given recent trade tensions, we believe China's device manufacturers have started to work with the domestic suppliers. From a cost perspective, most of the domestic suppliers are fabless companies; we estimate that their cost structure is 30-35% higher than the US internet download managers (IDMs). From a pricing perspective, we estimate they are generally priced 25-30% below their US counterparts.

Acquisition

As summarised in the figure below, Chinese semiconductor companies and Chinese private equity (PE) firms have invested over US\$20bn in the last five years alone to acquire semiconductor technology. According to Dealogic, over 30% of the targets, or US\$6bn, are US-based and US\$10bn is from the Netherlands. The Dutch acquisitions were related to NXP Semiconductors (NXP), where China acquired RF, mixed-signal and power-related technology. The other key acquisition area has been in semiconductor packaging; China has acquired STATS Chipac, AMD's packaging facilities, Unisem, and FlipChip International over the past several years.

However, as we [wrote](#) previously, we believe M&A restrictions and IP protection will likely become stricter, and future M&A opportunities could become scarce. Our analysis in the subsequent sections therefore focuses on what is possible given China's capabilities today, assuming that future developments could be mostly internal.

Figure 14: Acquisition of over US\$200m made outside mainland China by Chinese companies

Completion Date	Major Acquirer	Target	Target (Region/Country)	Status	Deal value (US\$m)
-	Ingenic Semiconductor Co Ltd	Integrated Silicon Solution Inc (100%)	United States	Pending	1,035
29-Oct-19	Wingtech Technology Co Ltd	Nexperia BV (62.18%)	Netherlands	Completed	6,122
02-Aug-19	Will Semiconductor Co Ltd Shanghai	OmniVision Technologies Inc (96.08%)	United States	Completed	4,182
02-Mar-19	Wingtech Technology Co Ltd	Nexperia BV (33.65%)	Netherlands	Completed	1,810
20-Jul-18	Hopu Investment Management Co	Arm Technology (China) Co Ltd (51%)	China	Completed	775
04-Apr-18	HC SemiTek Corp	Memsic Inc (100%)	United States	Completed	670
19-Dec-17	Nantong Fujitsu Microelectronics Co Ltd	TF AMD Microelectronics (Penang) Sdn Bhd (40.49%) Suzhou Tongfu AMD Semiconductor Co Ltd	Malaysia	Completed	366
11-May-16	E-Town Dragon	Mattson Technology Inc (100%)	United States	Completed	298
07-Dec-15	China Jianyin Investment Ltd - JIC Capital Beijing Jianguang Asset Management Co Ltd - JAC Capital	NXP Semiconductors NV (the RF power business, 100%)	Netherlands	Completed	1,800
27-Aug-15	Jiangsu Changjiang Electronics Technology Co Ltd	STATS ChipPAC Ltd (100%)	Singapore	Completed	1,752

Source: Dealogic

Development of domestic companies

We think several Chinese companies, such as AMEC, SG Micro and Silergy, and Pango Micro have reached scale and now have technology that could be competitive (albeit not necessarily world-class). We think HiSilicon has world-class technology. Internet companies such as Alibaba and Baidu have announced efforts to develop internal semiconductors, but we have not seen solid evidence of their readiness.

Where does China stand in the various segments of semiconductors?

With the background provided on how China got here, we discuss what capabilities we think China has.

Semiconductor capital equipment

China's overall market share in global semiconductor equipment is small, but we believe its technological know-how is more advanced than what its market share suggests, especially in the areas of etch, cleaning and chemical vapour deposition (CVD). We think China has the technology to replace most of the deposition, etch and clean equipment, but it lacks lithography and track. Given that all tools are required to establish a semiconductor manufacturing plant, either for logic or memory. Consequently, we think China could manage if only US companies were banned from selling semiconductor equipment to China. However, if the ban includes Japan and European companies, we believe China would not have all the necessary technology it needs.

Key domestic semiconductor equipment suppliers:

- **Advanced Micro-Fabrication Equipment Inc (AMEC, non-covered company):** AMEC is a Shanghai-based equipment company. Given the company's core products are in etch and metalorganic chemical vapour deposition (MOCVD), we would not be surprised if the company enters other deposition-related markets. AMEC was established in 2004. The key members of the company have experience in US equipment companies. Per company disclosure, AMEC has sales in China as well as key customers outside of China, such as TSMC and Hynix. The company listed on the China STAR market on 22 July 2019.
- **Naura Technology (non-covered company):** Naura is a Beijing-based equipment company with products in semiconductors, scientific equipment, microelectromechanical systems and LED, among others. The company has a diverse list of products in semiconductors, including etch, PVD, CVD, cleaning and atomic layer deposition (ALD), but it has a limited market share in each area.
- **Mattson Technology (private company):** Mattson is a Silicon Valley based company but was acquired by Chinese PE firm E-Town Dragon in 2015. Mattson has a strong history in dry strip tools, but through acquisitions, it has products in rapid thermal anneal (RTP), wet clean and ALD. Mattson has a broad customer base, including most top-tiered semiconductor companies globally.

Raw wafers

The technology barrier on raw wafer production is not as high as semi equipment, but we believe the key roadblock for new entrants is the imbalance between small cost savings compared with the potentially significant damages if yield is impacted.

If we look at 8" and 12" wafer production separately, China's 8" capability is more mature but the investment has been limited. We estimate China's 8" capacity to be less than 5% of global supply. China started to invest more aggressively in 12" wafer production five years ago, but it still mostly produces test and dummy wafers rather than production wafers. We think it could take 1-2 years before the Chinese wafer suppliers are ready to supply production wafers.

We think raw wafers are unlikely to be impacted by US restrictions, given that all of the raw wafer suppliers are not based in the US (they are based in Japan, Taiwan, Korea and Germany). Some companies have US-based factories. For example, GlobalWafers in Taiwan purchased MEMC Electronic Materials in the US.

Roughly 5% of the GlobalWafers' products have 25%-plus US IP and 5-10% of the manufacturing is based in the US.

Chinese competitors:

- **Zing Semiconductor (private company):** Zing is the leading 12" raw wafer company in China in terms of technology and capacity scale, according to the company. Its current 12" capacity is around 100-150kwpm (k wafers per month), which is about 2% of the global capacity. The company was founded in 2016 by SMIC's founder Mr. Chang. In the first few years following its establishment, the company was more focused on scale, but its target appears to shift to quality after the new CEO, Mr. Chiu, started his tenure in 2019.
- **Advanced Silicon Technology (AST, private company):** Unlike Zing Semiconductor, which purely focuses on raw wafers, AST has broader target products including semis wafers (12" and 18") and equipment. It started to build its Shanghai fab in July 2018, and targets 300kwpm 12" and 10kwpm 18" raw wafers in capacity when completed. Our understanding is that the ramp-up of production has been behind schedule owing to the low yield and quality of the product.
- **Zhonghuan Semis:** Zhonghuan's background is a solar wafer provider, and it intends to expand into the semis industry. The company started with 8" speciality raw wafers and is developing the capability for 12", with a 20kwpm testing line built in late 2018.

Foundry

China's key foundries are SMIC and Hua Hong Semiconductor (Hua Hong, with its subsidiary Huali Microelectronics (Huali)). TSMC and UMC have manufacturing facilities in China. TSMC has an 8" fab and a 12" fab that is capable of 16nm production. UMC has an 8" fab (located in Hejian in Jiangsu) capable of 0.11 micron production and a JV in Fujian that is capable of 28nm.

It is clear that there are choices for Chinese production at 16nm and above – whether by using domestic fabs or foreign-own but Chinese domiciled fabs. However, at the leading edge of technology, namely in 12nm, 10nm, 7nm and in the future 5nm and below, we believe China does not have the manufacturing technology yet. On the flip side, if we look at the requirements from the Chinese customers, we find 20-30% of logic chip demand is below 14/16nm.

Chinese companies:

- **SMIC:** SMIC ramped up its 14nm technology in 2019, but we believe capacity is likely to be kept at less than 20k/month as the company switches its focus to more advanced geometries. While SMIC has not announced its plans for 2020, our own view is the company will likely start developing its 7nm node, starting in 2020. Our best guess is the 7nm node will not be ready until late 2021 or 2022 at the earliest. SMIC accounted for 25% of China's 8" logic capacity as of 2018.
- **Hua Hong:** Hua Hong accounts for 25% of China's 8" logic capacity as of 2018. It has an associate company, Huali, which focuses on advanced 12" logic technology. Huali's phase I fab has 35kwpm capacity, capable of producing 28nm, 40nm and 55nm for applications in consumers, smart card, IoT and wearables. Although it announced that it will mass produce a MediaTek

wireless chip based on its 28nm low-power process in late 2018, we believe most of its output is still in 40nm. Huali is now ramping up phase II of its fab for 28nm and 14nm, with planned capacity of 40kwpm by 2021. It aims to have 14nm enter risk production in 2020. This is more than six years behind TSMC and over one year behind SMIC. Its key challenge includes a shrinking client base given the migration to 12nm or 7nm.

