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Equity Research
Asia Pacific | Japan

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Technology sector

Asia Feedback (Semiconductor/SPE): Self-restraint in purchasing

Technology | Comment

- **Summary:** We carried out our regular survey of the Asia tech markets from late May into early June, though once again COVID-19 impacts prevented us from visiting China, South Korea or Taiwan. We assume that DRAM and NAND prices will start to correct over the next 12 months as the market snaps back from the restocking demand from Chinese smartphone manufacturers and US hyperscalers. A capex slowdown in the Chinese datacenter sector is also an emerging concern. With semiconductors, the capacity correction has already started with mature-process 200mm and 300mm chips. Production of chips based on more advanced processes is still operating at full capacity, but a correction remains a risk for 2H. In wafers and fab equipment, memory chip price erosion is dashing any expectations of a capex rebound in 2021. Expansion plans for 5nm and 7nm processes have been shelved at HiSilicon, which is revising its production plans as Huawei faces renewed regulatory action. Overall, conditions in the SPE market are negative. In the back-end SPE sector, signs of a slowdown started to emerge in the second half of May as leading Chinese OSAT vendors deferred or canceled capex programs due to the Huawei-related impacts. In the FA-related sector, where there had been some signs of a post-COVID recovery in demand, the end of May saw new cancellations that put the tone of a post-COVID recovery in doubt, implying at least a degree of caution. The one thing we can say from this survey is that market conditions have deteriorated in terms of pricing. On the other hand, applications have been made for licenses to produce Qualcomm's Snapdragon chips used in Huawei smartphones. This has positive implications for the logic and foundry chip market (in both capacity utilization and capex terms) if these licenses are granted. In the memory chip sector, we think the correction is likely to continue, irrespective of licensing developments.
- **Investment implications:** Our recommended SPE sector investment stance was bullish in the short term and bearish in the medium-to-long term, based on strong conditions in the short term and a forecast of higher server DRAM prices starting in March 2020. We do not alter this stance. In addition to smartphone memory inventory adjustments, we expect data center demand to slow. We downgrade the four SPE majors (Tokyo Electron (8035), SCREEN (7735), Disco (6146), and Advantest (6857) to UNDERPERFORM in anticipation of a decline in valuations stemming from a downturn in memory prices over the next 12 months. However, should Qualcomm's licensing filing be approved, the sector as a whole could gain attention in the short term. However, given the heightened risk of inventory adjustments even before new sanctions were added to Huawei, we do not expect memory prices to turn up as a result of licensing approvals. In 5G-related products, we continue to recommend Anritsu (6754) as OUTPERFORM due to anticipated demand from chipset makers looking to reinforce their support set-ups amid increasing smartphone production volumes. With Advantest (6857), which is also active in this space, we do not recommend investing in the stock as a pure 5G play because (1) stronger regulatory action against Huawei is likely to have a generally negative impact on the stock, and (2) price erosion with memory chips is also a risk.
- **New intelligence from feedback survey:** See main text (pp. 6–7).

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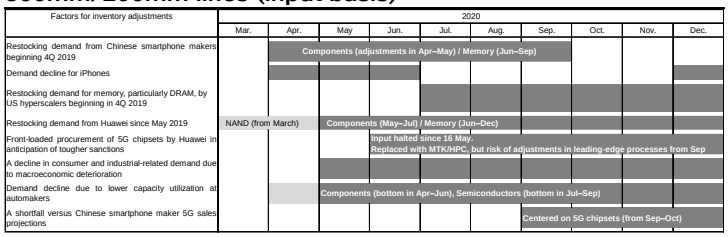
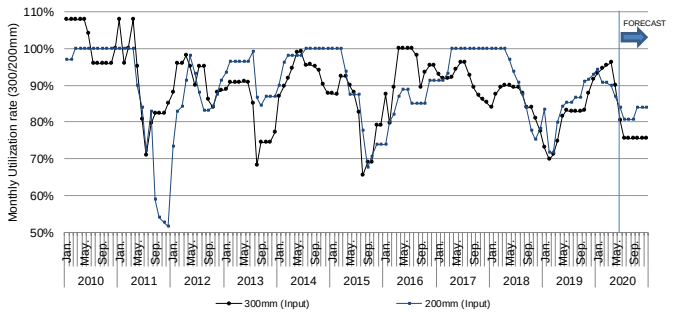
Key charts

Figure 1: Projected capacity utilization for Taiwanese foundry 300mm/200mm lines (input basis)



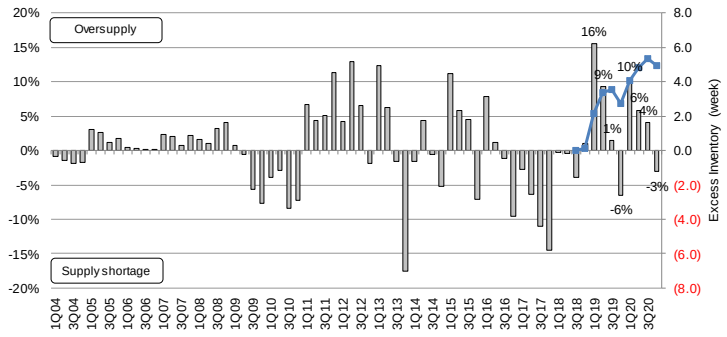
Source: Credit Suisse estimates

Figure 2: Projected capacity utilization for Taiwanese foundry 300mm/200mm lines (input basis)



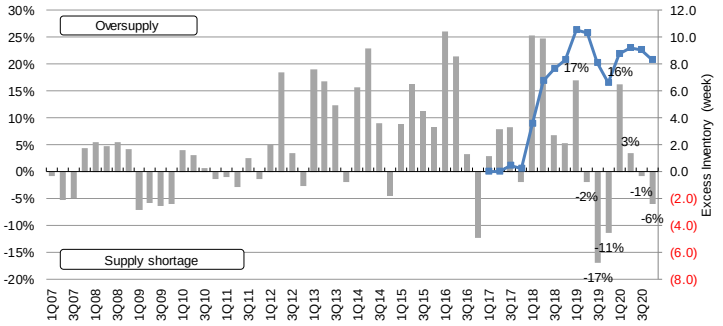
Source: Credit Suisse estimates

Figure 3: DRAM supply–demand model



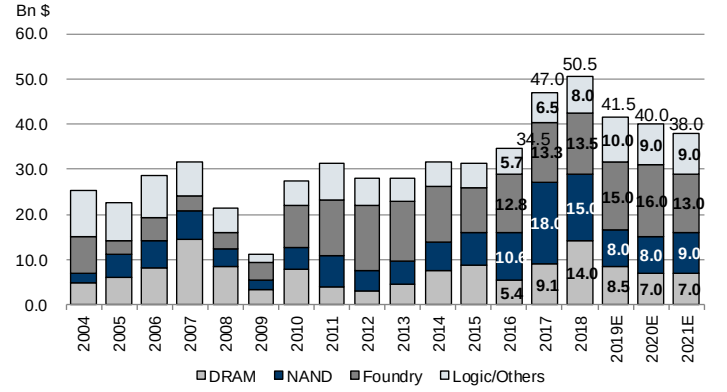
Source: Company data, Credit Suisse estimates

Figure 4: NAND supply–demand model



Source: Credit Suisse estimates

Figure 5: WFE capex forecasts (Japan team estimate)



Source: Credit Suisse estimates

Figure 6: 5G AP production plan and AP adoption by supplier

Company's Target as of June 2020

5G Production Plan (mn units)		Apple	Qualcomm	HiSilicon	Samsung LSI	Mediatek
Apple	87	87				87
Samsung	32		15		10	7
Huawei	70			60		10
OPPO	30		15			15
Xiaomi	20		15			5
vivo	33		12		12	9
Others	10		5	0	0	5
Total	282	87	62	60	22	138
5G Chipset Production Plan	333	87	143	70	30	90

Company's Target as of March 2020

5G Production Plan (mn units)		Apple	Qualcomm	HiSilicon	Samsung LSI	Mediatek
Apple	90	90				
Samsung	45		20		20	5
Huawei	120			100		20
OPPO	40		25			15
Xiaomi	40		25			15
vivo	40		20		5	15
Others	10		10	0	0	0
Total	385	90	100	100	25	70
5G Chipset Production Plan	375	90	150	110	35	80

Source: Company data, Credit Suisse estimates

Table of Contents

Executive summary

US, China data center demand to slow in 2H; signs of inventory adjustments, but semiconductor leading-edge processes at full capacity; Memory prices to fall in 2H

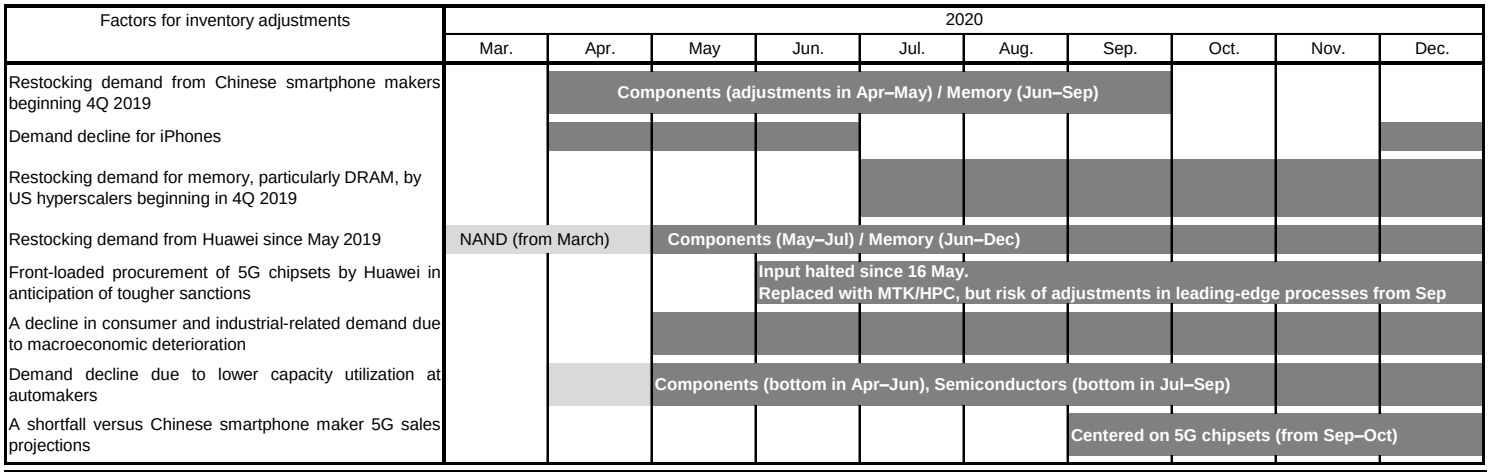
Smartphone makers reducing 5G handset production plans to more realistic levels

While hardware production trends are as stated in our Asia Feedback (Hardware) report published today, we note that 2020 smartphone and 5G smartphone production plans have been revised down. In particular, smartphone makers have lowered their aggregate 5G smartphone volume outlook from 380mn units to 280mn units.

Much to drive inventory adjustment

There are already emerging signs of inventory adjustments in the semiconductor supply chain due to COVID-19 and new Huawei sanctions, but there are a number of other factors in play. While some of these factors are already priced into the market's consensus outlook, it does not necessarily mean that fallout from their potential overlapping have been debated in detail. We expect inventory adjustments across the technology industry to result in (1) a pullback in restocking demand from Chinese smartphone makers that started in 4Q 2019, (2) a pullback in restocking demand for memory (particularly server DRAM) from hyperscalers, (3) a pullback in Huawei's restocking demand since May 2019, (4) inventory adjustments at Huawei due to the company bringing forward 5G chipset procurements in anticipation of stricter sanctions, (5) a decline in consumer and industrial-related demand due to macroeconomic deterioration, (6) weaker demand due to a decline in utilization rates at automobile manufacturing plans, and (7) a shortfall versus Chinese smartphone makers' 5G sales projections. Accordingly, unlike the previous inventory adjustment pattern, we need to keep a close eye on the length of the overall inventory adjustment period (over six months) and the extent of the correction.

Figure 7: Factors behind inventory adjustments and possible length of correction period



Source: Credit Suisse estimates

US hyperscaler investment slowing, as planned; Chinese data center demand set to lose momentum in 2H

In data center–related business, viewed as a potential beneficiary of COVID-19, investment by Alibaba and Tencent is expected to slow in 2H, weighed down by concerns about companies curbing IT investment in China due to the risk of a macroeconomic slowdown. Since the market had expected this domain to remain largely immune, the slowdown in 2H will make stock selection in the technology sector a difficult proposition.

Radical change in scenario in the event of Qualcomm licensing application

We understand Qualcomm has filed an application to supply Snapdragon processors for Huawei smartphones. We believe Huawei's approval will make stock selection even more difficult as this will be seen as a positive for the entire technology sector.

Cutting-edge 300mm processes remain at full capacity utilization

Semiconductors are undergoing inventory adjustments in response to falling demand for consumer electronics, automotive, and industrial applications in mature processes, but production remains at full capacity for leading-edge processes (5nm, 7nm, 16nm), where

smartphone and data center applications account for a significant portion of overall production. 5G smartphone production plans have also been cut sharply, so there is still a risk of a correction. At present, yields on 5G chipsets are not stable because these use the EUV process, and we understand that smartphone makers are securing volumes to mitigate the risk. However, we are concerned about the risk of a correction in 2H 2020.

Sharp DRAM/NAND market downturn in 2H

Memory prices are expected to worsen sharply for both DRAM and NAND from 3Q due to a slowdown in data center demand in the US and China and inventory adjustments at Huawei and Chinese smartphone makers. DRAM prices bottomed in 1Q 2020 and had been rising in 2Q, but the price uptrend cycle should end in six months. Price negotiations are currently underway for 3Q, but with data centers and smartphone makers showing little interest in securing volumes, memory makers are trying to determine future customer demand trends and price strategies at competitors. We expect DRAM prices to fall more sharply than NAND, but look for both to turn down in 3Q. The consensus at memory makers is for a recovery in demand in 2H 2021, which means memory prices will likely remain weak over the next 12 months. However, we see little risk of a sharp drop in memory prices like that seen in 2H 2018 through 2019 as memory makers, which currently have appropriate inventory levels, are in a position to keep supplies in check in case they become excessive.

Against this backdrop, we expect memory makers to remain cautious on capex plans for 2021 as it is difficult to formulate plans for growth when market conditions are deteriorating. Plans to expand foundry 5nm and 7nm processes (orders not placed yet) have been shelved due to demand decline at HiSilicon. This scenario would change considerably if Qualcomm secures licensing from Huawei.

Large Chinese OSATs also reviewing investment plans

In back-end OSATs, memory-related investment is expected to slow from 4Q, and major Chinese OSAT makers are revising or cancelling their investment plans, likely due to Huawei supply chain impact. We therefore expect back-end assembly and testing-related investment to slow.

Newly confirmed points in our survey

Positives include:

1. Emerging signs that Qualcomm will supply chips for Huawei smartphones. Qualcomm has apparently already filed an application for a license, with the general view that it has a 50% chance to be approved.
2. Samsung Electronics' first-generation 1znm process is EUV-less, but the company plans to use EUV in the second generation.
3. Demand for inverter and A/C-related semiconductors from Gree and Midea should rebound from June as production in China will be limited to products that meet new energy-saving standards from July.
4. Nintendo (7974) plans to produce 25mn units of the Switch in 2020, while Sony (6758) is planning for 7–7.5mn units of the PS5 (6mn units as of our previous survey three months ago). As the volume of parts procured is likely to be higher, we note bullish demand for components heading into 4Q.

Negatives include:

1. Taiwan foundries' 300mm wafer input for Huawei and HiSilicon averaged 70-75K/month in 2019, but was 30% higher in 1H 2020 than the 2019 average; pointing to inventory adjustment risk.
2. Huawei has roughly six months inventory of eMMC/eUFS NAND for high-end smartphones.
3. US-based hyperscalers to reduce investment. Memory procurement will undergo adjustments from 3Q. We expect demand for GPU accelerators and related HBM2 demand to slow in 2H.