Others: There are smaller fabs in China, such as TSMC's Fab 1 (6" fab), which was sold to Ningbo Zhongwei Semiconductor in 2002, and Advanced Semiconductor Manufacturing. None offer leading-edge technology, in our view. We think Huawei has the capital and internal demand to support a fab construction, although the company would have to recruit the necessary talent.

Package and test

Unlike other parts of semiconductors, China is already strong in assembly and test.

In 2018, three China-based OSAT suppliers were ranked among the top 10 suppliers globally. JCET was ranked No.3, Tongfu No.6 and Tianshui Huatian No.7. This is much better than four years ago. In 2014, JCET was the only Chinese company in the top 10, ranking at No.6. Looking at market shares, we estimate the top three China OSAT suppliers accounted for about 6% of the global share in 2014. However, by 2018, we estimate the market share for the top three China OSAT suppliers increased to roughly 21%.

- **JCET:** JCET is the largest OSAT supplier in China and ranks No. 3 globally. With government support, JCET acquired STATS ChipPAC (SC) in 2014, which was ranked as the fourth largest OSAT by revenue at the time of acquisition. SC's factories are located in Korea, Singapore and China. According to company disclosures, the company has leading technology in the OSAT sector, including fan-out, System in Package (SiP) and Through Silicon Via (TSV). In December 2019, JCET announced it will acquire ADI's test facility in Singapore.
- **Huatian:** Huatian has made significant technological progress in advanced IC assembly over the past few years, thanks to its ongoing investment in R&D and technology transfer arising from the acquisition of FCI in 2015. Huatian provides advanced IC assembly products (for example, flip chip, wafer-level packaging, TSV and SiP) to many domestic and international clients. Huatian completed the acquisition and consolidation of Unisem in Q119.

Central Processing Unit (CPU)

The shift away from x86

Intel's x86 architecture dominates the PC and server markets globally. Intel, combined with AMD, owns over 95% of the PC and server microprocessor markets. Given the US stronghold on x86, we think China could eventually move towards other architectures, such as ARM and RISC-V. ARM is already the dominant CPU architecture that is used in mobile devices. In the past decade, it has been working to shift into the data centre and networking space (two areas in which historically US-based providers have been strong).

Before we look into the investments that China has been making to build a non-x86 based eco-system, we want to highlight the following corporate activities in recent years.

- Tianjin Haiguang Advanced Technology Investment (THATIC, private company): In 2016 AMD established a JV in China, called THATIC, and agreed to license its x86 IP to the JV. However, in June 2019, AMD announced that it will not transfer any more technology to the China JV, and thus the JV will be limited to AMD's Zen architecture and not be extended to include the Zen 2 architecture. On 24 June 2019, the US government placed the JV on its entity list.
- Zhaoxin (private company): In addition to AMD, Taiwan-based Via Technologies established a JV in Shanghai in 2013, named Zhaoxin. The company also creates x86-compatible CPUs, based on the VIA architectures. The Zhaoxin chips are mostly used in consumer laptop computers; we are not aware of any applications in servers and high-performance computers (HPC).
- Imagination (non-covered company): In 2017, Imagination Technologies (which had graphics [GPU] technology and the MIPS CPU architecture) split and the graphics business was sold to Canyon Bridge, a Chinese private equity investor, while the MIPS business was sold to a US venture capital company and later onto an AI startup.

ARM ecosystem for high-performance continues to build

In our view, ARM is the de facto standard in mobile computing (smartphones/tablets). It has been investing to move into more high-performance computing environments for over a decade, particularly as power efficiency becomes more important to many tasks. Historically, ARM's main challenge to being used in server and PC applications has been a lack of software support and the need to port applications to run on the ARM architecture. This has, however, started to be addressed and there are now more initiatives.

- Amazon Web Services (Annapurna Labs): Amazon acquired Annapurna Labs in January 2015 and has continued to invest in its ARM server chip roadmap since then. On 20 December 2019, Amazon unveiled its Graviton2 chip, which it claims provide 20-45% better performance/vCPU and is also more efficient and cheaper for the customer.
- Ampere (startup): Ampere started from what was left of the Applied Micro X-Gen ARM server business with a number of ex-Intel execs as part of its leadership. It is backed by The Carlyle Group. Ampere is shipping its eMAG chip (16nm) and is sampling a 7nm chip.
- Marvell (Cavium/Qualcomm): Marvell's ARM initiative started within Cavium and was then acquired by Marvell. Marvell also then acquired the ARM server design team from Qualcomm.
- HiSilicon (Huawei): In early 2019, HiSilicon launched its Kunpeng 920 server chip, which is based on ARM's Ares Neoverse platform for data centres.

At this stage, Arm's penetration is still extremely low in the server space but these initiatives and particularly the performance data from Amazon at least suggest that Arm's server chips can be competitive in certain workloads as a replacement alternative for China. Many of the entities in the list above are US-based but HiSilicon is China-based and we think it will likely to become the replacement option for China.

Initially after Huawei was added to the entity list, Arm was reported to have ceased shipment and engagement with Huawei due to concerns regarding how much US

content was in its technology (>25% US content in a foreign company's product would be impacted by entity-list restrictions). It was then reported in October 2019 that after assessment by its legal teams, Arm had determined that its ArmvA-8 and 9 were below that threshold and Arm then re-engaged with Huawei. Arm has also created a JV in China (it retains 49% ownership) to further its initiatives in the region.

RISC-V – an open-source option gathers pace

There is one open source option in terms of processor architecture, and this is RISC-V. Technically, RISC-V is a US-based technology having been designed at the University of California, Berkeley. However, given its open source nature, we think this will unlikely be an issue for China. Today, there are many companies in China developing RISC-V processors. In August 2019, Alibaba announced it had created the most powerful RISC-V implementation in the form of the XuanTie 910 (16-core 64-bit RISC-V processor).

GPU

The discrete GPU (Graphics Processing Unit) market is dominated by US companies, Nvidia and AMD, with Intel as a distant third. We believe the prospects of China-made GPUs entering the market are low, but some GPU applications in servers can be replaced by CPUs, FPGA, and application-specific integrated circuits (ASICs). In the GPU realm, Imagination is a non-US IP vendor. However, Imagination's IP is mostly in mobile and it might struggle to move into high-performance compute (HPC) and AI-related applications.

FPGA

The FPGA market is also dominated by US companies Xilinx, Altera (now owned by Intel) and Lattice Semiconductor. China has three domestic FPGA vendors: Anlogic, Gowin, and Pango. We believe Anlogic is more competitive at the low-end for CPLD class devices. As [we have written in the past](#), Pango is working with Huawei on base stations. While Pango's products cannot replace the Xilinx FPGA, Huawei could use the Pango FPGA, combined with ASICs as the replacement, especially for lower density devices. This likely has negative performance implications, but it is a workable solution, in our view.

Wireline communications

The US also dominates the wireline communications market, with companies such as Broadcom and Marvell, but we note that HiSilicon itself is a strong company in communications, and there are some alternatives for the US: namely MediaTek (via its subsidiary Nephos) and Realtek, also based in Taiwan. In general, Huawei will likely be able to continue manufacturing communications equipment without the support of US semiconductor suppliers, but other companies in China may struggle as HiSilicon will unlikely sell to competitors.

Wireless communications

Qualcomm and MediaTek are the global leaders in cellular communications, and there are various options available for Wi-Fi and Bluetooth. HiSilicon (Huawei subsidiary) and Qualcomm both launched their 5G chip at similar time: HiSilicon in January of 2019 and Qualcomm in February 2019. Samsung is now a viable supplier of 5G chipsets, with some of Samsung's own phones in 2019 using the Samsung-designed and manufactured 5G chips. Where Qualcomm dominates is in

the mmWave frequencies, but we think that is unlikely to be used in China or countries to which China typically exports. We therefore do not consider this a significant roadblock. Net-net, we think this is an area where non-US replacements are viable and likely easily adopted.

We note that some of the smaller Chinese wireless companies, such as ASR Microelectronics and Bestech, have gained market shares.

High-performance analog

This is another market that has long been dominated by the US and European companies. We see Europe as a key beneficiary, but China, through several successful M&As, have also improved its capabilities.

JAC Capital, a Chinese state-owned investment company, bought two divisions from NXP in 2015-16 during NXP's consolidation with Freescale. One is NXP's own RF power unit, which supplies the laterally-diffused metal-oxide semiconductor (LDMOS) used for base stations and other industrial applications. The acquisition includes the management team and engineers, all relevant patents and IP, and the package facilities in the Philippines. The other deal is NXP's Standard Products business, later re-named Nexperia. Nexperia mainly provides high-end metal-oxide-semiconductor field-effect transistor (MOSFET) and discrete products. The company has fabs in the UK, Germany and back-end plants in China, Malaysia and the Philippines. In 2018, JAC sold Nexperia to Wingtech, a Chinese smartphone original design manufacturer (ODM).

Power management

Historically, power management was dominated by the US and European IDMs, as the cost saving in switching to domestic power management is not significant, but the performance gap and reliability gap was there. However, as China heads towards self-sufficiency, we believe power IC is an area where China will make progress. We think it is technically easier, and domestic suppliers like Silergy and SG Micro have less significant gap compared with the market leaders in certain products. Since the trade tensions started, we have seen increasing customer engagement with domestic companies for higher-end products, such as 5G base stations, automotives and servers. We believe the replacement should happen more imminently in low-dropout regulators (LDOs), direct current to direct current (DC/DC) with smaller output current (ie, less than 5A), supervisor and reset ICs, and power switches. In the near term, we think power management integrated circuit (PMIC) with an output current of above 20A will likely remain challenging for Chinese domestic suppliers. These products require standalone controller and high-performance MOS, and are now mostly supplied by companies such as Infineon, TI and On Semi. Separately, TI's recent drop of Asian distributors could be a positive for domestic companies to address their long-tail customers, especially in the industrial market.

Power amplifier

We believe Huawei is aggressively ramping up the smartphone RF capabilities through HiSilicon, and also partnering with Murata and a couple of domestic power amplifier (PA) suppliers, including the private companies Vanchip Tech and Lansus Technologies. Based on our teardown analysis, Huawei appears to have replaced the US PAs with HiSilicon's in Y9 Prime (4G) and Mate 30 (4G version). The antenna switch, front-end module and envelope tracker from Qorvo and

Skyworks are being replaced by HiSilicon and Murata. We think Huawei has likely resolved the RF supply for 4G phones, but it is unclear whether 5G remains an issue or not. In terms of technology, sub-6 GHz RF is simpler than mmWave, which involves beam forming and antenna integration. As we point out in the wireless communication section, we believe most Chinese 5G smartphone shipments could be sub-6 GHz RF, thus the technology barrier related to RF could be lower.

Memory

China memory remains a key long-term risk, more so for NAND than for DRAM

We think China's indigenous memory projects is one of the key long-term risks for the industry, more notably for NAND (driven by Yangtze Memory Technologies [YMTC]) than for DRAM, which looks more elusive. For NAND, YMTC announced it had successfully developed and started 64L mass production in the summer of 2019. As part of Tsinghua Unigroup, we believe YMTC is well supported. Moreover, NAND Flash is easier to manufacture than DRAM. As such, we believe YMTC alone could be more disruptive in the NAND flash market than China's DRAM companies. We estimate YMTC will add 20k wpm of 64L capacity by end-2019, and then skip 96L and jump straight into targeting 128L risk production by Q420. Hence, we think capacity addition in 2020 will likely remain limited and subject to the 128L progress. If 128L development goes well, we think YMTC will ramp up capacity aggressively – possibly to 70k wpm of 128L capacity addition in 2021. We expect YMTC to be 0.5%/1.4% of the industry's bit supply by 2020/2021.

China's DRAM remains a long-term potential risk for the industry, but this is influenced by the US/China trade/IP disputes and the efforts to build memory capacity are stalling. In the current state of technology restriction on semis manufacturing equipment sales to Jinhua IC, it is unlikely that Jinhua IC can ramp up its pilot production. Conversely, a reversal of such a ban and a resolution to the IP dispute between Jinhua IC and Micron (as [reported by the press earlier in May 2019](#)) could present upside risk to supply over time. However, there has not been any update on this front since. ChangXin Memory Technologies (CXMT)/Innotron (the other China DRAM contender) continues to invest, but at a modest pace and with limited visibility. Tsinghua Unigroup has announced its ramp-up of its DRAM capabilities, targeting mass production in 2021, which could be a more viable contender than others in terms of schedule. However, we think IP will remain the key challenge. We expect China to account for 0.4%/1.1% of the industry's bit supply by 2020/2021.

We estimate China's current market (excluding the iPhone and other devices that are made in China but are exported) as a percentage of global end-consumption to be 24%/26% for DRAM/NAND, respectively.

Figure 15: Summary of key memory projects by China's fabs

	Fab	Design capacity (k wpm)	Cumulative capacity by:			Comment
			End-2019	End-2020E	End-2021E	
DRAM						
Fujian Jinhua IC	Fab 1	120	0	0	0	Equipment activities for FJIC has all stopped following the US semis equipment ban
	Fab 2	120	0	0	0	
Changxin Memory /Innotron	Fab 1	125	10	30	40	Target 125k by 2020, but equipment activities limited
Tsinghua Unigroup	Chongqing fab	TBD	0	0	10	Targeting mass production in 2021
NAND						
YMTC	Fab 1	120	20	30	100	Currently 10k of 32L, adding 20k 64L by end-2019, then 128L ramp from end-2020/21
	Fab 2	TBD				Early stage and scale/timing TBD, depending on 128L ramp and funding

Note: TBD – To be determined.

Source: Company data, UBS estimates

Key Chinese companies

The figure below summarises the key Chinese semiconductor companies by segment and their core products.

Figure 16: Major companies by sector and by product in China

Sector	Major companies	Product/Application
Wafer Fab Equipment		
	Advanced Micro-Fabrication Equipment/ 688012.SH	Etch, MOCVD
	NAURA Tech/ 002371.SZ	Etch, PVD, CVD, Cleaning
Silicon Wafer		
	Advanced Silicon Technology	300mm, 200mm
	National Silicon Industry Group (Zingsemi)	300mm
	Zhonghuan Semi/ 002129.SZ	300mm, 200mm
Fabless		
Wireless/ Wireline		
	HiSilicon	
Analog		
	SG Micro/ 300661.SZ	Power management
	Silergy/ 6415.TW	Power management
CPU		
	Shanghai Zhaoxin Semiconductor Co., Ltd.	PC
	Sugon/ 603019.SH (THATIC)	Server
FPGA		
	Shanghai Anlogic Technology	
	GOWIN Semiconductor Co.	
	Pango Micro	Communication
Power Amplifier		
	Vanchip	
Foundry		
	SMIC/ 0981.HK	Leading nodes (14nm)
	Hua Hong/ 1347.HK	Mature nodes
OSAT		
	JCET/ 600584.SH	
	Huatian/ 002185.SZ	
Memory		
DRAM		
	ChangXin Memory Tech	
	Fujian Jinhua IC	
	Tsinghua Unigroup	
NAND		
	Yangtze Memory Tech	

Source: Company data, UBS

What are the factors impacting this bifurcation and what are the potential scenarios?

How regulations could change

As stated previously, we think the question is not whether export restrictions will increase but how it will increase. [We recently hosted a call](#) with representatives from Jones Day's Government Regulations group in Washington, DC. The US Department of Commerce (DoC) is finalising a list of key "emerging" technology – a preliminary version of which was issued in November 2019. DoC is also developing a preliminary list of "foundational" technology that the experts believe will face similar restrictions. These technologies have been exported but are considered critical to national security and would therefore be restricted going forward. The experts we hosted believe the implementation of legislation on export control is independent of any trade negotiations around tariffs. In addition, a key objective of the "emerging" technology list is for the US government to protect critical technology, such as semiconductor and – in particular – semiconductor manufacturing technology.

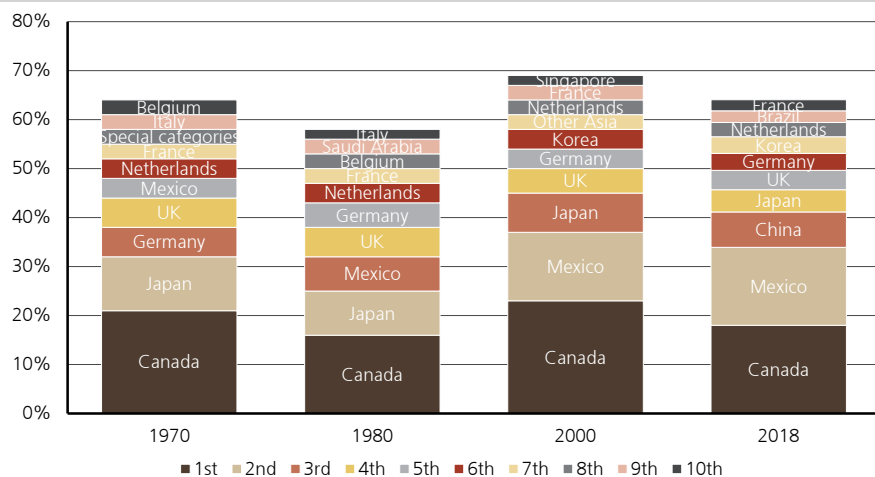
With that as the backdrop, we highlight three scenarios on how events could unfold. We believe the key variables are: 1) whether all companies to China will be restricted on key enabling technology or only a limited set of technology; and 2) whether manufacturing will be restricted. With this in mind, we created Figure 19 to show our estimates of key global semiconductor companies' exposures to China, overall Chinese customers and those on the entity list, plus the portion of IP that is US-based.