4. In China, Alibaba/Tencent brought forward data center demand into 2Q, so demand is likely to fall in 2H.
5. Taiwan foundries' 200mm wafer inventory adjustments began in May and 300mm wafer inventory adjustments began in June, mainly for mature process (28nm–90nm). We expect inventory adjustments to continue through the end of the year.
6. Following demand decline at HiSilicon, TSMC has shelved expansion plans for 5nm and 7nm processes.
7. There were no signs of strong demand for both DRAM and NAND from customers during 3Q price negotiations, with little buying interest.
8. In South Korea, the largest player in memory plans to slightly reduce investment YoY in 2021. The largest player plans to cut DRAM but increase NAND investment.
9. Although inquiries about assembly equipment in China have been strong despite COVID-19, major OSATs started to cancel orders and request postponement of deliveries from late May.
10. We understand that Chinese factory automation (FA)-related order cancellations started around end-May. This represents a sharp slowdown versus post-COVID-19 production recovery. We think the guidance revisions reflect the weak economy and concerns about weak external demand.

Investment summary: Re-evaluation inevitable due to memory price deterioration; downgrade four SPE majors

Implications for semiconductor and network equipment stocks

Remain bullish on Anritsu

Compared with three months ago, manufacturers have lowered their aggregate 5G smartphone production plans by 105mn units (385mn to 280mn), to what appears to be a more realistic figure. In this environment, Anritsu is likely to benefit from MediaTek beefing up its support system for Huawei, which should offset demand decline for HiSilicon, so we think tester demand during the 5G smartphone expansion phase will actually be positive. We would expect a further positive impact if Qualcomm's Snapdragon shipment license to Huawei were to be approved. We therefore maintain our bullish stance on Anritsu's 5G growth prospects. Advantest, another 5G play, is likely to see a negative impact overall due to lower demand at HiSilicon, which uses cutting-edge processes, even if there is a backup from MediaTek, which currently lags by more than six months in term of technology. A decline in base station demand is also likely to be negative for the company.

SPE investment implications

Expecting memory market downturn to trigger valuation correction; more cautious investment stance heading into 2H CY20

We expect memory prices to improve through 2Q supported by smartphone and data center restocking demand, but look for prices to worsen in 2H for both DRAM and NAND applications due to smartphone inventory adjustments and slowing data center investment in the US and China. In light of healthy inventory levels, we think memory makers will be able to avoid oversupply and price declines as severe as in the previous cycle from 2H 2018 through 2019, but expect markets to review their valuations. Moreover, if memory prices continue to deteriorate in 2H 2020 and the timing of a recovery is unclear, memory makers will have to take a cautious approach to their 2021 capex plans, and the environment will not be conducive to expectations for a recovery in memory investment (valuations rose after expectations emerged for a bottom in memory investment in 2H 2019).

Taiwan foundries have already begun to adjust inventories for mature processes, and unlike short-term corrections seen in the past, we expect the adjustments to continue through the end of the year. We remain concerned about the fact that production cuts by Chinese smartphone makers (including Huawei) and a slowdown in data center investment have yet to lead to production adjustments in Taiwanese foundries' leading-edge processes. We note a consensus in the equities market on the risk of inventory adjustments and believe the adjustments will be deeper the more they are delayed. Once inventory adjustments begin, we think share price corrections will be unavoidable until prospects emerge for a recovery.

Based on the above, we downgrade the four SPE majors from Neutral to UNDERPERFORM. Rather than company-specific factors, we revise our view to reflect a likely de-rating of the memory sector, as memory prices deteriorate over the next 12 months. We rank the stocks in qualitative order, although this varies from the difference in price between our target price and the share price: Tokyo Electron (8035; premium for share buybacks) > Advantest (premium for system-level testing) > Disco (6146; slower OSAT investment in China, slower memory investment) > SCREEN (7735; lower TSMC investment, GA earnings deterioration in 2021). In March, this order was: Advantest, Tokyo Electron, Disco, and SCREEN.

If Qualcomm licensing application to Huawei is approved, memory inventory adjustments will likely continue in response to restocking demand, but expectations for investment in capacity expansion at Qualcomm's cutting-edge processes could prompt investors to favor logic/foundry-related stocks such as SCREEN.

Our order of preference for midsize SPE names is Lasertec (6920) > JEOL (6951) > Tokyo Seimitsu (7729) & Towa (6315) > Micronics Japan (6871) > Ferrotec (6890) (prev.: JEOL & Tokyo Seimitsu > Lasertec > TOWA > Micronics Japan & Ferrotec).

The scaling back of TSMC's capex plans for 5–7nm process expansion and the lack of additional investment plans through 1H CY21 are likely to weigh on orders for Lasertec's EUV mask defect inspection systems (EUV non-pellicle compatible: ULTRA) from 1Q FY6/21. On the other hand, Samsung's shift to EUV for the second-generation 1znm process could lead to additional orders for ULTRA. Overall, we expect a negative net impact on ULTRA demand, given that foundry demand usually outweighs memory-maker demand.

In our view, the risk of data-center memory demand not recovering until at least 2Q CY21 could cause a slump in Micronics Japan's probe card orders, which were strong in Jan–Mar CY20.

Implication for semiconductor materials: utilization adjustments in older processes; advanced-process utilization still high, but risk of adjustment remains

Taiwanese foundries started adjusting mature-process capacity utilization for 300mm wafers at end-May; 28nm–90nm utilization rates have corrected by around 20–30ppt, while 16nm and more advanced processes continue to operate at full tilt. We therefore forecast capacity utilization of 88% in 2Q CY20 (prev. 94%) and 77% in 3Q and thus expect 300mm wafer demand to miss our previous estimate by 50k wafers (roughly 1% of 300mm wafer market shipments) in 2Q CY20. Furthermore, raw-material inventory adjustments are underway, and we expect Taiwan foundry demand for semiconductor materials to decline by around 20–30% in 3Q. This will likely reduce 3Q demand for 300mm wafers by around 200,000 units (about 3%).

Demand for semiconductor materials (mainly silicon wafers) has been buoyed by Taiwanese foundries amid weak memory-maker demand for 300mm wafers. However, recent evidence of slowdown in Taiwan foundries' demand is a concern. We see a risk of a further correction in semiconductor materials demand, especially silicon wafers, as we expect output adjustments in cutting-edge processes during 3Q as well as a prolonged pullback from recent moves to secure inventories in the Huawei smartphone supply chain. Given this, we think the focus will remain on when demand bottoms. If Qualcomm's application for a license to export to Huawei goes through, we would see a risk of further output adjustments, so we will watch developments on this front also.

In small-diameter wafers, we learnt Taiwanese foundries began adjusting capacity utilization for 200mm wafers in mid-May. We now see a higher risk of weaker demand and lower prices for lower-tier manufacturers with low long-term agreement (LTA) ratios.

Makers cannot commit to investment in 96/1XX-layer 3D NAND, as the high technological barriers and level of yields relative to increased capital intensity preclude cost reductions. This could keep growth in demand for KrF resists used in thick-film processes short of Tokyo Ohka Kogyo's (4186) expectations.

Our order of preference for the semiconductor materials sector is JSR (4185) > Shin-Etsu Chemical (4063) > Tokyo Ohka Kogyo (4186) > SUMCO (3436)

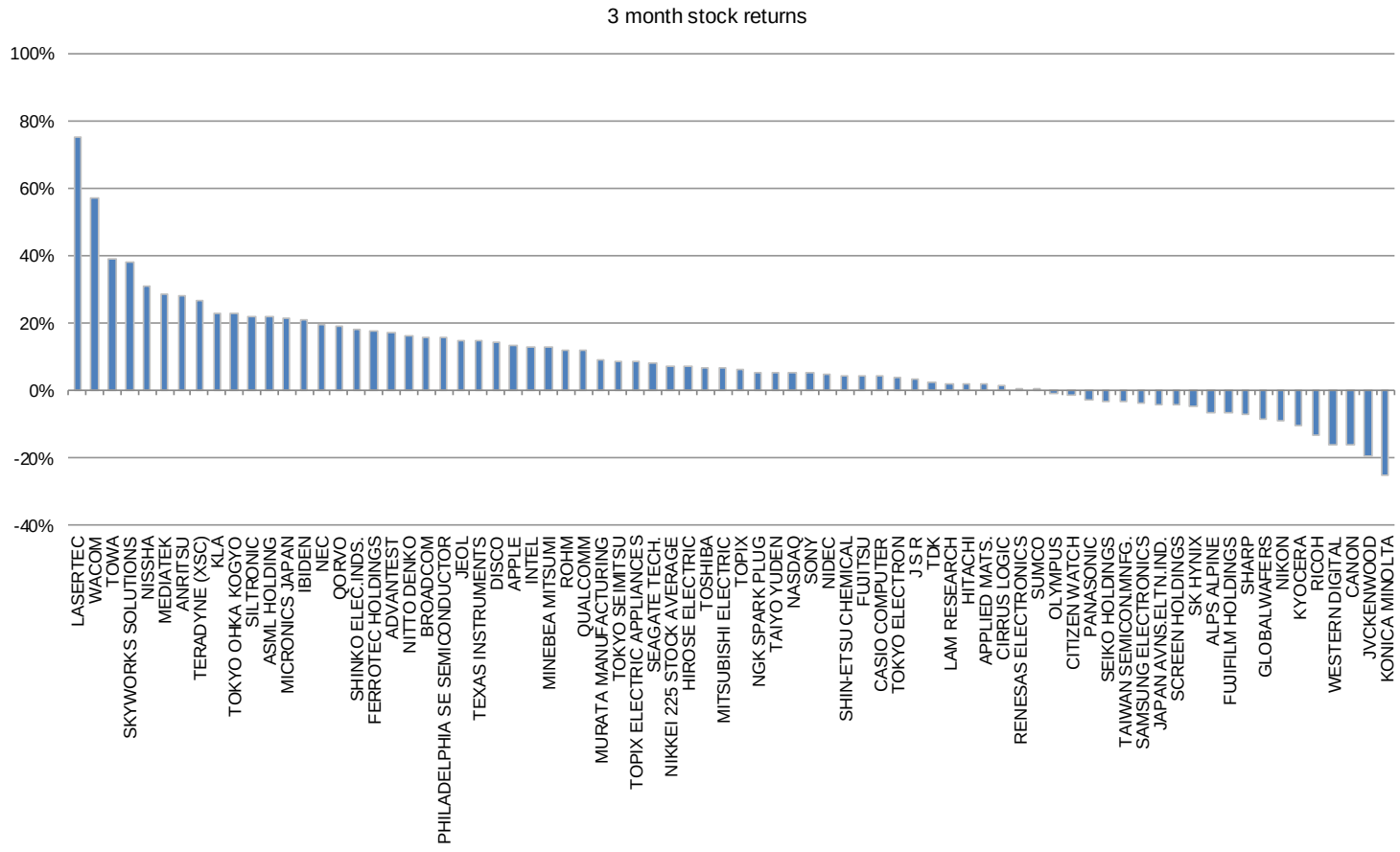
(prev.: JSR > Shin-Etsu Chemical > SUMCO > Tokyo Ohka Kogyo).

CIS investment implications

Sony's CMOS image sensors (CIS) are exposed to short-term inventory adjustments, but we expect demand to expand from 2H into next year as the shift to higher-resolution, multi-lens smartphone cameras accelerates, especially for 5G models. We remain bullish on Sony in expectation of growth in overall profit in FY3/22 as COVID-19 fades.

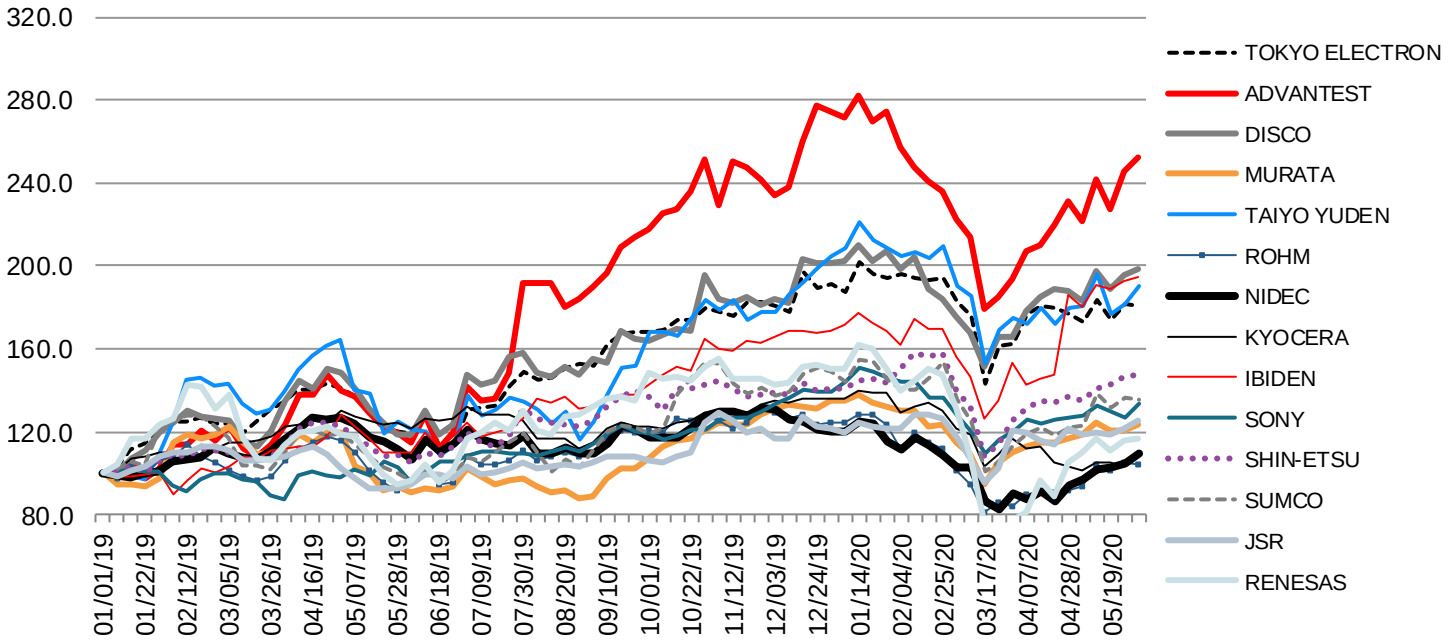
Valuation tables

Figure 8: Japanese technology stocks' performance over the past three months



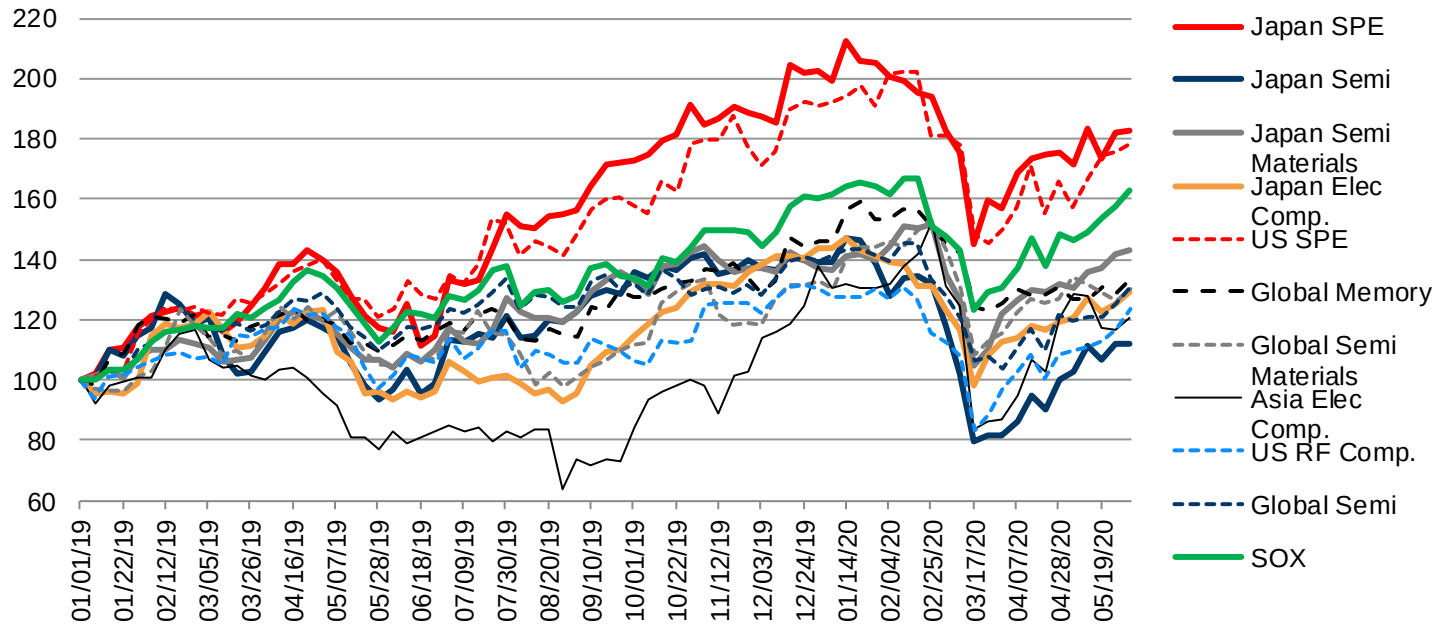
Source: Refinitiv Datastream, Credit Suisse