Scenario 1: A return to Cold War-like restrictions? Unlikely

The bear case is the reversal to restrictions similar to those in the Cold War era, where the Soviet Union's launch of Sputnik in 1957 spurred significant policy change in the US, and the US eliminated technology-related trade with the USSR. We think this type of scenario is unlikely.

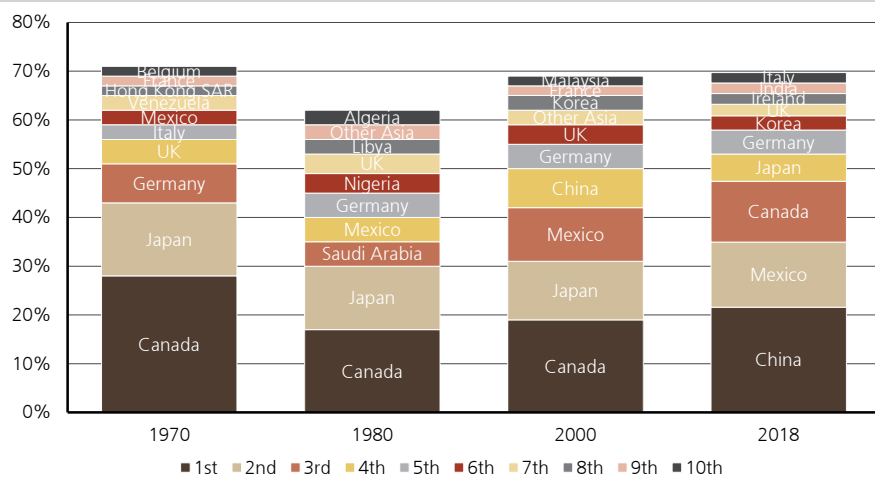
- In 1957, the USSR accounted for 1% of US trade including import and export. In 2018, China accounted for 20% of US imports and 7% of US exports. The economic impact of reducing trade with China is significantly larger than that of the USSR.

Figure 17: Top 10 US trade partners (%) – export



Source: United Nations

Figure 18: Top 10 US trade partners (%) – import



Source: United Nations

- Technology has changed. In 1957, the US could restrict technology relating to military and defence, such as missile guidance, nuclear, satellite and surveillance. How would it make that determination today? A GPU can be used in a game console, but it can also be used in a military-related AI system. A GPS chip is as much about maps on the smartphone as missile guidance. The distinction between military technology and consumer and industrial technology are blurred, and we think restricting a certain technology because it has security- or military-related usages could also eliminate opportunities in other markets.

If the bear-case scenario plays out, we believe it would significantly impact the development of China's technology industry: not just semiconductors, but internet, telecom equipment and downstream manufacturing as well. We analyse this later in the report.

We think this would also be negative for non-Chinese companies. As shown in Figure 19, total sales to China is significantly greater than sales to China's companies on the entity list.

Scenario 2: Our base case is investment restrictions and end-user-based control, not product-based control

Instead of stopping all technology trades and partnerships between the US and China, this scenario still fosters trade but puts restrictions on China's technology development and its access to US technology.

Foreign investment restrictions. As stated earlier, more restrictions on foreign investments are already in place. In the previous section, we examine where China has made significant acquisitions and where non-US technology is available, but we believe China's ability to purchase key US technology will likely diminish significantly in this scenario.

End-user-based control. Instead of limiting the export of a type of chip to China, for example, it is much more practical to restrict only exports of specific applications. This is what the entity list does, where companies on the list are ineligible to receive US technology without a licence from the Export Administration. Take the GPU as an example, a PC maker who is not on the entity list can buy the GPU that a company which is on the entity list is not allowed to purchase.

As shown in Figure 19, we break down China's sales for the global semiconductor companies versus sales to companies on the entity list. For total sales to China, the largest exposures are MediaTek, Hua Hong, Chipbond, Samsung, SK Hynix, Nidec, TDK, Hirose, Taiyo Yuden, Murata, AMD, Qorvo, and Xilinx. However, if we look only at the entity list, TSMC, Chipbond, SK Hynix, Micron, Qorvo, and Xilinx have the biggest exposures (above 7% of revenues).

Scenario 3: Manufacturing control via curbs on semi equipment

While the export of chips can be restricted to applications, we think the export of equipment by application or company is much harder. The same equipment is generally used for memory as well as logic manufacturing, and within logic, the same fab is used for surveillance chips and consumer chips.

The export of equipment to China is not restricted except to Jinhua, but we think this could change.

Figure 19: Global semiconductor companies' exposure to China

Company	Listed country/ region	Domiciled country/ region	% of sales to China in 2019			Within China sales	
			Total	Portion going to CN companies on entity list	Portion going to non-entity list CN customers	% that can be replaced by China replacements	% that can be replaced by non-US, non-China replacements
MediaTek	Taiwan	Taiwan	50%	5%	45%	5%	100%
TSMC	Taiwan	Taiwan	19%	13%	6%	10-20%	25-35%
GlobalWafers	Taiwan	Taiwan	12-13%	2-3%	10%	40%	100%
Silergy Corporation	Taiwan	Mainland China	45%	5%	40%	50%	100%
Hua Hong Semiconductor	Hong Kong	Mainland China	58%	<5%	53%	100%	100%
Chipbond Technology	Taiwan	Taiwan	20-25%	10-15%	10%	0%	100%
Samsung (Semis)	Korea	Korea	20%	5%	15%	1-3%	100%
SK Hynix	Korea	Korea	27%	7%	20%	0-2%	100%
Renesas Electronics	Japan	Japan	22%	>5%	<17%		
Tokyo Electron	Japan	Japan	18%	0%	18%	<5%	15%
SCREEN Holdings	Japan	Japan	14%	0%	14%	0%	0%
Ibiden	Japan	Japan	43%	0%	43%	0%	30%
NGK Spark Plug	Japan	Japan	20%	0%	20%	0%	85%
MinebeaMitsumi	Japan	Japan	24%	<5%	>19%	15%	80%
Mabuchi Motor	Japan	Japan	23%	0%	>18%	30%	100%
Nidec Corporation	Japan	Japan	52%	<5%	>47%	20%	60%
TDK Electronics	Japan	Japan	53%	5%	48%	10%	50%
AlpsAlpine	Japan	Japan	20%	<5%	>15%	5%	90%
Hirose Electric	Japan	Japan	32%	3%	29%	0%	100%
Rohm Semiconductor	Japan	Japan	29%	<5%	>24%	5%	100%
Kyocera Group	Japan	Japan	24%	<5%	>19%	10-15%	60%
Taiyo Yuden	Japan	Japan	35%	5%	30%	5-10%	35%
Murata Manufacturing	Japan	Japan	50%	5%	45%	5%	20%
Micron Technology	US	US	15%	12%	3%	0%	100%
Intel	US	US	27%	<5%	>22%	5%	95%
AMD	US	US	39%	<5%	>34%	5%	95%
Qualcomm	US	US	24%	6%	18%	10%	10%
Nvidia	US	US	24%	3%	21%	0%	100%
Qorvo	US	US	25%	13%	12%	20%	80%
Skyworks	US	US	21%	9%	12%	20%	80%
Texas Instruments	US	US	18%	3%	15%	10%	90%
Broadcom	US	US	20%	4%	16%	10%	90%
Marvell Technology	US	US	8%	4%	4%	30%	70%
Analog Devices	US	US	22%	5%	17%	10%	90%
Microchip Technology	US	US	22%	1-2%	20-21%	10%	90%
Xilinx	US	US	28%	7%	21%	40%	60%
Teradyne	US	US	12%	0%	12%	5%	95%
Applied Materials	US	US	29%	0%	29%	20%	80%
Lam Research	US	US	23%	0%	23%	20%	80%
KLA Corp	US	US	27%	0%	27%	0%	100%

Source: Company data, UBS estimates

What are markets pricing in for these scenarios and where do opportunities lie?

In the previous sections, we broke down the competitive dynamics by subsectors, and we also looked at global companies' exposure to China, both on entity-list companies and overall. This should help us to gauge the potential impact for each company. Within the semiconductor industry, we believe semiconductor equipment, assembly and test, and analog semiconductors could experience the most significant impact and we therefore provide additional analysis here.