Figure 9: Japanese technology stocks' YTD performance



Source: Refinitiv Datastream, Credit Suisse

Figure 10: Global/Japanese technology stocks' YTD market value performance by subsector



Source: Refinitiv Datastream, Credit Suisse

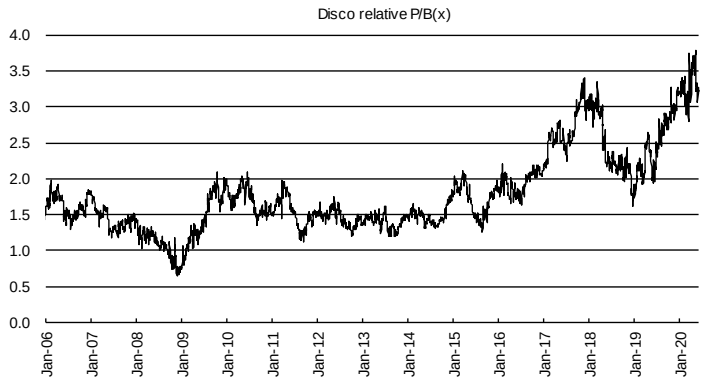
Figure 11: Global/Japanese stocks' valuation/performance by sector

	Company	EV/Sales (x)		EV/EBITDA (x)		P/E (x)		P/B (x)		ROE (%)		Absolute performance (%)		
		FY1	FY2	FY1	FY2	FY1	FY2	FY1	FY2	FY1	FY2	12M	3M	1M
Japan SPE	Tokyo Electron	2.6	2.4	11.0	8.8	18.8	15.2	4.0	3.5	21.2%	23.3%	55.7%	3.8%	10.0%
	Advantest	2.9	2.6	13.0	9.7	24.5	19.6	4.6	4.0	18.9%	20.3%	122.6%	17.2%	19.0%
	SCREEN	0.8	0.8	7.8	6.2	14.8	11.3	1.3	1.2	8.7%	10.5%	32.1%	-4.5%	3.6%
	Disco	5.1	4.6	15.6	13.1	30.2	25.2	3.9	3.6	13.0%	14.3%	63.7%	14.3%	9.7%
Japan Semi	Renesas	2.3	2.1	9.0	8.0	74.1	26.6	1.7	1.6	2.3%	6.0%	25.3%	0.6%	16.4%
	Rohm	1.2	1.1	6.0	4.7	37.5	22.3	1.0	1.0	2.8%	4.6%	11.9%	11.9%	20.0%
Japan Semi Materials	SUMCO	1.9	1.8	6.6	5.8	17.0	14.5	1.6	1.4	9.1%	10.0%	38.1%	0.1%	11.9%
	Shin-Etsu Chemical	2.8	2.7	8.1	7.4	17.9	16.3	1.9	1.7	10.4%	10.6%	36.0%	4.5%	8.9%
	JSR	1.0	0.9	7.8	6.3	21.4	15.1	1.1	1.0	4.9%	6.7%	26.4%	3.5%	3.8%
	Tokyo Ohka Kogyo	1.4	1.3	7.9	7.2	26.2	22.4	1.4	1.4	5.3%	6.1%	50.9%	22.8%	10.1%
Japan Elec. Comp.	Murata manufacturing	2.6	2.3	10.0	8.3	24.5	18.7	2.3	2.1	9.4%	11.4%	38.0%	9.2%	8.3%
	TDK	1.0	0.9	5.2	4.5	18.4	13.9	1.5	1.4	8.1%	9.9%	41.8%	2.6%	21.6%
	Taiyo Yuden	1.4	1.3	6.4	5.3	18.0	13.9	1.8	1.6	10.1%	11.8%	63.4%	5.1%	11.0%
US SPE	Applied Materials	2.8	2.6	10.1	9.6	15.8	14.0	5.5	4.7	34.8%	33.6%	48.3%	1.8%	23.2%
	Lam Research	3.6	3.2	12.5	10.7	19.9	17.2	9.1	7.0	45.9%	40.8%	67.2%	1.9%	25.6%
	KLA	4.3	4.3	11.2	11.3	19.4	19.1	12.3	10.3	63.4%	53.9%	81.1%	22.8%	23.7%
Global Memory	Samsung	1.0	0.9	3.8	3.0	15.1	10.2	1.4	1.2	9.1%	12.2%	26.4%	-4.0%	14.4%
	SK Hynix	2.0	1.6	4.0	2.9	14.0	7.5	1.3	1.1	8.9%	14.6%	38.9%	-4.7%	11.6%
	Micron Technology	2.4	2.1	6.0	4.5	21.0	10.9	1.5	1.4	7.4%	12.8%	61.1%	0.0%	18.3%
Global Semi Materials	Siltronic	2.1	2.0	7.5	6.4	19.5	14.9	2.8	2.5	14.6%	16.6%	59.4%	21.9%	27.2%
	GlobalWafers	2.5	2.2	6.4	5.6	14.2	12.7	3.8	3.5	26.8%	27.6%	29.6%	-8.7%	-2.0%
	Waferworks					25.5	15.4	2.0	1.8	7.6%	11.7%	2.4%	-3.7%	4.2%
Asian Elec. Comp.	Yageo	3.2	2.5	10.0	8.1	13.9	11.2	3.0	2.8	21.5%	24.7%	51.4%	-5.6%	-4.8%
	SEMCO	1.2	1.1	6.6	5.7	22.5	16.4	1.8	1.7	8.0%	10.1%	36.4%	-2.2%	20.1%
US RF	Qorvo	3.9	3.5	12.8	10.6	20.6	16.3	2.9	2.7	14.2%	16.3%	82.3%	18.9%	18.4%
	Skyworks	5.6	5.1	13.3	11.6	23.6	20.1	5.4	5.0	23.1%	25.0%	100.4%	38.1%	30.0%
	Broadcom	7.0	6.7	12.7	11.7	14.6	13.3	5.6	5.9	38.5%	44.6%	19.3%	15.7%	19.7%
Global Semi	Texas Instruments	8.7	7.8	20.7	16.8	32.7	27.1	17.9	19.3	54.8%	71.4%	20.1%	14.6%	17.8%
	STMicroelectronics	2.3	2.1	12.3	8.7	30.6	17.3	2.9	2.6	9.4%	14.8%	79.1%	2.6%	10.0%
	NXP semiconductors	4.4	3.9	14.3	11.2	23.8	16.2	3.6	3.7	15.0%	22.8%	21.8%	-1.3%	14.7%
	Infineon	3.4	2.8	14.4	10.6	38.0	23.7	2.6	2.4	6.8%	10.2%	43.7%	22.0%	28.6%
	ADI	8.6	8.0	19.2	17.6	28.8	24.5	3.9	3.8	13.7%	15.6%	24.8%	14.4%	17.6%
Index	SOX											49.0%	15.6%	18.6%

As of 2020/6/10

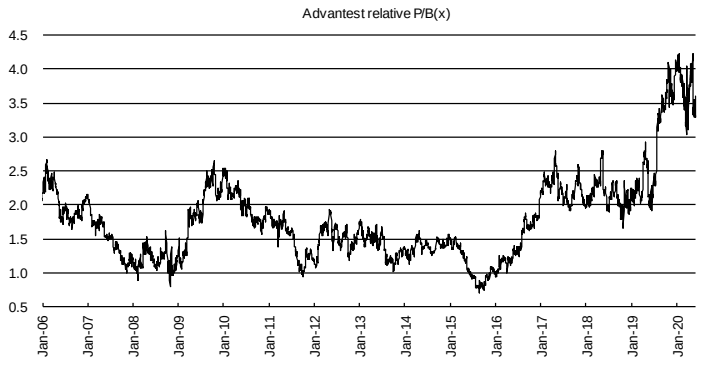
Source: Refinitiv Datastream, Credit Suisse

Figure 12: Disco – Relative P/B vs. TOPIX



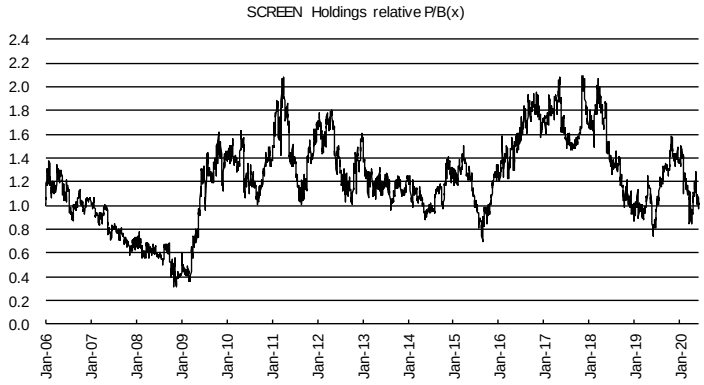
Source: Refinitiv Datastream, Credit Suisse

Figure 13: Advantest – Relative P/B vs. TOPIX



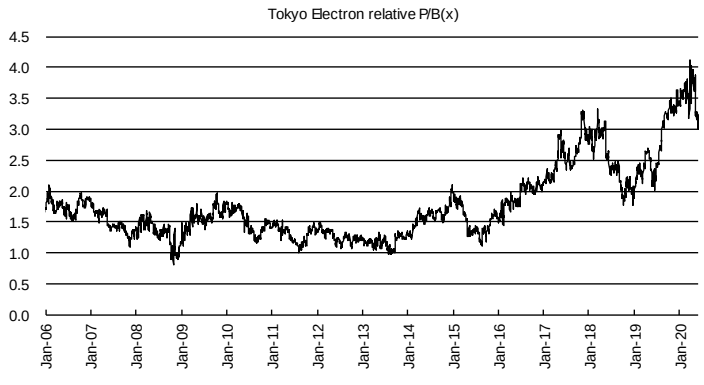
Source: Refinitiv Datastream, Credit Suisse

Figure 14: SCREEN – Relative P/B vs. TOPIX



Source: Refinitiv Datastream, Credit Suisse

Figure 15: Tokyo Electron – Relative P/B vs. TOPIX



Source: Refinitiv Datastream, Credit Suisse

Huawei-related

Our view based on market survey

Parts procurement by PC makers could continue

Tighter regulations announced by the US Department of Commerce are unlikely to impact Huawei's production of PC hardware. CPUs and OSs had been licensed for four years prior to the tightening of regulations, and procurement should be able to continue. However, regulations on smartphones, base stations, and servers are in line with the market consensus, meaning the company will probably be unable to make base stations and servers.

Qualcomm licensing application the wild card

For smartphones, MediaTek has been planning to provide support. The company is developing its P50 spring 2021 flagship model, but a mismatch in MediaTek's AP and the specifications of Huawei's high-end models could impact the specifications of future Huawei flagship/high-end models. Apart from the initiative with MediaTek, Huawei also appears to have asked Samsung LSI to supply its Exynos chips. There have also been reports that Qualcomm has filed for a license, and if the company can get support for flagship models, the outlook for Huawei's smartphone business could improve substantially, so we will keep a close eye on developments. At this point, the possibility of a license being granted seems to be about 50%.

In the first week of June, we looked at Huawei and its suppliers, assuming only support from MediaTek. However, regarding APs, HiSilicon has secured at least 3–4 months of inventory, and we estimate that OSATs have about three months of wafer inventory for cutting-edge processes. The company also invested in an additional 5nm next-generation AP in Mar–Apr, and appears to have secured volume of 5–25mn units across a wide range. TSMC's plans to expand 5nm/7nm processes have unwound now that demand for these processes from HiSilicon has fallen away. If Exynos/Snapdragon can be supplied, we think Samsung LSI will need to expand 5nm/7nm process capacity.

Post-restocking memory inventory adjustment

On the other hand, regarding the restocking of memory chips since May last year, demand has been revised down by more than 30–40% from 3Q (in 2019, Huawei's actual demand for DRAM was at 8%, while NAND demand was at 9%). In particular, demand for DRAM and NAND for flagship/high-end models was lowered, and demand for eMCP (DRAM + NAND multilayer packages) used in midrange and low-end models was revised up. As a result, there is a temporary supply shortage of eMCP.

While base station shipments have been revised down 20% versus initial guidance, we think ZTE and overseas makers will be able to provide support over the medium term, and we do not expect tougher Huawei regulations to be a bottleneck for the spread of 5G in China.

Market feedback

- Regarding smartphone AP, Huawei is seeking supply of Exynos from Samsung LSI as well as chip supply from MediaTek.
- There have also been reports that Qualcomm will supply chips for Huawei smartphones. Qualcomm has apparently already filed an application for a license, with the general view that it has a 50% chance to be approved.
- HiSilicon launched an additional 5nm process AP (Kirin 1000) in Mar–Apr, and the company plans to use the Kirin1000 for flagship models from 4Q 2020. The company has reportedly secured supply of 5mn to 25mn units, across a broad range. 300mm wafer input to Huawei and HiSilicon averaged 70–75K/month in 2019, but was 30% higher in 1H 2020 than the 2019 average. As a result, the company appears to have secured 2–3 months' worth of inventory.
- The company appears to have secured around four months' supply for 7nm+ process products (Kirin 990/820). Taiwan's OSATs also appear to have three months' worth of Kirin990 processed wafer inventories.

- MediaTek's high-end Dimensity 1000 series APs do not match the specifications of Huawei's flagship/high-end models and products. However, the company is considering adopting MediaTek AP in its spring 2020 P50 model.
- Huawei appears to have roughly six months inventory of eMMC/eUFS NAND for high-end smartphones.
- It has no eMCP inventory. Existing UFS: MFP ratio likely to change from 3:2 to 1:4.
- HiSilicon ASIC for Huawei 5G base stations will shift to the SMIC 14nm process (previously TSMC 16nm).
- In the wake of the Huawei sanctions, other Chinese smartphone makers have not moved to increase memory procurement to boost their market share.
- Huawei has a four-year license for Intel/AMD and has a Windows OS license, so we expect PC production to continue. The sanctions will have an impact on base station, smartphone, and server production. The company plans PC production of 8–9mn units in 2020 (3mn units in 2019) and 15mn units in 2021. It had planned to use its own CPU (Hunpeng 920 ARM v8) for desktop PCs in 2H, but the project was cancelled.
- The outlook for 5G base station shipments has been lowered from 1.5–1.6mn to 1.2mn units. Procurement of related materials is likely decline in 2H after peaking in 2Q.

Datacenter-related

Our view based on market survey

2H adjustment by US hyperscalers, as expected; Chinese data center investment set to slow in 2H

Datacenter demand for memory peaked in 2Q 2020, raising the likelihood of a slowdown in 2H. In our previous survey three months ago, we had expected US hyperscalers' procurement of memory to slow in 2H given it is normal for bit growth to rise. Demand looks poised to decelerate from 3Q, as we anticipated, as additional demand has not materialized despite higher needs for datacenters due to COVID-19. In addition, datacenter demand peaked in 2Q at Alibaba and Tencent in China, and looks likely to decline QoQ in 3Q in both China and the US. Demand in 2H should be about the same as in 1H.

GPU accelerator, HBM2 adjustment in 2H

Looking at demand for related semiconductors, we see the possibility of a snapback from the DRAM and NAND restocking demand that started in 4Q 2019. We believe price negotiations in 3Q may become drawn out as buyers are not moving to secure volume. Prices rose 35–40% QoQ in 2Q, but some memory makers may strategically lower prices in 3Q to secure market share, depending on customer demand for 4Q onward. At this point, we find it prudent to watch closely how memory makers and customers negotiate prices, and how rivals offer prices. Demand for GPU accelerators and the high-bandwidth memory (HBM2) it uses has trended in line with hyperscaler demand. This GPU demand should be lower in 2H than 1H.