Semiconductor manufacturing

Semiconductor manufacturing and therefore semiconductor equipment could experience significant changes over the next decade. On the one hand, if China shifts to using more domestic semiconductors, manufacturing is an area where supply/demand is imbalanced. This is not as simple as adding capacity, as we think the technical barriers are high, but we calculate the size of the opportunity could be in excess of US\$11bn for logic alone.

On the flip side, a potential US restriction on equipment sales to China could impact all semi equipment companies globally.

On the supply side, we look at 8" and 12" foundry capacity for the Chinese foundries: SMIC, Hua Hong, and Huali. We estimate that in 2019, China has roughly 6.7 million wafers/year in 8" capacity, and 3.5m wafers/year in 12" capacity (8" equivalent).

On the demand side, we estimate that China requires 5.4m wafers/year in 8" foundry wafers, and 4.9m wafers/year in 12" capacity (8" equivalent).

How much would China have to spend for it to become fully self-sufficient? If we look at the gap between supply and demand on all 12" wafers, we estimate that it would require roughly 1,500k wafers/year (8" equivalent), or about 700k in 12" capacity. Assuming US\$200m per thousand wafers in capex (which would be a combination of new and used tools), this would translate into an additional US\$11bn in capex. Just to put this into perspective, we estimate China's total logic capex in 2019 is about US\$2bn.

Looking at it another way, we think what China is lacking is the leading-edge technology, namely 7nm and below processes. We estimate China is consuming around 40k/month in 7nm capacity, mostly from Huawei and HiSilicon. Using US\$200m/k wafers, this would mean an incremental US\$8bn in capex in total.

SMIC is China's most advanced logic foundry. The company is on 14nm, and we think SMIC could skip 10nm and go straight to 7nm, which likely implies higher capex in 2020E/2021E.

Figure 20: Foundries' supply and demand analysis

	2017	2018	2019E
Revenue from mainland China (US\$m)			
- 8"	3,101	3,966	3,735
- 12"	3,678	5,445	6,228
Total	6,779	9,411	9,963
Shipment to mainland China (8" equiv., k unit)			
- 8"	4,295	5,478	5,410
- 12"	3,123	4,379	4,870
Total	7,418	9,857	10,280
Capacity in mainland China (8" equiv., k unit)			
- 8"	6,174	6,321	6,665
- 12"	2,724	3,092	3,452
Total	8,898	9,413	10,117
Supply vs Demand (8" equiv., k unit)			
- 8"	1,879	843	1,255
- 12"	(399)	(1,287)	(1,418)
Total	1,480	(444)	(163)

(Note: Including TSMC, UMC, Vanguard International Semiconductor (VIS), SMIC, Hua Hong)

Source: Company data, UBS estimates

Figure 21: China as % of memory end-demand consumption – DRAM

Mobile as % of bit demand	35%
CN as % of mobile	27%
% of total DRAM demand	9%
PC as %	15%
CN as % of PC	21%
% of total DRAM demand	3%
Server as %	24%
CN as % of server	25%
% of total DRAM demand	6%
Other as %	26%
CN as % of other	20%
% of total DRAM demand	5%
% of total DRAM	24%

Source: Company data, Gartner, UBS estimates

Figure 22: China as % of memory end-demand consumption – NAND

Mobile as % of bit demand	32%
CN as % of mobile	27%
% of total NAND demand	9%
PC as %	12%
CN as % of PC	21%
% of total NAND demand	3%
Server as %	13%
CN as % of server	25%
% of total NAND demand	3%
Enterprise SSD, flash arrays	16%
CN as %	20%
% of total NAND demand	3%
Other as %	43%
CN as % of other	20%
% of total NAND demand	9%
% of total NAND	26%

Source: Company data, Gartner, UBS estimates

Figure 23: Chinese companies as % of memory demand – DRAM

	Chinese companies	Huawei	
		% of CN	% of total
Mobile as % of bit demand	35%		
CN as % of mobile	23% of DRAM demand		
% of total DRAM demand	23%	34%	8%
PC as %	15%		
CN as % of PC	30%		
% of total DRAM demand	5%		
Server as %	24%		
CN as % of server	11%		
% of total DRAM demand	3%		
Other as %	26%		
CN as % of other			
% of total DRAM demand	0%		
% of total DRAM	30%		8%

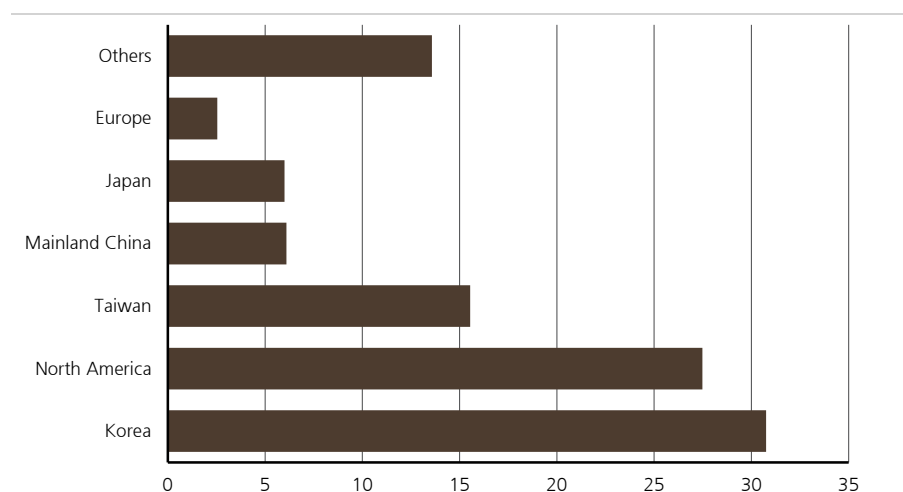
Source: Company data, Gartner, UBS estimates

Figure 24: Chinese companies as % of memory demand – NAND

	Chinese companies	Huawei	
		% of CN	% of total
Mobile as % of bit demand	32%		
CN as % of mobile	15% of NAND demand		
% of total NAND demand	15%	34%	5%
PC as %	12%		
CN as % of PC	30%		
% of total NAND demand	4%		
Server as %	14%		
CN as % of server	11%		
% of total NAND demand	2%		
Other as %	42%		
CN as % of other			
% of total NAND demand	0%		
% of total NAND	20%		5%

Source: Company data, Gartner, UBS estimates

Figure 25: Semis capex forecasts by region (2019E, US\$bn)



Source: Company data, Gartner, UBS estimates

Analog semiconductors

As stated in the previous section, we think analog semiconductors are one area that could experience change because: 1) the US has been dominant; and 2) there are non-US replacements available, from Europe, Japan, Taiwan and mainland China. We expect China to gain market share in power management and the lower end of high-performance analog (HPA), ie, where power and precision requirements are not as critical. We also believe Chinese customers' desire to shift away from US suppliers could benefit European suppliers as well – particularly where they might be better placed to meet high-end requirements. At the UBS TMT conference, Texas Instruments' management commented that it is witnessing the use of Chinese replacements at the low-end analog chips.

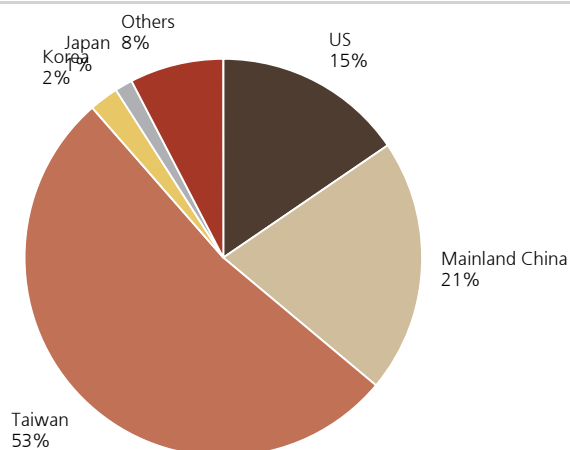
In power management, non-US suppliers have already been taking share for consumer-related products. Now, we find opportunities in 5G base station, automotive and servers, among others. We believe the replacement could occur sooner in LDOs, DC/DC with smaller output current (ie, less than 5A), supervisor and reset ICs, and power switches. In the near term, PMIC with output current of above 20A should remain challenging for Chinese domestic suppliers.

In high-performance analog (HPA), Nexperia (spinoff of NXP, now owned by Chinese companies) and Huawei's internal division can supply the lower end, ie, level shifter and some of the amplifiers. However, we think most of the HPA opportunities are likely to move to European suppliers.

Packaging and test

Unlike other parts of semiconductors, packaging is an area where China is already a market leader. As shown in Figure 26, mainland China's global market share in 2018 was 21%, trailing only Taiwan. We find several reasons for this: 1) the technology barrier for packaging and test is generally low; and 2) China was successful in acquiring foreign packaging and test companies, whereas it has struggled with M&A in other segments of semiconductors.