While datacenters are expected to drive demand, most hyperscalers are waiting for Intel's new CPUs based on the Ice Lake architecture (mass production and supply to start in 1Q 2021), not the earlier available Cooper Lake architecture (3Q 2020). As a result, datacenter demand for memory is unlikely to rebound until 2Q 2021 at the earliest, and the consensus among memory players is forming around an outlook for excess supply of DRAM and NAND again from 2H 2020 to 1H 2021.

We envision a 2–3 year cycle for datacenter investment. Investment was in a growth cycle from 2017 through 1H 2018, and again from 2H 2019 to mid-2020. It went through weak phases from 2H 2018 to 1H 2019, and should enter another down cycle from 2H 2020 through 1H 2021 in our opinion. Based on current trends and cycles, we expect weak conditions for datacenter investment over the next 12 months or so.

Server DRAM demand

Market feedback

- Some US hyperscalers have started to talk about cutting back on investment. Memory procurement entered an adjustment phase in 3Q, and server demand should also adjust in 4Q.
- Chinese data center demand set to lose momentum in 2H despite Alibaba and Tencent bringing forward demand to 2Q; forecasting memory demand 15-20% lower in 3-4Q than in 2Q.
- Looking at demand for server DRAM, bit growth should be around +35–40% YoY in 2020. 1H, YoY growth was higher than 50% due to a low year-earlier hurdle.
- 32GB modules are still the main lane in the demand zone. Demand for 64GB modules is also steadily increasing.
- We see a high risk for a correction in memory demand at Google and Amazon in 3Q, but we expect solid demand at Microsoft through 3Q.
- Amazon and Microsoft have ample inventory approaching 8–10 weeks as of end-June. Google's inventories are appropriate, but we expect a correction in server DRAM demand in 3Q. Facebook continues to be a reliable buyer of server DRAM.
- DRAM makers have already changed their production mix for 2H in anticipation of a correction in demand for server DRAM, so we do not expect the market downturn to be as

severe as in 2019. Also, as inventory levels appear normal, we do not expect a major correction in prices.

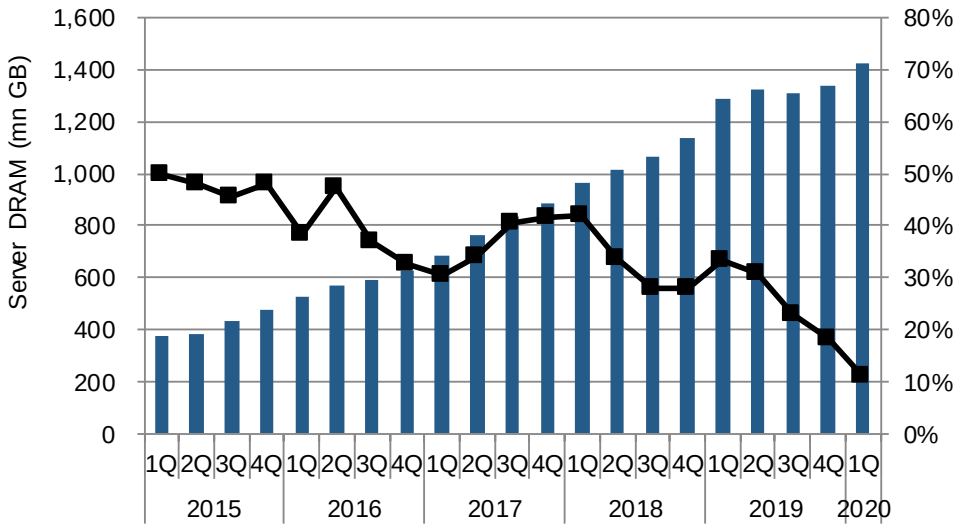
- We expect demand for HBM2 used in GPU accelerators to slow in 2H.
- Only Facebook, which has not moved to current-generation Cascade Lake CPUs, looks likely to adopt the next-generation Cooper Lake CPU.
- Intel will begin shipping Ice Lake CPUs in 4Q, and server makers will start to ship their products in 1Q 2021. We forecast Ice Lake CPU adoption will rise to 50% of shipments by 4Q 2021.
- In demand for server DRAM, we forecast bit growth of 30% YoY in 2021 owing to increased use of the Ice Lake architecture (8 channels). However, we expect prices to tighten in 2021 because supply is unlikely to keep pace with growth as DRAM makers continue to curtail capex.

2H slowdown to extend to China as well as the US

We expect demand from US hyperscalers to stall out in 2H. We anticipate weak demand from Amazon and Google in 3Q and expect demand from Microsoft to decline in 4Q. As was the case three months ago, we still forecast little change in demand from 1H to 2H this year. Demand for GPU accelerators is expected to soften in 2H, with demand for HBM2 likely to follow step with a HoH decline in 2H.

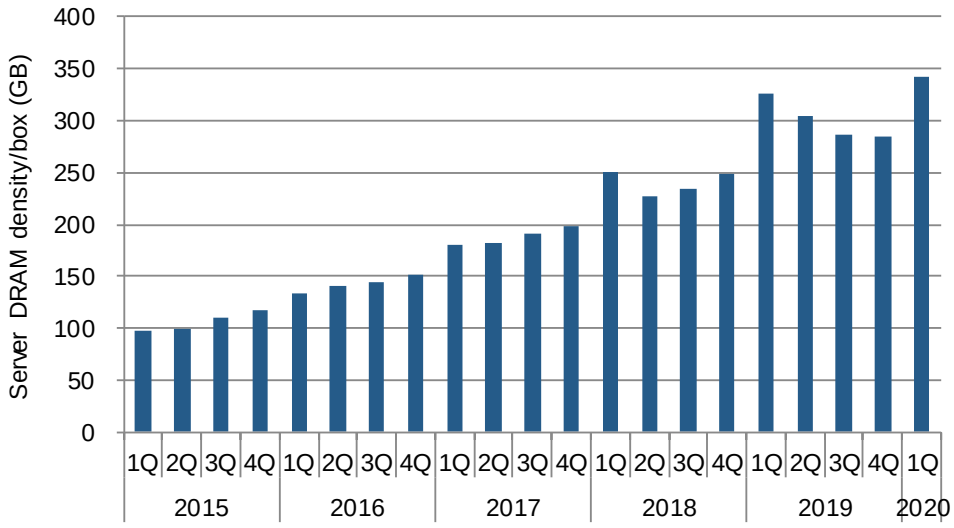
Turning to Chinese datacenter builders, only ByteDance is constructing several datacenters in China and India, taking advantage of firm demand in 2H, while demand is poised to fall quickly in 2H from Alibaba, Tencent, and Huawei. We believe demand in China peaked in 2Q and will be stuck in the 15–20% range in 3Q–4Q.

Figure 16: Server DRAM bit demand



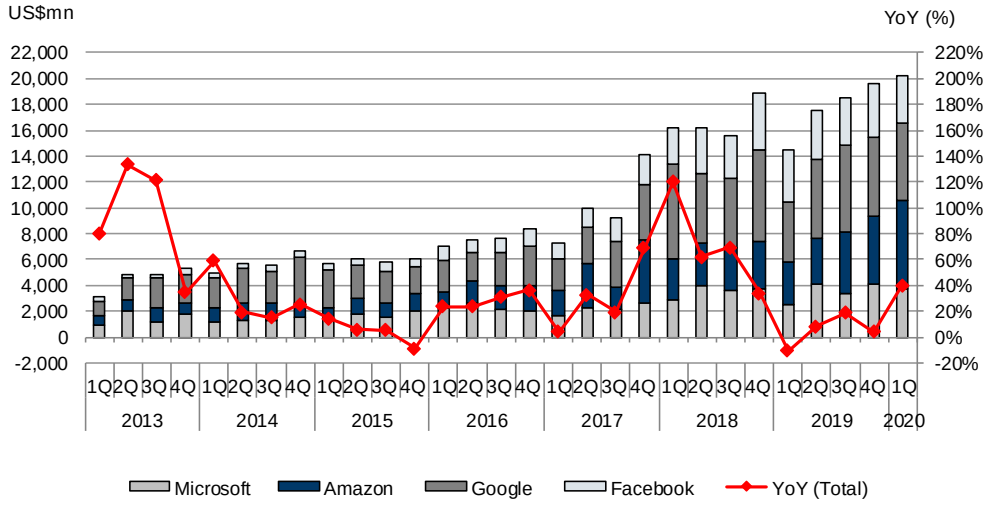
Source: DRAMeXchange

Figure 17: Server DRAM average density



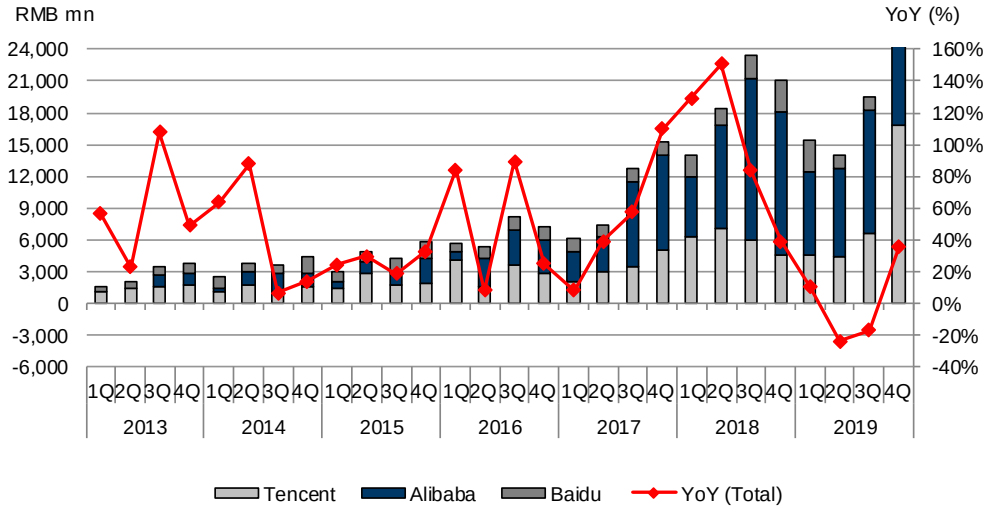
Source: DRAMeXchange

Figure 18: US hyperscale capex



Source: Company data, Credit Suisse

Figure 19: BAT capex



Source: Company data, Credit Suisse

Limited adoption of Cooper Lake

Intel has not fallen behind schedule for its new CPU.

In our survey three months ago, we reported that enterprise server makers were hesitant to adopt the Cooper Lake architecture, which will begin mass production in 3Q 2020. We recently confirmed that a majority of hyperscalers, with the exception of Facebook, are waiting for Ice Lake to come out. Facebook has not adopted the current-generation Cascade Lake CPU, so it is likely to use Cooper Lake.

Plans call for Ice Lake CPU shipments to commence on schedule in 4Q 2020, and enterprise server makers to feature it in their products from 1Q. We therefore expect DRAM demand to increase as a result of the shift to 8-channel memory. Amazon and Google are apparently planning to completely refresh their systems with the Cooper Lake architecture, and an increase in Ice Lake volume would be positive for DRAM demand. However, it is unclear whether supply of 10nm-process Ice Lake CPUs will be stable. If all goes smoothly, we expect Ice Lake CPUs to account for more than 50% of shipments by end-2021, leading us to expect server DRAM demand to improve sharply in 2H 202, and overall DRAM prices to turn up again. DRAM prices in 2021 will likely hinge on Intel's Ice Lake CPUs.

Figure 20: Intel server CPU roadmap

	2014	2015	2016	2017	2018	2019	2020
Platform	Grantley			Purley		Whitley	
CPU	Haswell (22nm)		Broadwell (14nm)	Skylake (14nm+)	Cascade Lake (14nm++)	Cooper Lake (14nm+++)	Ice Lake (10nm)
Channel	4		4	6	6	8	8
						→ MP : 3Q20	→ MP : 4Q20

Source: Company data, Credit Suisse estimates

Server DRAM price trends

Market feedback

- Server DRAM prices for US hyperscalers are 35–40% higher in 2Q than 1Q.
- Server DRAM prices for 32GB have risen from a bottom of around $100 in Oct–Dec to $140–145.
- Some server DRAM makers have started to consider cutting prices in 3Q in order to secure volume while keeping an eye on demand from smartphone makers.

Tough price negotiations in 3Q

In 2Q, large-lot prices increased 35–40% QoQ, and price negotiations are now underway for 3Q. However, in response to offers from DRAM makers, we understand that hyperscalers have not moved as aggressively to secure volume as in the past. This has led to growing disarray among DRAM makers, and we believe price strategies will have to be revisited, depending on stances taken by the hyperscalers.

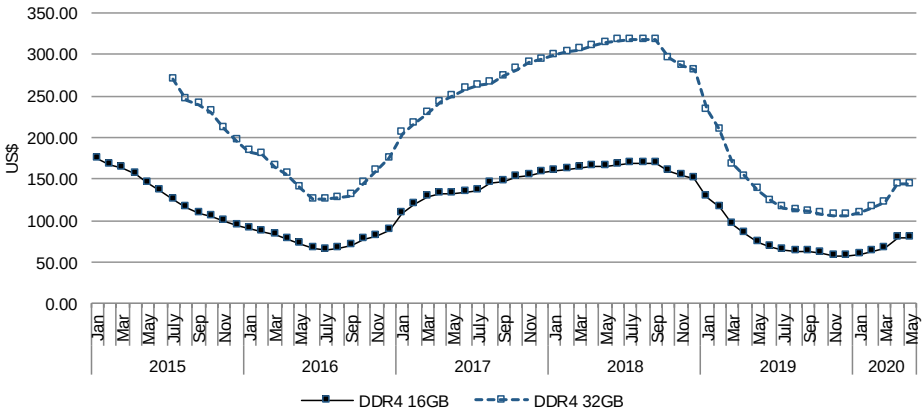
At present, DRAM makers expect prices QoQ to remain flat at best in 3Q, but we see the possibility of cutting prices in order to secure volume in 3Q after assessing the outlook for demand in 4Q. We expect price cuts of 5–10% in 3Q and at least 10% in 4Q.

Unlike the previous downturn cycle, most DRAM makers believe that prices will not fall by as much as 50% in six months, like they did from 4Q 2018, owing to low inventory on hand (in-house wafer inventories allow them to control supply). We do not expect market-destroying price competition to emerge as customers are waiting for Ice Lake CPUs to hit the market in 1H 2021. However, we see the risk that prices for 32GB modules may sink back to their previous low of $100.

Strategic win for hyperscalers

Changing topic, we take a look at US hyperscalers' strategies for success. We believe the lack of trustworthy relationships between DRAM makers and hyperscalers was behind the restocking demand that started in 4Q 2019. In other words, based on the assumption that supply–demand will tighten for DRAM in 2H 2020, we believe that hyperscalers adopted a procurement strategy that anticipated DRAM makers would raise prices by more than usual during tight supply–demand conditions. DRAM makers raised prices by 35–40% when supply–demand tightened in 2Q, so we believe hyperscalers read the market correctly this time. If hyperscalers trusted DRAM makers, this kind of price volatility would probably not happen. On the flip side, DRAM makers have learned from experience that they are not good at forecasting demand from hyperscalers, as seen in 2017–18, and are therefore reluctant to aggressively invest in production capacity. We think the company could raise prices substantially if DRAM market conditions allow. We believe both parties will continue to try and outfox each other.

Figure 21: Server DRAM contract price (16/32 GB RDIMM)



Source: DRAMeXchange

dSSD/eSSD trends

Market feedback

- Chinese enterprise SSD demand doubled YoY in CY19 and is set to increase 60–70% in CY20. We forecast CY20 quarterly demand will peak in 2Q then drop 15% QoQ in 3Q. Demand from Alibaba and Tencent is set to lose momentum in 2H.
- Chinese datacenter builders are moving to operate their own SSD assembly plants. Inspur and Tencent are mulling similar moves.

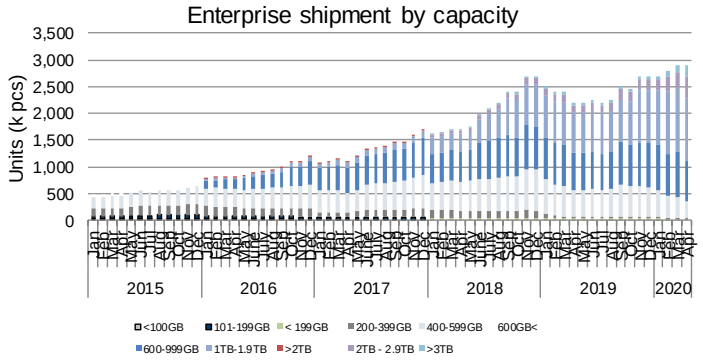
Growing number of datacenter customers moving toward in-house SSD assembly

Our outlook for SSD demand is similar to that for server DRAM, meaning that we see a high risk of a 2H slowdown in SSD demand.

Regarding SSDs, datacenters are moving to produce their own products in-house, leading to an increase in procurement of single NAND products (raw NAND), not SSD systems. This poses a risk to the earnings structures of NAND makers.

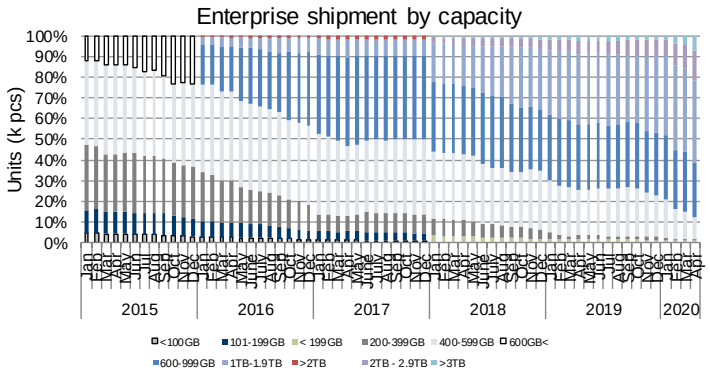
In addition to Amazon and Google, Microsoft plans to increase its procurement of raw NAND. Among Chinese datacenter builders, Inspur and Tencent are examining building their own SSD assembly operations, in addition to enterprise server makers Lenovo and Huawei. However, it is unclear whether Chinese firms will succeed, considering that Alibaba's in-house assembly plans have failed.

Figure 22: Enterprise SSD shipments by capacity



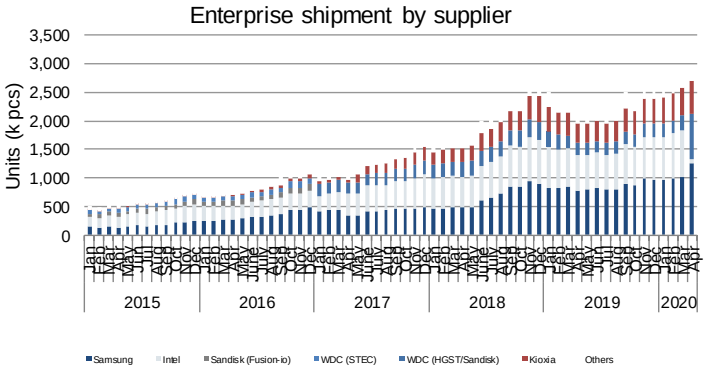
Source: TSR, Credit Suisse

Figure 23: Enterprise SSD shipment mix by capacity



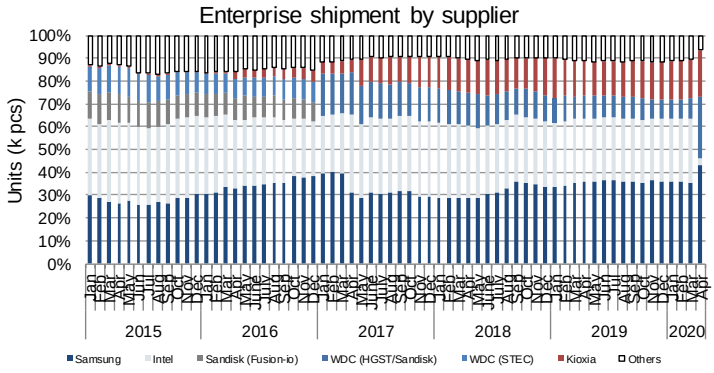
Source: TSR, Credit Suisse

Figure 24: Enterprise SSD shipments by maker



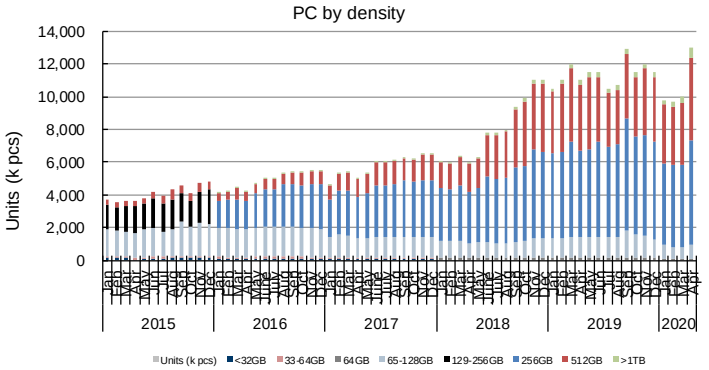
Source: TSR, Credit Suisse

Figure 25: Enterprise SSD share by maker



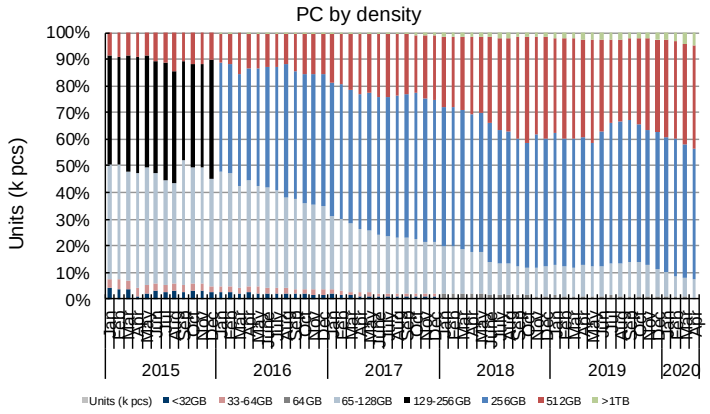
Source: TSR, Credit Suisse

Figure 26: PC SSD shipments by density



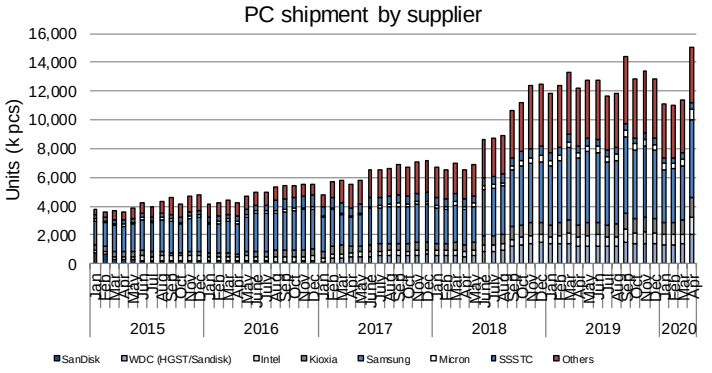
Source: TSR, Credit Suisse

Figure 27: PC SSD shipment mix by density



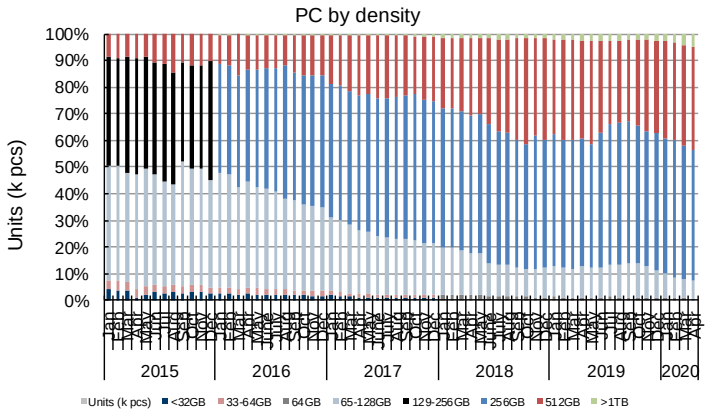
Source: TSR, Credit Suisse

Figure 28: PC SSD shipments by maker



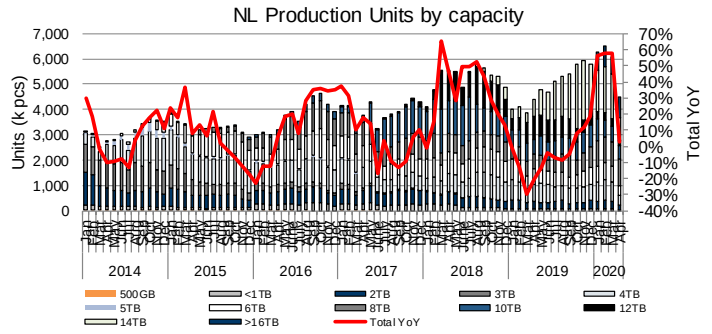
Source: TSR, Credit Suisse

Figure 29: PC SSD share by maker



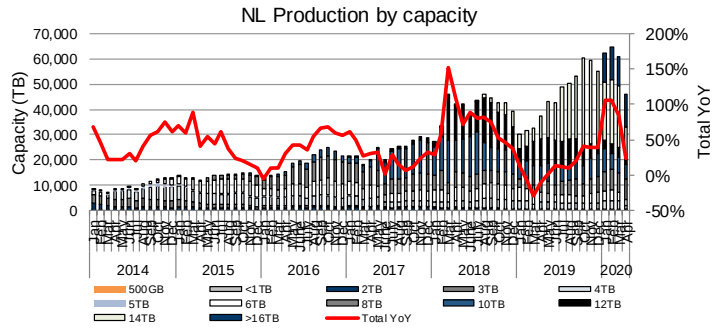
Source: TSR, Credit Suisse

Figure 30: NL production units by capacity



Source: TSR, Credit Suisse

Figure 31: NL production volume by capacity band



Source: TSR, Credit Suisse

Logic/foundry trends

Our views based on survey feedback

Cutting-edge 300mm processes at full capacity, inventory adjustment for mature processes

Inventory adjustments at Taiwanese foundries began in mid-May for 200mm wafers and from end-May for 300mm wafers. Among 300mm lines, however, adjustments of 20–30ppts were seen mainly at those making 28nm–90nm process wafers (i.e., mature processes); those making 7nm–16nm process wafers (i.e., for smartphone and data center chips) continue to run at full capacity. We previously thought that inventory adjustment risk in the latter half of 2Q and 3Q would mainly involve the smartphone supply chain. That production adjustments only involve mature processes is thus a surprise.

That said, HiSilicon has 3–4 months of chips for Huawei in inventory, while the OSATs have three months of wafers for flagship models in inventory. Thus, it is possible that inventory demand in excess of actual demand boosted 7nm/16nm process capacity utilization at Taiwanese foundries over the past six months or so. Given the tight supply of cutting-edge process wafers, we think production capacity is still running at full capacity because large-size chips (e.g., nVidia's data center chips, AMD's PS5 chips) are taking up production capacity, and because there is still an order backlog for MediaTek, which expects additional demand for HPC chips and for chips for Huawei. This raises the risk of production adjustments for cutting-edge process wafers in 3Q. In addition, we expect Chinese smartphone makers to revise their 5G volume forecasts sometime from the latter half of 3Q through 4Q, which should accelerate the correction.

Taiwanese foundries tend to complete inventory adjustments in 3–4 months, but this time, various factors could affect the length of this time period, so we think it will take some time for capacity utilization to recover. We therefore expect a second bottom.

Foundry fab capacity utilization

Market feedback

- 200mm wafer inventory adjustments began in May and 300mm wafer inventory adjustments began in June, mainly involving mature process (28nm-90nm). We expect inventory adjustments to continue not only through 3Q, but through 4Q. For mature processes, the adjustment is around 30ppts. Capacity utilization for 28nm-90nm processes was 92% in 1Q and is projected to be 81% in 2Q and 64% in 3Q.
- Taiwanese foundries' cutting-edge 300mm processes (5nm-16nm) continue to run at full capacity. They are now launching the products that they could not manufacture for Huawei, so lines are still operating at full capacity even after the imposition of additional sanctions on Huawei. The risk of input adjustments is a concern.
- We understand that remote-work-related demand for WiFi6 chips (28nm-process chips for WiFi routers) was weaker than expected. There have been notable corrections in WiFi6 chips and PMICs for 5G.
- At Samsung Electronics' LSI business, 300mm wafer lines continue to operate at full capacity. CIS momentum looks somewhat weak.
- Raw material inventory adjustments have begun recently, making a 20–30% decline in 3Q likely.

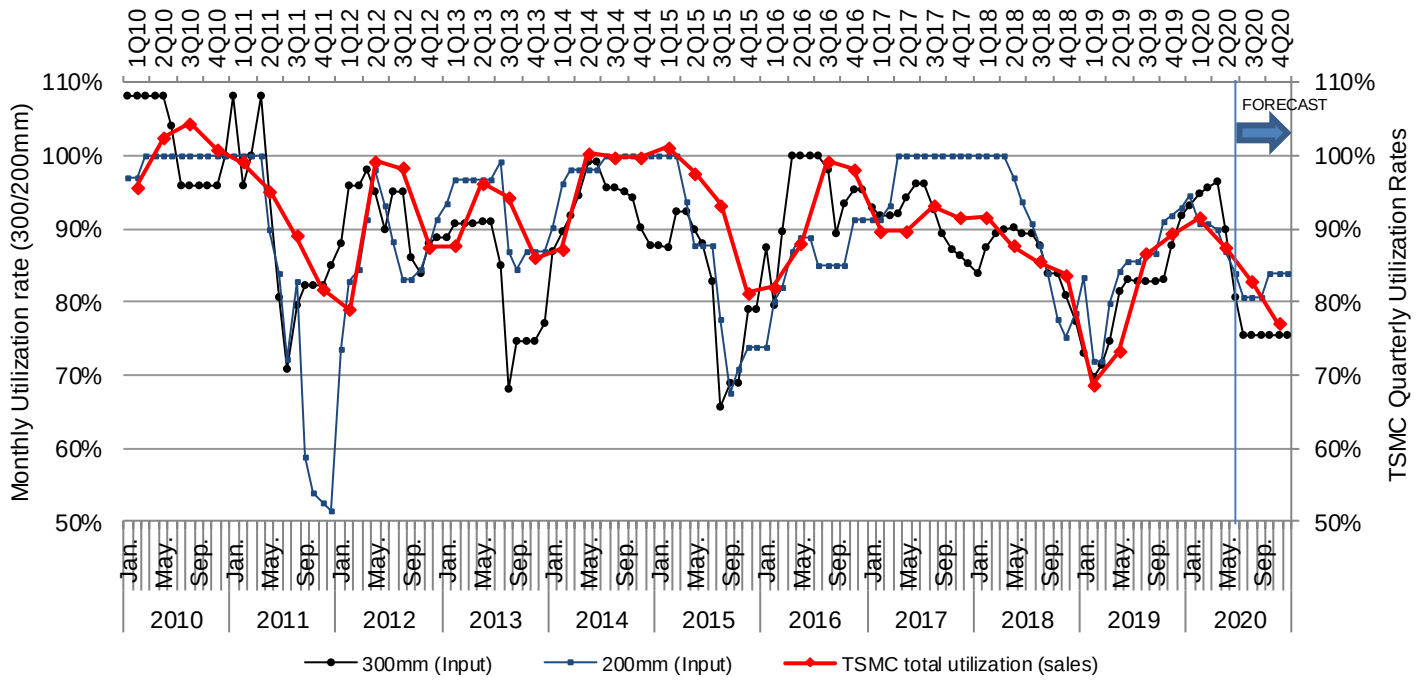
Adjustments only in mature processes; risk of adjustments in cutting-edge processes in 3Q–4Q

We estimate that Taiwanese foundry 300mm wafer capacity utilization (input basis) will be 88% in 2Q (March estimate: 94%), 77% in 3Q and 76% in 4Q. For 200mm wafers, our forecasts are 87% in 2Q (March estimate: 90%), 81% in 3Q, and 84% in 4Q.

Adjustments began at 200mm lines and mature 300nm process lines (28nm-90nm) in May. We attribute this to inventory adjustments in the consumer, industrial, and automotive-related electronics industries, and to a slump in demand due to COVID-19. Despite a slump in smartphone demand in 4Q 2019 and Jan–Feb 2020, cutting-edge 300mm lines (7nm–16nm process) continue to run at full capacity, and we have for some time noted a high risk of inventory adjustments. We think the risk of adjustments has increased, given that smartphone makers have reined in their 5G smartphone production plans over the past three months and that some HiSilicon demand has disappeared due to the Huawei sanctions. In the near term, we expect Taiwanese foundries to continue operating at full capacity as they work down their order backlogs, which built up despite their operating at full capacity. In 2H, we expect the adjustments now anticipated in the memory supply chain (e.g., reduced demand for smartphone and data center related HPCs) to have a knock-on effect on foundry production.