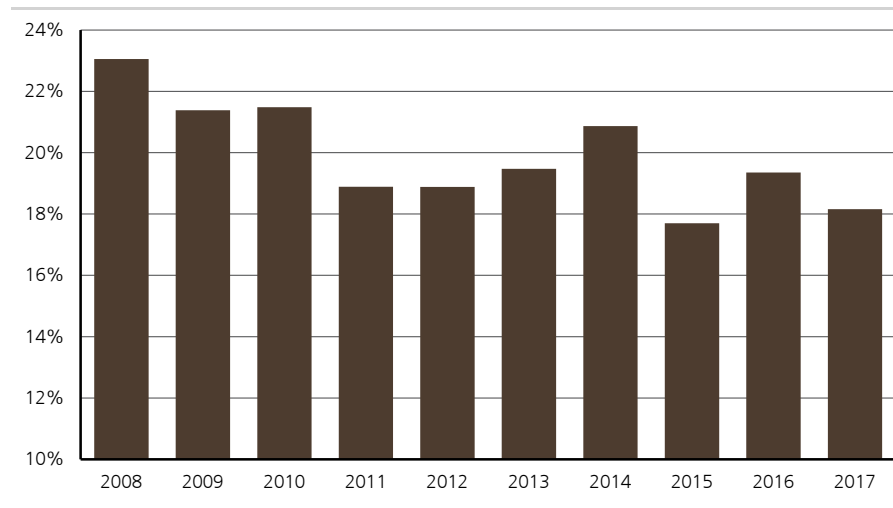
Figure 26: Market share of OSAT by region (2018)



Source: Yole Développement

Looking ahead, we do not think China's market share will increase in the near term because there is already enough capacity for domestic demand and non-US customers may not be eager to move to China. Additionally, the merger of Taiwanese companies ASE and SPIL could create a stronger competitor. On the flip side, we have concerns about pricing. We believe there are structural pricing issues, as indicated by ASE's margins (Figure 27). Mainland China's aggressiveness in the test and packaging industry will likely cap pricing upside for its competitors, in our view.

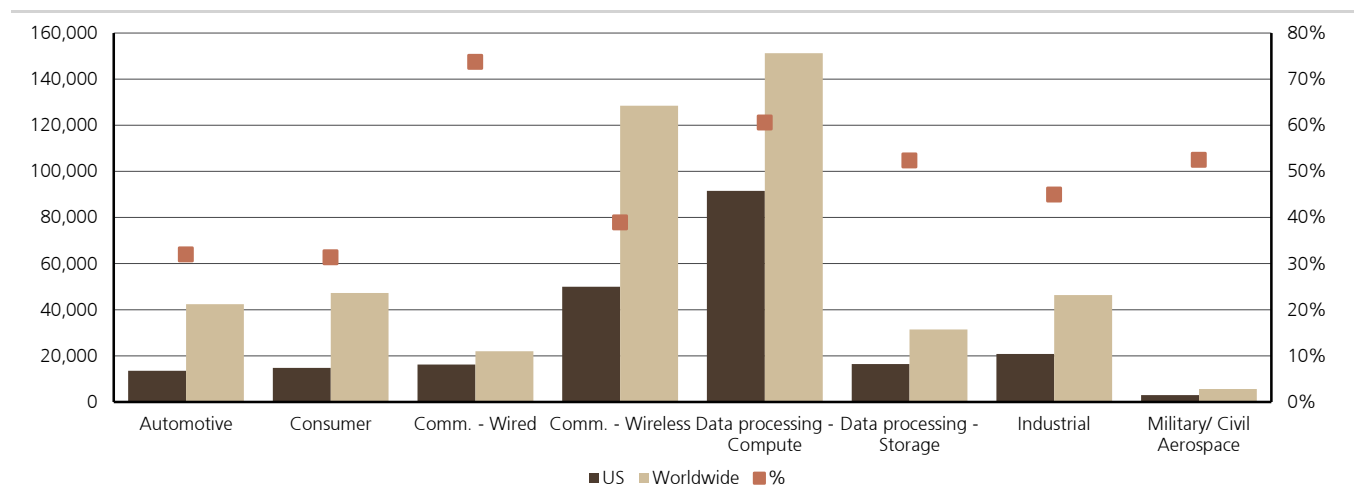
Figure 27: ASE's historical gross margin (standalone)



Source: Company data

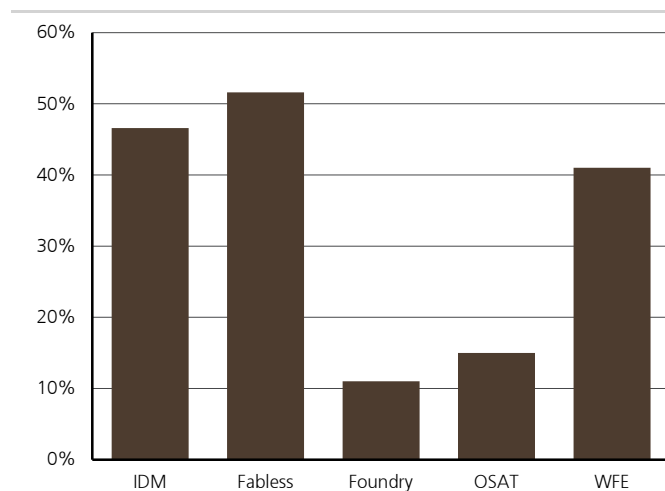
Basic statistics on the global semiconductor industry

Figure 28: US semiconductor market share by end demand (2018)



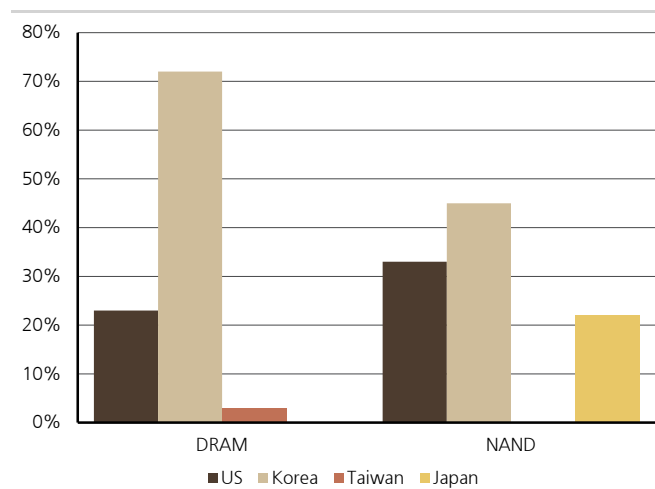
Source: Gartner

Figure 29: US market share by semis subsectors (logic) (2018)



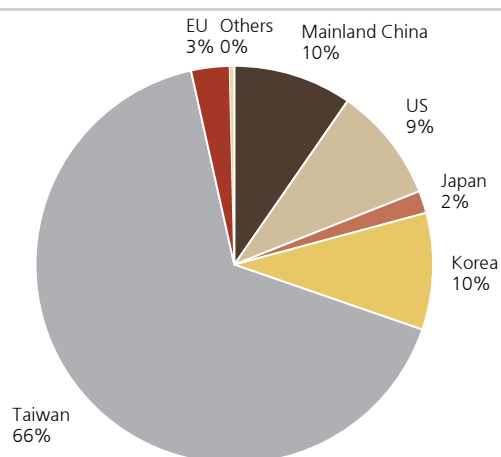
Source: Gartner, Yole Développement

Figure 30: Market share of memory (DRAM vs. NAND) by region (2018)



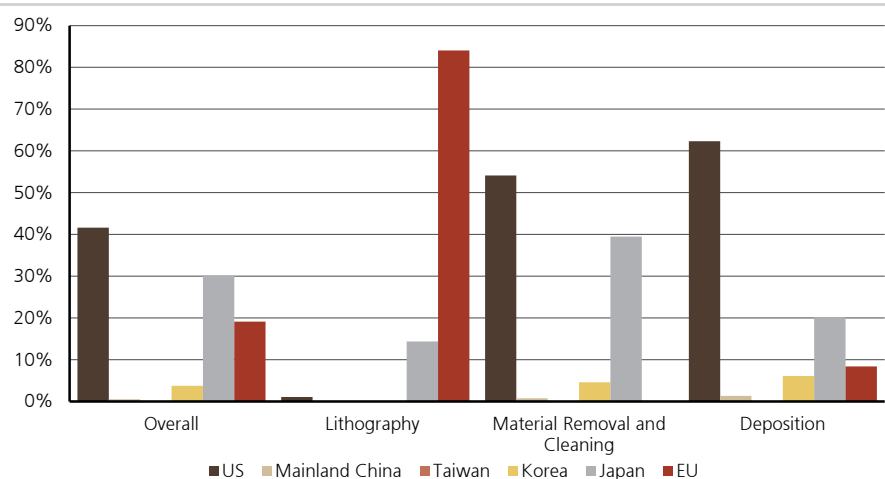
Source: Gartner

Figure 31: Market share of foundries by region (2018)