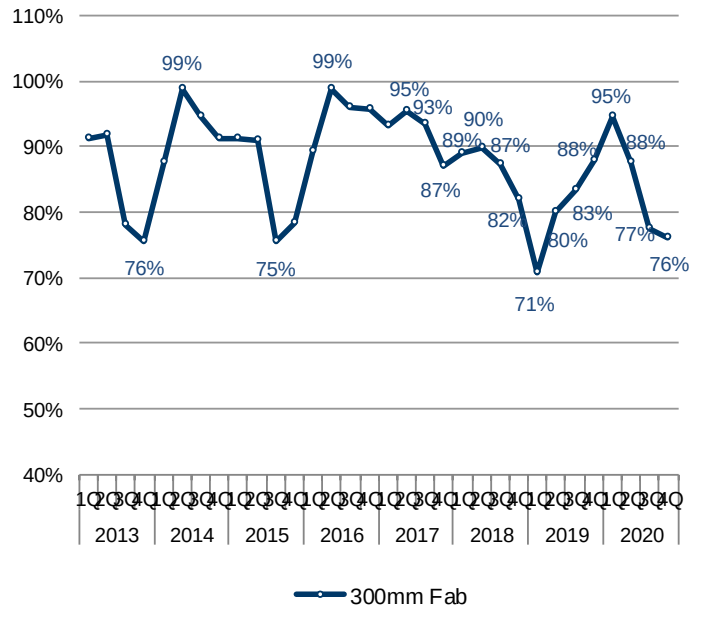
Looking at demand by process, we understand that demand for 28nm process chips (confirmed to be strong three months ago, specifically for WiFi6 and PMIC-related chips) has already peaked out. For WiFi6-related chips, this is due to unexpectedly weak remote-work demand for home-use routers. For 5G-related chips, this is due to PMIC inventory adjustments. Demand for 16nm/7nm process chips remains solid for 5G and HPC applications. While there have been inventory adjustments in APs for LTE smartphones, we think production of large-size chips for HPCs (nVidia, AMD) will compensate for this. We see major risk of a 20ppt+ adjustment in HiSilicon's 16nm-process chips for ASICs used in 5G base stations, as well as its 7nm-process chips for high-end and mid-range 5G smartphone APs. We expect 5nm process chip capacity utilization to remain relatively thanks in part to the production of chips for new iPhone models and in spite of adjustments in production for HiSilicon.

Figure 32: Projected capacity utilization for Taiwanese foundry 300mm/200mm lines (input basis)



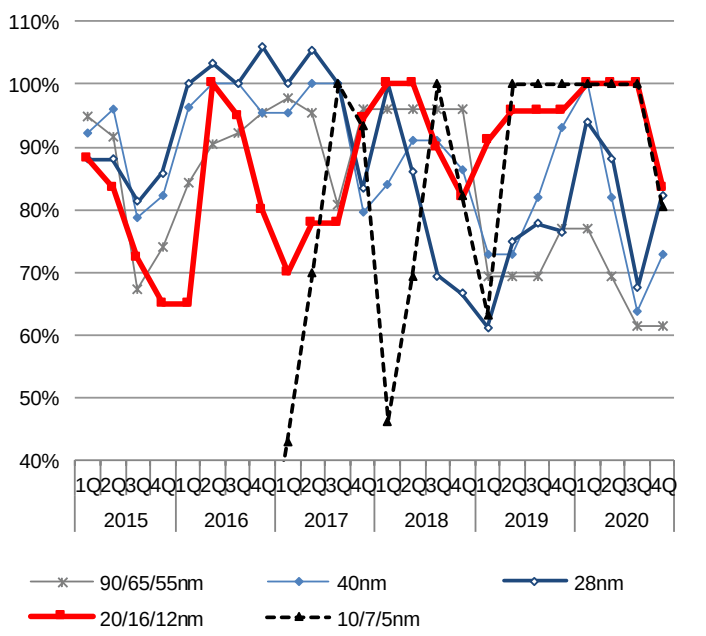
Source: Credit Suisse estimates

Figure 33: Projected quarterly utilization rates for major Taiwanese foundry 300mm lines (input basis)



Source: Credit Suisse estimates

Figure 34: Projected quarterly utilization rates for major Taiwanese foundry 300mm lines, by process (input basis)



Source: Credit Suisse estimates

Taiwanese foundries and Korean LSI makers: Trends in cutting-edge processes (7nm, 5nm, 3nm)

Market feedback

- In 5nm-process wafers, HiSilicon appears to have installed additional equipment around March and April, suggesting that the company has taken steps to deal with the strengthening of sanctions on Huawei.
- 5nm process expansion plans have been reined in. HiSilicon's 5nm-process demand had been projected to be 20–30K wafers/month through 2021, but this has dropped to zero, so beyond the expansion to production capacity completed in 1Q, virtually no additional investment is planned through 1H 2021.
- In 7nm-process wafers, with demand from HiSilicon no longer expected, expansion plans (involving 20–30K of capacity) appear to have been shelved.
- In 3nm-process wafers, there has been no talk of postponing development plans, but it appears that the timeframe for supplying equipment has slipped somewhat.
- Samsung Electronics' LSI lines are operating at full capacity. In cutting-edge processes (7nm/10nm), capacity utilization remains at 100% despite weak demand for the Galaxy S20. The new Galaxy Note models for 2020 will feature Samsung's Exynos 992, which is its first 5nm-process LSI.

Plans to expand 5nm/7nm capacity shelved owing to disappearance of HiSilicon demand

Although such plans had not yet led to actual orders for manufacturing systems, expansion plans related to HiSilicon's demand for 5nm/7nm-process chips have been completely shelved. If Huawei adopts MediaTek's chips, demand at TSMC for 7nm-process chips will partially offset this, but given that MediaTek lags HiSilicon by more than six months technologically, it is unlikely to be a driver of capex for TSMC.

TSMC has planned to mass-produce 5nm-process chips for only two companies in 2020: Apple and HiSilicon. With Apple now likely to be the only customer for some time, 5nm-process chip capacity utilization will depend largely on the iPhone cycle. We originally expected the ramping up of production in 4Q (timed to Huawei's flagship-model cycle) to support 5nm-process chip capacity utilization. Now, however, we expect production adjustments in the latter half of 4Q through 1Q 2020.

In Taiwan, there have been reports of delays to TSMC's 3nm-process investment plans, but there have been no delays in its actual material procurement plans.

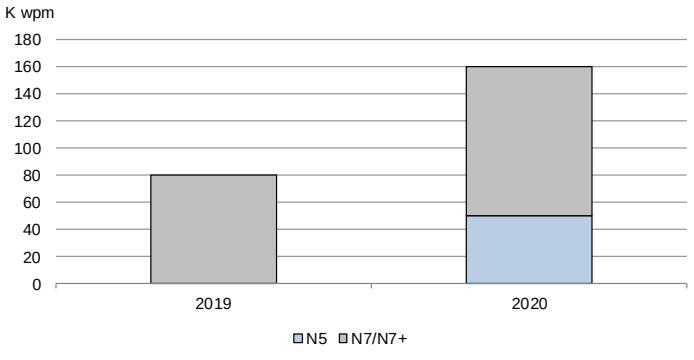
At Samsung Electronics, Galaxy S20 sales are weak, but at the company's LSI business (which manufactures the Exynos 980 and Snapdragon 865 chipsets used in the Galaxy S20), cutting-edge process manufacturing is still at full capacity. Although yields on EUV processes are still poor, the company plans to feature the 5nm Exynos 992 in its new Galaxy Note model this autumn, so we think it may be starting to ramp up production early.

Figure 35: Smartphone application processor maker technology roadmap

5G SoC	2 Chips (modem+AP)			2019		2020				2021
	1 Chip (Integrated chip of AP + Modem			3Q	4Q	1Q	2Q	3Q	4Q	1Q
Qualcomm	Flagship	SDM865	2 chips with X55 (TSMC 7nm Pro)		MP (TSMC 7nm)					
		SDM875	2 chips with X60 (TSMC 7nm Pro)						MP (Samsung 5nm EUV)	
	High-end	SDM765			MP - only Sub-6 (Samsung 7nm EUV)	MP - mm-wave/sub-6 (Samsung 7nm EUV)				
		SM7350								MP ? (Samsung 5nm EUV)
	Middle-end	SDM768G					MP (Samsung 7nm EUV)			
Apple	Flagship	A14	2 chips with X55 (TSMC 7nm Pro)				MP (TSMC 5nm EUV)			
Samsung	Flagship/High-end	Exynos 9825	2 chips with Exynos5100 (Samsung 10nm)	MP (Samsung 7nm EUV)						
		Exynos 980 (9830)	2 chips with Exynos5123 (Samsung 7nm EUV)		MP (Samsung 7nm EUV)					
		Exynos 992						MP (Samsung 5nm EUV)		
	High-end	Exynos 980			MP (Samsung 8nm)					
	Middle-end	Exynos 880 (9630)					MP (Samsung 8nm)			
		Exynos 881 (9640) ?							MP (Samsung 7nm EUV)	
HiSilicon	Flagship/High-end	Kirin 990	2 chips with Balong 5000 (TSMC 7nm)	MP (TSMC 7nm+ EUV)						
		Kirin 1000 ? (post-Kirin990)						MP (TSMC 5nm EUV)		
	Middle-end	Kirin820					MP ? (TSMC 7nm+ EUV)			
	Low-end	Kirin 7XX						MP - Pending (TSMC 7nm EUV ?)		
Mediatek	Flagship	Dimensity 1000 (MT6889)			MP (TSMC 7nm+ EUV)					
		Dimensity 1000L (MT6885)			MP (TSMC 7nm+ EUV)					
		Next gen of Dimensity 1000								MP (TSMC 6nm EUV)
	High-end	MT6883	The same design as MT6885 (slightly low-cost ver.)			MP (TSMC 7nm+ EUV)				
	Middle-end	Dimensity 800 (MT6873)					MP (TSMC 7nm+ EUV)			
	Low-end	Dimensity 600						MP (TSMC 7nm+ EUV)		
UniSoC	Middle-end	T7520					MP ? (TSMC 6nm EUV)			

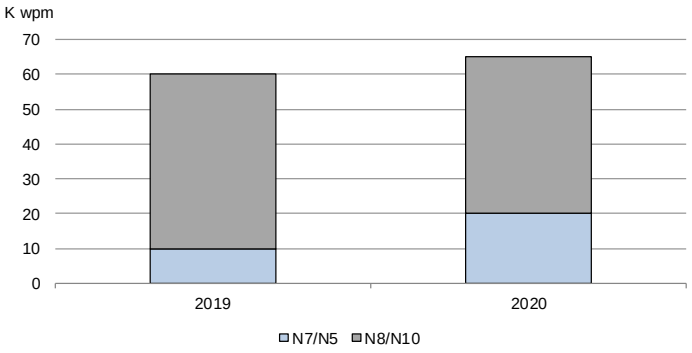
Source: Credit Suisse estimates

Figure 36: TSMC N7/5 process production capacity estimates



Source: Credit Suisse estimates

Figure 37: Samsung Electronics' N7/5 process production capacity estimates



Source: Credit Suisse estimates

5G smartphone trends

Our view based on our survey

We had noted that the 5G AP (chipset) makers had downgraded production plans from 515mn units as of September 2019 to 465mn units as of March 2020. Plans have now been lowered further, to 420mn units. In particular, major downward revisions were made at HiSilicon (down 40mn units), largely to reflect the new Huawei sanctions. Qualcomm and Samsung Electronics LSI have also lowered their plans slightly, while MediaTek has raised its outlook to reflect increased Huawei supply. However, in aggregate makers have lowered total forecast 5G smartphone production volume to 282mn units, down by around 100mn units vs. three months ago.

Downward revision for production plan by 5G smartphone maker from 385mn to 282mn, and for production plan by 5G chipset maker from 465mn to 420mn

We have yet to confirm utilization adjustments for cutting-edge processes at TSMC and Samsung Electronics LSI (5nm, 7nm, 8nm) in response to the downward revision to 5G chipset volumes. We understand that MediaTek has asked TSMC to increase volume by several tens of millions of units, and that this has been compensated for by a larger order backlog as well as redirecting capacity for HPC and other applications which were not at full capacity. However, we think inventory adjustments for cutting-edge processes will be unavoidable due to a correction in the overall smartphone market since the start of the year and a slowdown in data center investment in 2H.

Chipset production trends

Market feedback

- Total 5G chipset production volume outlook lowered from 465mn units to 420mn.
- HiSilicon cut its outlook from 110mn units to 70mn, Qualcomm from 240mn to 230mn, and Samsung Electronics from 35mn to 30mn. MediaTek raised its outlook from 80mn units to 90mn.
- There have been reports that HiSilicon already has four months of inventory on hand, and that OSATs have three months of Kirin 990 wafer inventory. Some observers expect that operations will be managed so as to not run out of inventory through next spring's models.

MediaTek has asked TSMC to boost volumes and HiSilicon also has inventory, suggesting excess inventory for Huawei.

As we discussed in a separate section, we understand that HiSilicon itself has more than four months of inventory, and is also preparing 5–25mn units for its Kirin 1000 (5nm process). From this, we surmise that Huawei has secured 5G chipsets volumes for flagship and high-end models through next spring. MediaTek, on the other hand, which is starting inventory adjustments after its previous restocking, is apparently asking TSMC to increase capacity by several tens of millions of units in order to increase the use of MediaTek product in smartphones by Huawei (which currently plans to procure 90mn units). This suggests sufficient inventory for Huawei smartphones. Qualcomm's 5G chipset procurement plans look particularly aggressive based on its actual market share outlook. We think the downward revisions to production plans by Chinese smartphone makers have yet to be reflected. Samsung Electronics LSI, which produces Qualcomm's 5G chipsets, is operating at full capacity for 7nm process. We therefore see lingering risk of production adjustments for cutting-edge processes at TSMC and Samsung Electronics LSI.

Qualcomm has applied for a license to export chips to Huawei; if granted, we would expect this scenario to change substantially. In other words, Samsung Electronics' LSI capacity utilization would like remain at 100%, with risk of production adjustments moved back onto MediaTek. We will be keeping a close eye on the progress of Qualcomm's licensing application.

Figure 38: Production plan by 5G smartphone supplier and 5G chipset adoption forecast

Company's Target as of June 2020

5G Production Plan (mn units)		Apple	Qualcomm	HiSilicon	Samsung LSI	Mediatek
Apple	**87**	87				87
Samsung	**32**		15		10	7
Huawei	**70**			60		10
OPPO	**30**		15			15
Xiaomi	**20**		15			5
vivo	**33**		12		12	9
Others	**10**		5	0	0	5
Total	**282**	**87**	**62**	**60**	**22**	**138**
5G Chipset Production Plan	**333**	**87**	**143**	**70**	**30**	**90**

Company's Target as of March 2020

5G Production Plan (mn units)		Apple	Qualcomm	HiSilicon	Samsung LSI	Mediatek
Apple	**90**	90				
Samsung	**45**		20		20	5
Huawei	**120**			100		20
OPPO	**40**		25			15
Xiaomi	**40**		25			15
vivo	**40**		20		5	15
Others	**10**		10	0	0	0
Total	**385**	**90**	**100**	**100**	**25**	**70**
5G Chipset Production Plan	**375**	**90**	**150**	**110**	**35**	**80**

Source: Credit Suisse estimates

Figure 39: 5G chip supplier production forecasts

5G SoC	2 Chips (modem+AP)			2019		2020				2021
	1 Chip (Integrated chip of AP + Modem			3Q	4Q	1Q	2Q	3Q	4Q	1Q
Qualcomm	Flagship	SDM865	2 chips with X55 (TSMC 7nm Pro)		MP (TSMC 7nm)					
		SDM875	2 chips with X60 (TSMC 7nm Pro)						MP (Samsung 5nm EUV)	
	High-end	SDM765			MP - only Sub-6 (Samsung 7nm EUV)	MP - mm-wave/sub-6 (Samsung 7nm EUV)				
		SM7350								MP ? (Samsung 5nm EUV)
	Middle-end	SDM768G					MP (Samsung 7nm EUV)			
Apple	Flagship	A14	2 chips with X55 (TSMC 7nm Pro)				MP (TSMC 5nm EUV)			
Samsung	Flagship/High-end	Exynos 9825	2 chips with Exynos5100 (Samsung 10nm)	MP (Samsung 7nm EUV)						
		Exynos 980 (9830)	2 chips with Exynos5123 (Samsung 7nm EUV)		MP (Samsung 7nm EUV)					
		Exynos 992						MP (Samsung 5nm EUV)		
	High-end	Exynos 980			MP (Samsung 8nm)					
	Middle-end	Exynos 880 (9630)					MP (Samsung 8nm)			
		Exynos 881 (9640) ?							MP (Samsung 7nm EUV)	
HiSilicon	Flagship/High-end	Kirin 990	2 chips with Balong 5000 (TSMC 7nm)	MP (TSMC 7nm+ EUV)						
		Kirin 1000 ? (post-Kirin990)						MP (TSMC 5nm EUV)		
	Middle-end	Kirin820					MP ? (TSMC 7nm+ EUV)			
	Low-end	Kirin 7XX						MP - Pending (TSMC 7nm EUV ?)		
Mediatek	Flagship	Dimensity 1000 (MT6889)			MP (TSMC 7nm+ EUV)					
		Dimensity 1000L (MT6885)			MP (TSMC 7nm+ EUV)					
		Next gen of Dimensity 1000								MP (TSMC 6nm EUV)
	High-end	MT6883	The same design as MT6885 (slightly low-cost ver.)			MP (TSMC 7nm+ EUV)				
	Middle-end	Dimensity 800 (MT6873)					MP (TSMC 7nm+ EUV)			
	Low-end	Dimensity 600						MP (TSMC 7nm+ EUV)		
UniSoC	Middle-end	T7520					MP ? (TSMC 6nm EUV)			

Source: Credit Suisse estimates

CIS market and production trends

Our view based on our survey

CIS demand could correct near term, but growth likely from 2H into next year

We see risk of CIS inventory adjustments in Apr–Jun following smartphone makers' frontloading of component procurement in Jan–Mar amid supply-chain disruptions. However, we see little risk of these adjustments becoming prolonged given tight supply–demand through end-December 2019. With the 5G ramp from 2H likely to further tilt smartphone shipments toward quad lenses and high resolutions, we expect a recovery in both CIS volumes and unit prices.

Market feedback

- Samsung Electronics' CIS production volume slightly fell (50k/wpm for 300mm wafer input, 50-55k/wpm in 1Q). The company plans to increase output to 60–70K by end-2020 (by converting Line 11 and all of its former DRAM production lines).
- SK Hynix has already expanded its 300mm CIS production line to 20K wafers/month.
- Samsung is planning to manufacture CIS in Xian.

Trends toward multiple cameras and higher resolution continues

Raising assumptions for multi-camera weighting, mainly for quad

Multi-camera smartphones accounted for 79% of total smartphone shipments Jan–Mar, exceeding our estimate. The weighting of dual- and triple-camera phones fell slightly QoQ, but quad-camera phones rose to 26% of total shipments (including ToF cameras) from 16% in Oct–Dec.

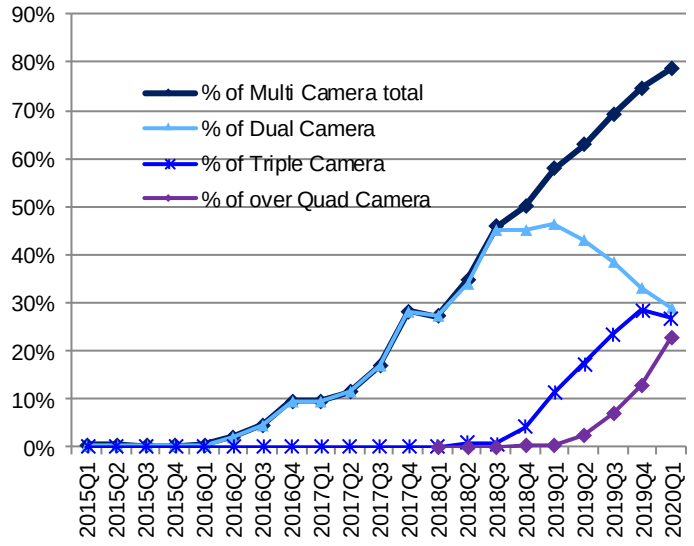
We accordingly update our assumptions for multi-camera installation rates. We now assume an overall weighting of 85% in 2020 (dual 23%, triple 30%, quad 32%) and 93% in 2021 (20%, 30%, 43%). We previously (as of March) assumed 80% in 2020 (dual 25%, triple 35%, quad 20%), and 90% in 2021 (22%, 40%, 28%).

Triple and quad-camera cameras are increasingly being installed not just in high-end phones but also in US$200–400 midrange models. Moreover, a full 53% of 5G smartphones shipped in Jan–Mar had quad cameras. With two of the four 2020-model iPhones also likely to feature quad cameras (including ToF), we see no indication of the trend toward higher-performance smartphone cameras abating.

Smartphone camera resolution also increasing

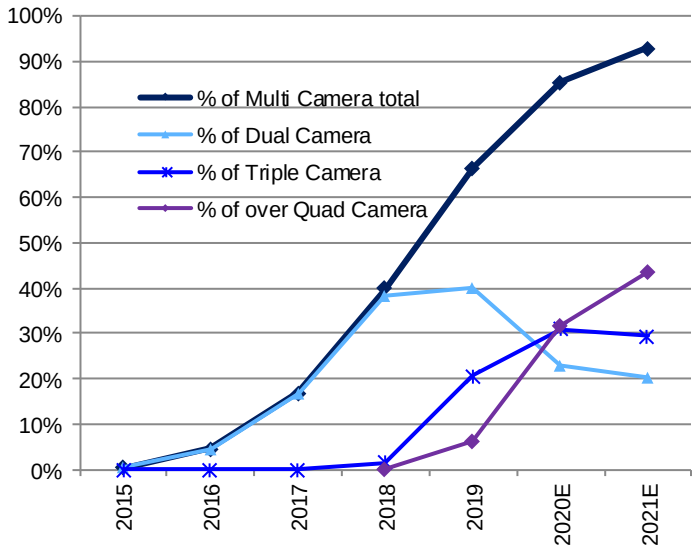
The trend toward higher resolutions in smartphone main cameras continued in Jan–Mar, with 36% of total shipments having 24MP or more (Jan–Mar 2019 11%, Oct–Dec 28%). Smartphone makers have been bumping up resolutions in 5G models by one level versus similarly spec'd 4G phones, with 46% of 5G phones shipped in Jan–Mar equipped with 48MPs or more. We expect further growth in demand for high-resolution CIS as 5G smartphones ramp.

Figure 40: Multi-camera smartphone quarterly sales weightings



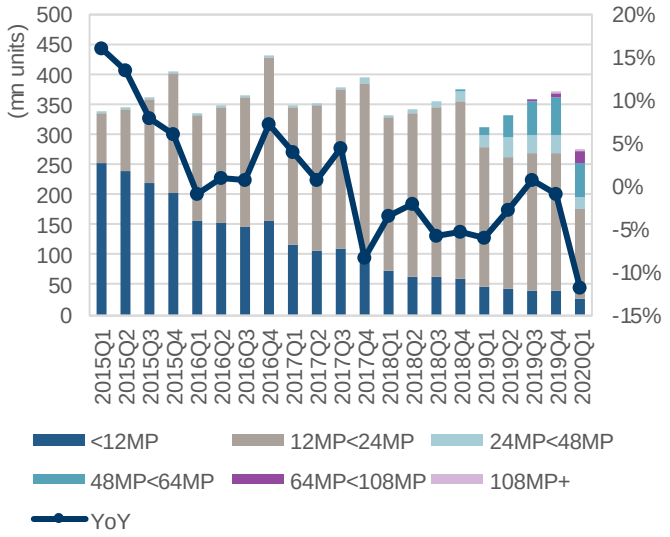
Source: IDC, Credit Suisse

Figure 41: Multi-camera smartphone weightings



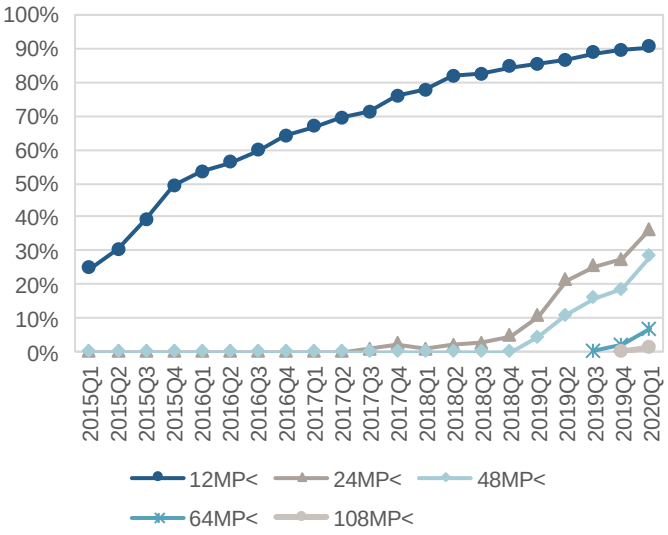
Source: IDC, Credit Suisse estimates

Figure 42: Smartphone shipments by camera resolution (units)



Source: IDC, Credit Suisse

Figure 43: Smartphone shipments by camera resolution (%)



Source: IDC, Credit Suisse

DRAM market trends (excluding data center DRAM)

Our view based on our survey

For more on data center DRAM, please refer to the section on data centers (pp.16-23).

Customer apathy towards 3Q price negotiations

DRAM prices rebounded in 1Q 2020. We attribute this to supply tightness stemming from restocking demand among smartphone and server customers, accounting for around 40% of demand. However, there is a growing risk of deterioration in market conditions from 3Q due to weak demand for Samsung's flagship Galaxy S20 models, inventory adjustments by Chinese smartphone makers, and the completion of restocking by US hyperscalers. Actual demand from OEM customers has already deteriorated, but because contracts are on a quarterly basis, OEM customers will have to continue to purchase products through June for contractual reasons. Consequently, we expect customer inventories to rise further. Thus, although price negotiations for 3Q are already under way, customer interest is waning, and there is no visibility on how customers will behave when supply–demand tightens (e.g., whether they will accept price hikes to secure volume).

DRAM makers have already turned bearish on market conditions in 2H. The best case scenario for prices is that they remain level QoQ in 3Q, but we think the DRAM makers are also considering a scenario in which they cut prices in 3Q to preserve volume, depending on the outlook for customer demand through 4Q. However, no DRAM maker is forecasting a steep decline in prices akin to that seen in late 2018, as inventory levels at both customers and DRAM makers are lower now than they were at the time. That said, in light of this, we think price declines of 5–10% in 3Q and over 10% in 4Q are essentially unavoidable.

Slowdown through 1H CY21

Turning to 2021, we continue to see little prospect of an upturn in DRAM prices through 1H, given deterioration in the 5G smartphone mix (with demand rising for mid-range smartphones only) and the uncertain timing of growth in demand among hyperscalers.

In addition, in terms of technology trends, we think the shift to DDR5 will accelerate in mobile devices if LP DDR5 is priced to boost its adoption in mid-range and high-end models. However, we do not expect this to happen until the spring 2021 models at the earliest. Server DDR5 is compatible with Intel's next-generation Sapphire Rapids CPU (the successor to Ice Lake), so we do not expect a shift to take place until 4Q 2021. We therefore expect DDR5-related investment to pick up again from 4Q 2020 at the earliest.

DRAM supply–demand outlook

Market feedback

- In terms of the volume of DRAM in Chinese smartphones, we expect to see the use of 6GB DRAM in mid-range smartphones increase in 2H. However, most high-end models use 8GB DRAM, and we do not foresee an increase in demand for models with 12GB of DRAM.
- It appears that because of poor visibility on market conditions, no Chinese smartphone makers are looking to increase the use of 12GB DRAM if it means higher DRAM costs.
- In Chinese smartphones, 6GB/8GB of eMCP DRAM and 128GB of NAND is the mainstream combination.
- Demand for mid-range 5G smartphones is expected to increase in 2H, so the memory mix is expected to deteriorate. Memory makers are pessimistic about 2H demand.
- Some suppliers are starting to be wary of a 3–4% DRAM supply glut in 4Q 2020. They also see a high risk of oversupply in 1H 2021.

- As of the first half of 1Q, production had shifted from mobile RAM to server DRAM, but production shifted back to mobile RAM around May.

Risk of demand-mix deterioration in 2H, not only in data center DRAM but also in smartphone DRAM

In March, server DRAM demand was expected to support a correction in mobile RAM in 1H, and increased demand for 5G smartphone mobile RAM was expected to compensate for slowdown in server DRAM in 2H. However, pessimism about 2H is growing, with observers wary about both a slowdown in data center server DRAM and about smartphone mobile DRAM demand in 2H.

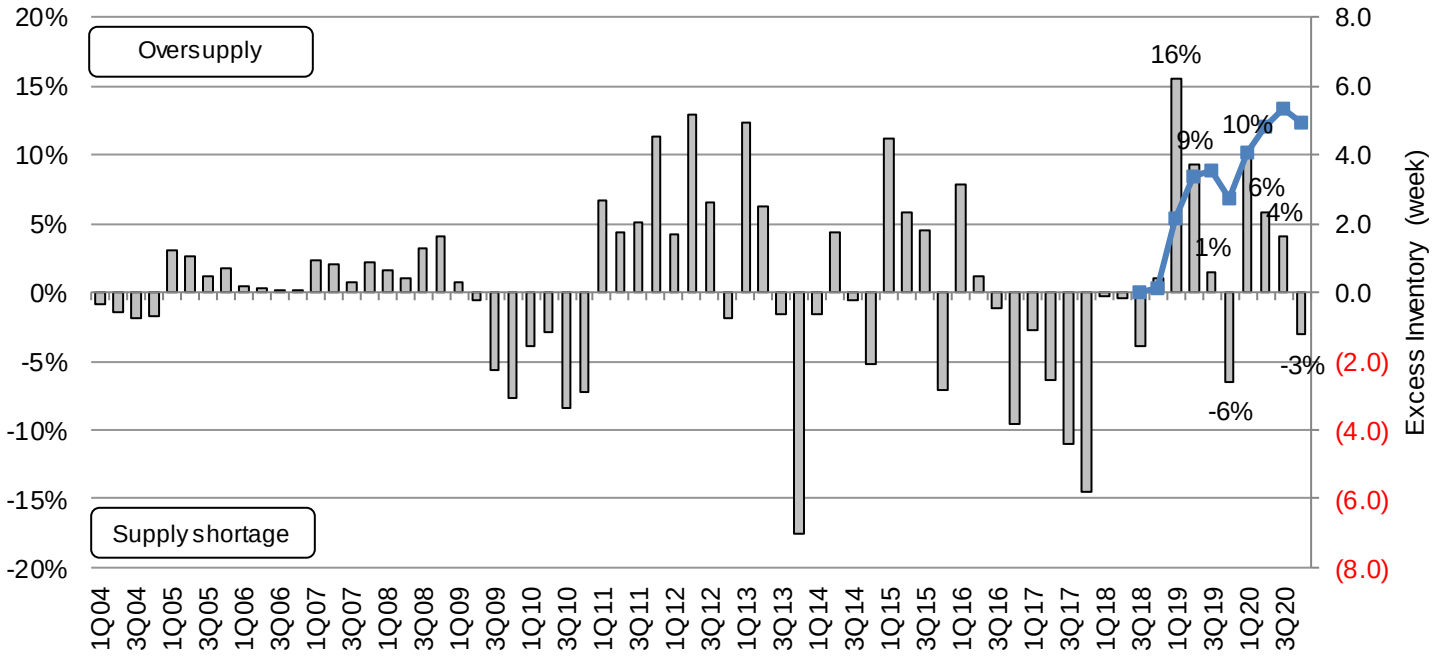
Risk related to mobile RAM demand in the latter half of April and beyond has increased, given weak sales of Samsung's flagship Galaxy S20 models and restocking-related inventory adjustments by Chinese smartphone makers. Moreover, although they expect 5G smartphone volume to rise in 2H, DRAM manufacturers seem to be becoming extremely cautious about 2H demand. The factors they cite include a 30–40% decline in Huawei's 2H procurement volume in the wake of new sanctions; the lack of high-end 5G models featuring 12GB of DRAM; and the hesitance of smartphone makers, amid a lack of visibility on market conditions, to increase DRAM volume if it will increase costs.