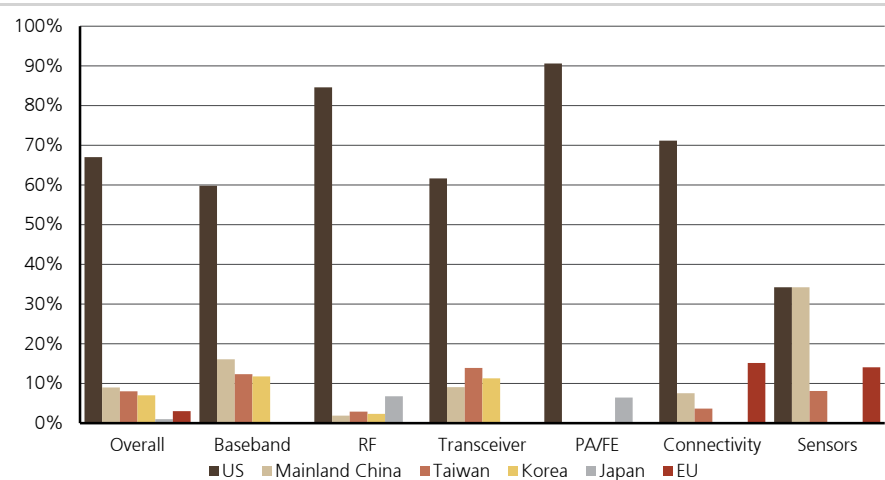
Source: Gartner

Figure 32: Market share of key wafer fab equipment by region (2018)



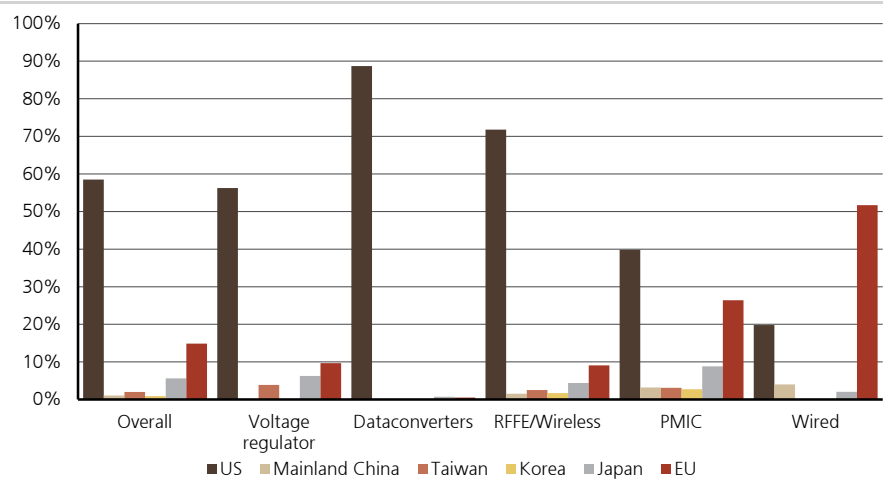
Source: Gartner

Figure 33: Market share of key smartphone ICs by region (2018)



Source: Gartner

Figure 34: Market share of analog/mixed-signal ICs by region (2018)



Source: Gartner

Beyond the semis value chain: what are the implications of this across the broader technology landscape?

Internet

As stated earlier, our base-case scenario is that only companies on the entity list will be banned, and other Chinese companies would be unaffected. If our base case materialises, we think the impact on Chinese internet companies would be minimal as access to US technology would not be impacted.

Is it possible that Chinese internet companies are put on the entity list? We believe this is a long-tail risk scenario. One of the key questions would be how does the US government assess Chinese Internet companies' relationships with the Chinese government. For example, how does Tencent monitor users in WeChat inside and outside of China? Similarly, how does Bytedance monitor content in Douyin and TikTok? Beyond content and social networks, there have been concerns about whether AI and other technology from Chinese internet companies are being used for surveillance or other activities that could be a cause of concern for the US. If the Chinese internet companies are put on the entity list, we think the potential business impact increases significantly. In our view, these companies face the same potential regulation and restrictions as most other companies in China. Most importantly, they depend on Intel and Nvidia for CPUs and GPUs, which we think are difficult to replace.

What are the alternatives? We believe the larger top-tier Chinese internet companies have started their internal semiconductor efforts, mostly in AI-related ASICs and CPUs. Alibaba has its DAMO research institute focused on AI, data computing, robotics and fintech. We think Baidu still produces some of the best AI researchers in China. If there is an opportunity to shift from x86 and AMD/NVDA to ARM or RISC-V, we believe the Chinese internet companies would jump at it. This started out mostly as an effort to improve efficiency of AI and other tasks, similar to what US tech companies do, but we believe the Chinese internet companies are more ambitious and they could step up these efforts if a ban were to materialise.

In the scenario where there is a ban, we think the impact on Chinese internet companies could be similar to other companies in China. There could be an initial impact from a lack of chips, but we think this could be mitigated by potential delays in the implementation of any bans. In such a case, the impact would lessen as the domestic semi industry advances further. We believe Chinese data centres could be less efficient for a period of time as they lose access to leading-edge technology. However, we do not think this would have a critical effect on the large-cap companies under our coverage as we consider their budgets large enough to stomach higher opex and capex in cloud for a while.

Telecom and Telecom Equipment

If the bans are only on entity-list companies, the telecommunications industry in China could be cut off from US-made CPUs, FPGAs, GPUs, ASICs and other chips.

With that said, we believe that the alternatives are more readily available for telecom equipment than internet companies. For telco equipment, China is already

capable of making its own ASICs with low-end FPGAs, and HiSilicon is a global technology leader in 5G chips. Since the telco equipment are mostly closed systems, we think the use of a non-standard chip such as RISC-V would also be easier to implement than a cloud system.

Net-net, the Chinese telecom industry could be negatively impacted if availability to US technology is cut off, but we believe the industry has already begun an aggressive initiative to replace US tech. This likely implies a lower performance level for now (including on integration, power consumption and reliability) but we think the longer-term impact is likely limited.

China surveillance

Hikvision and Dahua were added to the US entity list in October 2019. Inclusion on the list poses two potential challenges for their businesses: 1) a loss of business in the US market, particularly government contracts, as well as other countries allied with the US; and 2) supply chain disruption when sourcing key components from US companies (eg, CPU, GPU and FPGA). Hikvision and Dahua have been preparing for these challenges since early 2018 at the start of the China-US trade war. We highlight the preparations made in the section below.

- **Stocking up on key components.** Both companies started increasing inventories of key components including CPU and GPU, which are important for back-end products (eg, video recorders, encoders and various AI solutions). After being added to the entity list, the companies said they had 12 to 24 months of supply for certain components. We have witnessed their inventories levels increasing, particularly for raw materials, over the past 12-16 months. We would become more concerned if component sourcing restrictions last beyond 2020.
- **Increased domestic sourcing.** The companies are increasing sourcing of key components domestically. There are no Chinese replacement options for x86 CPU/GPU as the two largest suppliers are Intel and NVIDIA. We think this is the riskiest component (CPU and GPU are used in back-end systems). However, customers could use Hikvision's and Dahua's camera systems with other brands' back-end systems, but Hikvision and Dahua would therefore lose out on back-end sales. FPGA and ASIC are important in AI cameras and both companies have shifted from US suppliers to Chinese suppliers.
- **Accessing projects with channel partners.** Typical surveillance projects involve a number of camera systems matched with back-end systems (such as servers, video recorders and management software). Products are generally standardised, meaning one brand's front-end camera could work with another company's back-end system. Hikvision and Dahua would need to work closely with system integrators to ensure they can gain business if there were restrictions or product supply limitations. While not ideal, we think this would be a viable solution to maintain relationships.

Can Hikvision and Dahua fully source domestically?

Our talks with Hikvision and Dahua suggest they have been accelerating the testing of domestic suppliers since early 2018 at the start of the China-US trade tensions. They have increased sourcing of mechanical components domestically (PCB, FPGA and ASIC used in AI cameras), and other key components. The one area where there is no domestic supplier is for server CPU and GPU.

- Front-end products require components including lens, ISP (Image Signal Processing) chip and CMOS (Complementary Metal Oxide Semiconductor). We think China has a robust ecosystem for these products, and Hikvision and Dahua would unlikely have a problem sourcing components. Our conversations with both companies suggest they are satisfied with domestic design and technology. Alternatively, Hikvision and Dahua can source these components from Sony, Samsung and ST Microelectronics.
- AI-related components (GPU, FPGA and AI camera chips) and some back-end product components (eg, x86 CPU and hard drives) rely more on US suppliers, in our view. Here, GPU and server CPUs are the main challenges with no alternative suppliers in China or elsewhere. Hikvision and Dahua said they have stocked up components from system integrators and distributors. Both companies are also evaluating domestic semi-designs, namely HiSilicon's AI chips.
- Without server CPU and GPU, the companies could lose 15-20% of their revenues from back-end systems. However, we think their customers could source back-end systems from other vendors given the inter-operability of Hikvision's and Dahua's front-end cameras.

Figure 35: Key components and potential domestic replacement

Product	Components	Current supplier	Potential domestic supplier	Other options and comments
Front-end- Camera	Lens	Yu Tong Optical Technology/Sunny Optical Technology/Union Optech/Forecam Optics	Current suppliers are all Chinese companies	
	CMOS	WillSemis/GalaxyCore/Sony (Japan)/Samsung (Korea)/ON Semiconductor (US)	Will Semis/GalaxyCore	
	ISP/IPC chip	HiSilicon/Ambrella (US)/Fuhanwei	HiSilicon/Fuhanwei	
	Power Management IC	TI (US)/Ambrella (US)/Infineon(Europe)/Stmicroelectronics (Europe)/Silergy	SG Micro/Silergy	
	AI chip	Mainly from Nvidia (US)	HiSilicon Shengteng 310 series	
Front/Back-end products	FPGA	Xilinx (US)/Intel (US)/Lattice (US)	Pango Micro/Fudan Micro/Anlogic	Could also replace FPGA with ASIC in some products
Back-end-DVR/NVR	DVR/NVR chip	HiSilicon/TI (US)/Marvell (US)/Stmicroelectronics (Europe)	HiSilicon	
Hard Drive/Memory	Memory	Western Digital (US)/Seagate (US)	Gigadevice/MaxioTech	Western Digital/Seagate can continue supplying Hikvision/Dahua
Central control system-Server	x86 CPU	Intel (US)	THATIC/ZhaoXin (performance not ideal)	Huawei KunPeng Server (Arm Architecture)
Central control system- AI products	GPU	Nvidia (US)	HiSilicon Shengteng 910 series	Shengteng 910 series targets to match Nvidia GPU's function

Source: Company data, UBS estimates

Servers

Inspur gaining market share from Huawei and Sugon

Huawei and Sugon were added to the entity list in May and June 2019 respectively, and are unable to source key server components from the US, namely Intel and AMD x86 server CPU. Inspur is not on the US entity list. However, it could be at risk as Inspur has been key in helping Baidu, Alibaba and Tencent build up their high-performance and cloud computing infrastructures and the US appears to be focusing on restricting China's progress in these areas. Inspur, Huawei and Sugon together control 55% of the current Chinese server market. Huawei's market share has collapsed from 20% in 2017 to 12% in Q219. Sugon temporarily gained market share in H119, but started experiencing disruptions in H219 after burning through any CPU inventory on hand. We believe Inspur has gained the most from Huawei, and this explains its outperformance versus the sector in H119. We expect Inspur to benefit from Sugon's disruption as early as Q419.

What is the impact on business for Huawei and Sugon?

Huawei and Sugon cannot source key components and technology from US companies. Huawei has been granted a temporarily licence, but scrutiny over purchases from the US are high. Our conversation with Sugon suggests the same (ie, the company can make purchases for select projects and customers). The key components of concern are x86 servers CPU, supplied by Intel and AMD. There are no viable x86 server CPU suppliers in China. GPU is also a key component for AI servers but penetration is small and there are competing solutions, such as ASIC and FPGA. There are domestic suppliers for ASIC and FPGA suppliers domestically, but again the penetration is low. What is clear, in our view, is China's increasing interest in ARM-based solutions from domestic server suppliers.

Figure 36: The comparison of current suppliers and potential domestic replacements for key server components

Components	Current supplier	Potential Chinese replacement	Other options or comments
x86 CPU	Intel(US)/AMD(US)	THATIC/ZhaoXin (Performance not ideal now)	Huawei KunPeng CPU (Arm Architecture)
GPU	Nvidia(US)	HiSilicon Shengteng 910 series	Shengteng 910 series targets to match Nvidia GPU's function
BMC chip	Aspeed(Taiwan)/HiSilicon	HiSilicon	
Memory	Western Digital(US)/Seagate(US)	Gigadevice/MaxioTech	Some Korea/Japan suppliers can also replace US ones

Source: UBS estimates

Bibliography

The US policy section in this report uses information obtained from the following sources:

“Emerging Technologies and Managing the Risk of Tech Transfer to China”, James Andrew Lewis, September 2019, Center for Strategic and International Studies (CSIS)

“China’s Technology Transfer Strategy: How Chinese Investments in Emerging Technology Enable a Strategic Competitor to Access the Crown Jewels of US Innovation”, Michael Brown and Pavneet Singh, January 2018, Defense Innovation Unit Experimental (DIUx)

Valuation Method and Risk Statement

Alibaba: Our price target is based on DCF methodology, supported by an SOTP analysis and peer valuation comparisons.

Applied Materials: We use a PE valuation methodology for AMAT.

Baidu: We derive our price target based on a DCF model.

Broadcom: We use an EV/FCF methodology for valuation of AVGO

GUC: Our valuation is based on a PE approach relative to its historical range.

Huatai: We value Huatai using a P/BV multiple.

Infineon: We value Infineon using a DCF methodology.

LAM Research: We use a PE valuation methodology on LRCX.

MediaTek: Our price target is based on a sum-of-the-parts (SOTP) approach.

Murata: Our price target is based on PE.

Qualcomm: Our price target is based on a NTM PE methodology.

Rohm: Our price target is based on a PE valuation.

Silergy: We derive our price target on a DCF methodology.

STMicro: Our valuation for STMicro is based on a DCF methodology.

Tencent: Our price target is based on a DCF model.

TSMC: We derive our price target using P/BV and PE multiples.

Investing in the technology sector involves a high degree of risk. Rapid technological changes, increasing competition and exposure to macroeconomic cycles are among the many risks faced by investors in technology stocks. Moreover, it is extremely difficult to project the financial results of tech companies, since their operating models are highly volatile and unpredictable. Finally, valuing technology stocks can prove challenging, as neither traditional nor non-traditional valuation measures have provided much insight into how these stocks trade.

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12-Month Rating	Definition	Coverage ¹	IB Services ²
Buy	FSR is > 6% above the MRA.	44%	32%
Neutral	FSR is between -6% and 6% of the MRA.	41%	29%
Sell	FSR is > 6% below the MRA.	15%	20%
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Buy	Stock price expected to rise within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%
Sell	Stock price expected to fall within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%

Source: UBS. Rating allocations are as of 31 December 2019.

1: Percentage of companies under coverage globally within the 12-month rating category.

2: Percentage of companies within the 12-month rating category for which investment banking (IB) services were provided within the past 12 months.

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Company Name	Reuters	12-month rating	Short-term rating	Price	Price date
Alibaba Group ^{2, 4, 5, 7, 16a, 16b, 22}	BABA.N	Buy	N/A	US\$223.83	10 Jan 2020
Applied Materials Inc ^{16b, 20}	AMAT.O	Sell (CBE)	N/A	US\$61.47	10 Jan 2020
Baidu, Inc. ^{16b}	BIDU.O	Neutral	N/A	US\$144.51	10 Jan 2020
Broadcom Limited ^{16b, 22}	AVGO.O	Buy	N/A	US\$299.22	10 Jan 2020
Global Unichip	3443.TW	Buy	N/A	NT\$250.50	10 Jan 2020
Infineon Technologies AG ¹⁸	IFXGn.DE	Buy	N/A	€21.42	10 Jan 2020
LAM Research Corp ^{16b}	LRCX.O	Sell	N/A	US\$294.34	10 Jan 2020
MediaTek Inc.	2454.TW	Buy	N/A	NT\$432.00	10 Jan 2020
Murata Manufacturing	6981.T	Buy	N/A	¥6,884	10 Jan 2020
Qualcomm Inc. ^{16b}	QCOM.O	Neutral	N/A	US\$90.26	10 Jan 2020
Rohm	6963.T	Buy	N/A	¥8,900	10 Jan 2020
Silergy Corporation ¹³	6415.TW	Buy	N/A	NT\$1,080.00	10 Jan 2020
STMicroelectronics ^{5, 16b, 18}	STM.PA	Neutral	N/A	€24.73	10 Jan 2020
Taiwan Semiconductor Manufacturing ^{16b}	2330.TW	Buy	N/A	NT\$339.50	10 Jan 2020
Tencent Holdings ^{16a, 22}	0700.HK	Buy	N/A	HK\$398.60	10 Jan 2020
Tianshui Huatian Technology	002185.SZ	Neutral	N/A	Rmb7.85	10 Jan 2020

Source: UBS. All prices as of local market close.

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