Although DRAM makers' inventories are at essentially appropriate levels, we believe smartphone makers have over one month of excess inventories and hyperscalers have several weeks to around two months of excess inventories. Price negotiations for 3Q are under way, but we see no eagerness to buy among customers.

Unlike the previous oversupply cycle, DRAM manufacturers and customers do not have high inventory levels, and because DRAM makers curbed capex in 2019–20, bit supply growth is likely to be limited in 2021, meaning that building up inventories in 2020 may be a strategic option. For these and other reasons, many DRAM manufacturers do not expect the market to deteriorate as severely as last time.

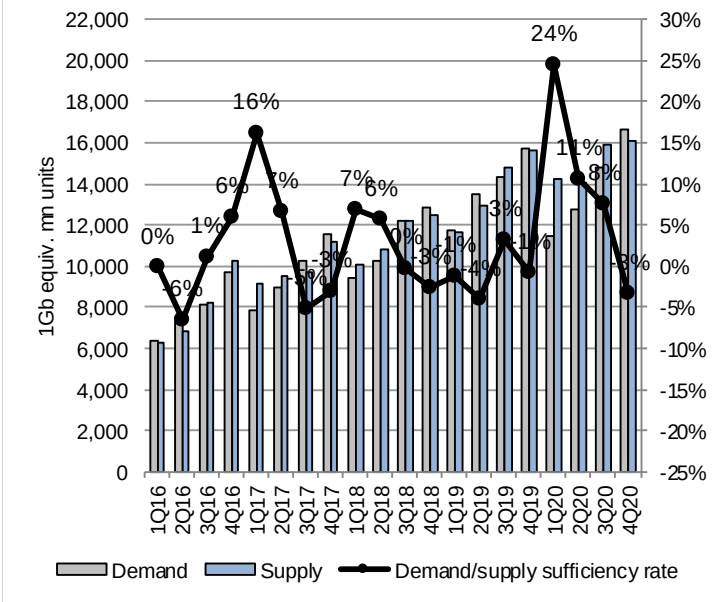
Some DRAM makers forecast an oversupply of 3–4% in 4Q CY20, but we forecast 2H oversupply of 0.4% (previously a shortage of 4%, excluding inventory). We forecast 8% oversupply in 1H CY20, but restocking by smartphone and data center makers has kept prices from collapsing.

Figure 44: DRAM supply–demand model: We expect a shortage of supply in 4Q and collapse due to excess inventory in 1–3Q



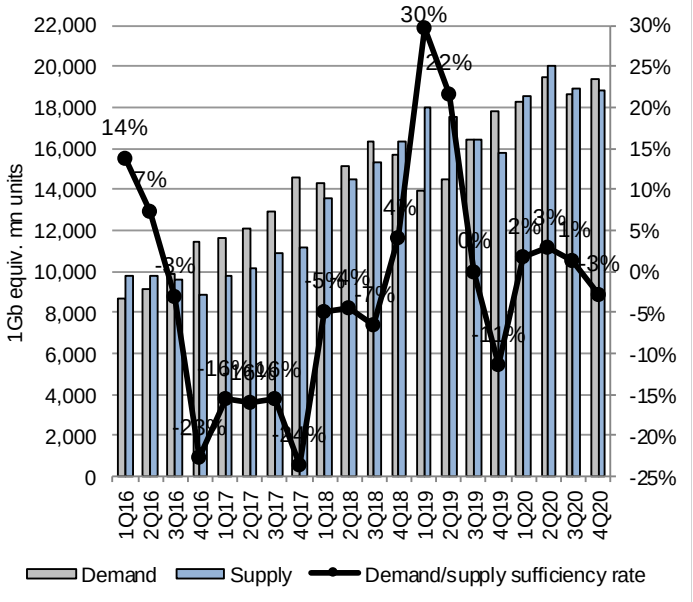
Source: Credit Suisse estimates

Figure 45: Mobile RAM supply–demand model



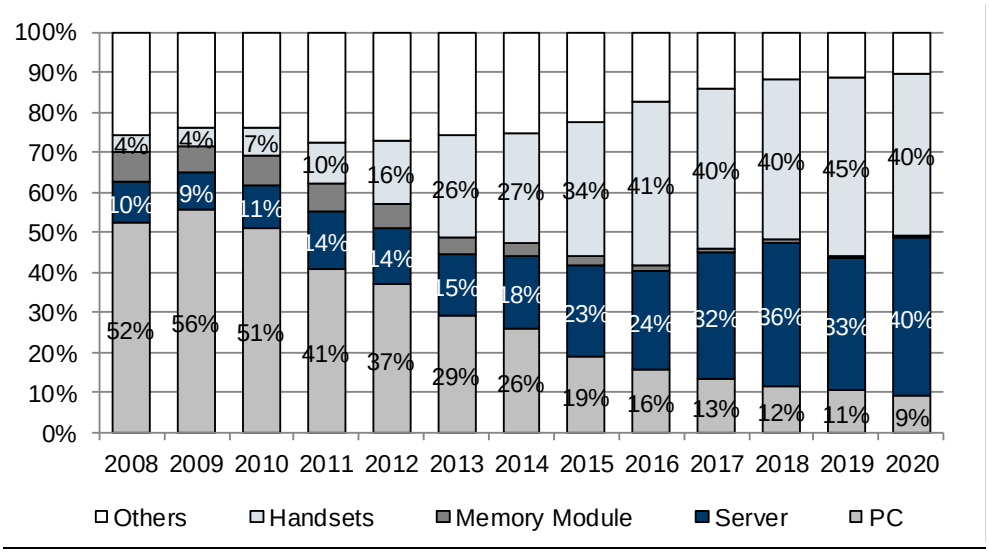
Source: Credit Suisse estimates

Figure 46: PC/server DRAM supply–demand model



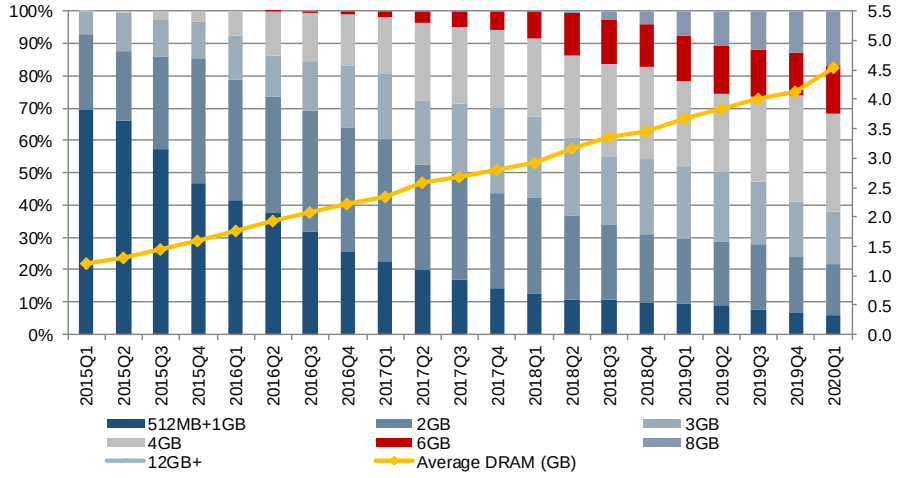
Source: Credit Suisse estimates

Figure 47: DRAM bit demand breakdown by application



Source: Credit Suisse estimates

Figure 48: Chinese smartphone DRAM density



Source: IDC, Credit Suisse

DRAM price trends

Market feedback

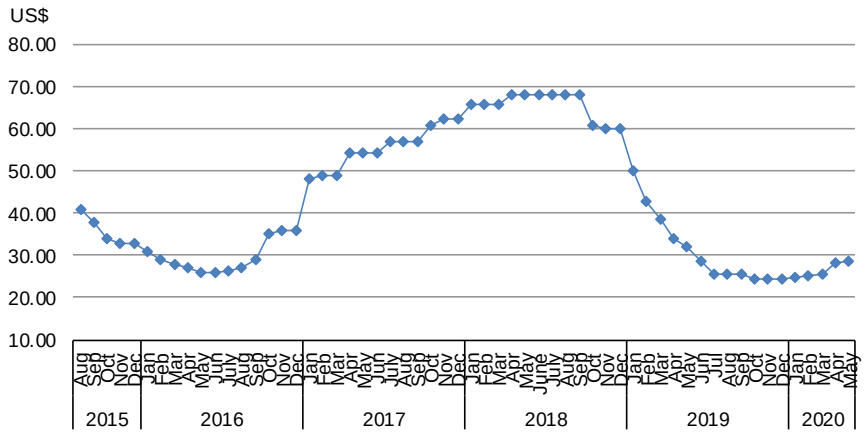
- Server DRAM prices rose 30–35% in 2Q, but many DRAM market observers expect that prices will fall in 3Q (or remain flat in a best-case scenario).
- We expect DRAM prices to recover in 2H 2021. We think prices will fall only slightly from 2H 2020. Unlike the previous down cycle, DRAM makers' inventories are low, so they intend to build up wafer inventories and adjust supply.
- Because of a lack of visibility on 3Q demand by application (data center, smartphone, PC), DRAM makers seem to have not decided how to approach price negotiations.

Prices likely to decline in 2H, but many think steep price cuts in 2021 can be avoided

In 2Q, prices increased by 5% for mobile DRAM and 35–40% for server DRAM, in line with DRAM makers' expectations. At the time of our previous survey, the consensus view among DRAM makers was that DRAM prices would continue to rise gradually in 3Q, but the present survey shows a major change in outlook, with prices expected to be flat in 3Q in the best case scenario. Price negotiations for 3Q have already begun, but we think these negotiations will take some time, since unlike in the past, the eagerness of customers to buy is down sharply. Even among individual companies, the negotiations are difficult to read, as they depend on how customers respond. However, because there have been no capital expenditures made with a view to meeting demand in 2021, there are currently no DRAM makers who believe they need to aggressively lower prices. Accordingly, we think that amid slowing demand in 2H, the DRAM makers will adopt a strategy of holding wafer inventories, and will not need to sell at a loss.

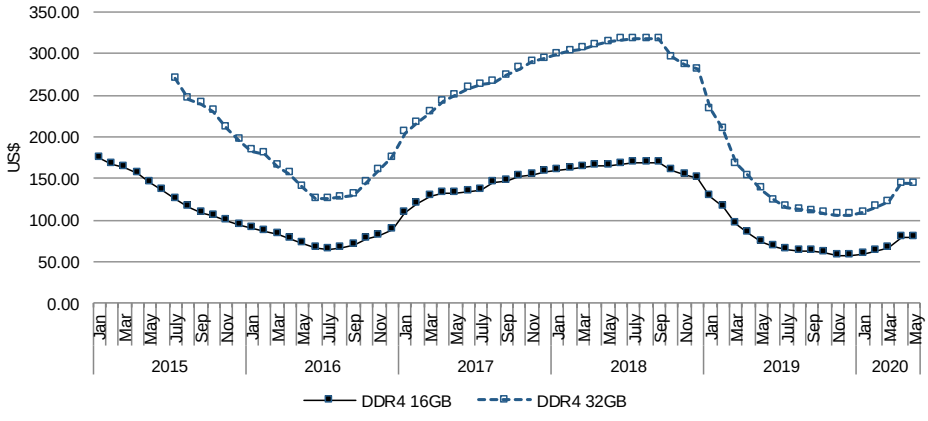
Even so, we think it is essentially inevitable that DRAM prices will fall by 5–10% in 3Q and by over 10% in 4Q.

Figure 49: DDR4 8GB module large lot price



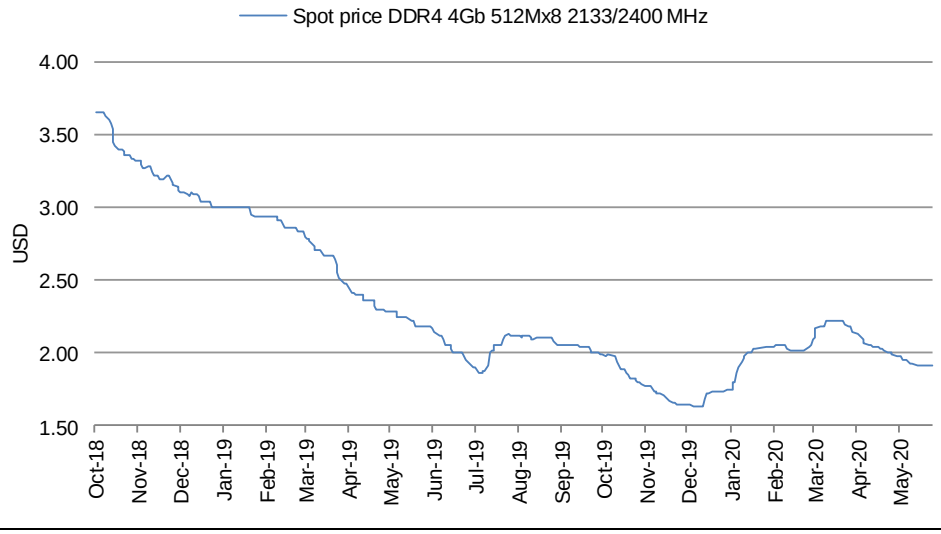
Source: DRAMeXchange

Figure 50: Server DRAM contract price (16/32 GB RDIMM)



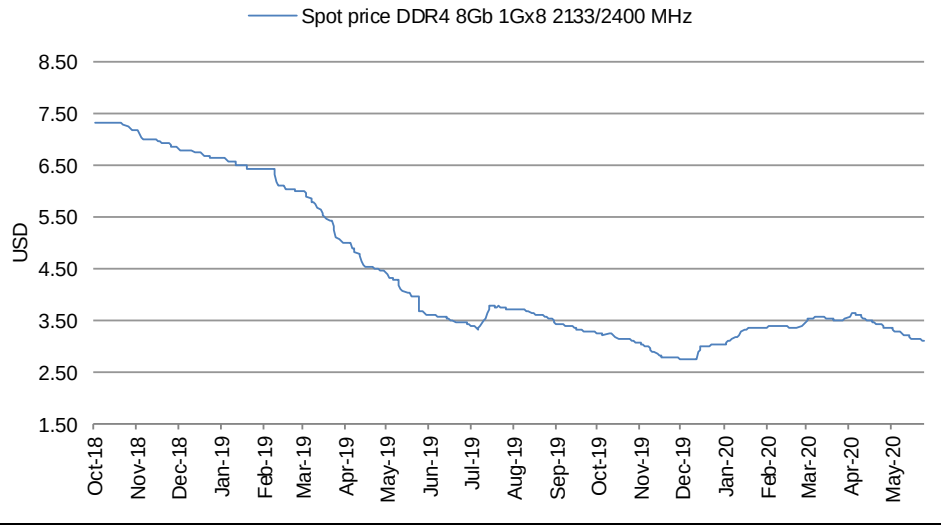
Source: DRAMeXchange

Figure 51: DDR4 spot price (4Gb)



Source: Bloomberg, Credit Suisse

Figure 52: DDR4 spot price (8Gb)



Source: Bloomberg, Credit Suisse

DRAM technology trends

Market feedback

- Samsung Electronics' first-generation 1znm process is EUV-less, but the company plans to use EUV in the second generation.
- We expect DDR5 server DRAM to be used in the Sapphire Rapids CPU, which Intel plans to release in 4Q 2021.
- Projected HBM2 demand is based on the use of 16GB of HBM2 in 2021's next-generation GPU accelerators (the current generation uses 8GB).
- Projected HBM2 demand is 60mn GB in 2020 (+100% YoY) and 85–90mn GB in 2021 (+40–50%), with nVidia and Broadcom driving this growth. We expect Intel to use HBM in supercomputers for the US Department of Energy.

1znm process technology

Samsung's roadmap for miniaturization previously called for the full-scale adoption of EUV from the 1Anm process for cost reasons. Although mass production of the first-generation of 1znm using and EUV-less process is now under way, it appears that the company has changed course and will use EUV from the second generation. The company plans to invest in a pilot 1znm-process line at Pyeongtaek Fab2 (P2) in the latter half of 2020. The pace of DRAM miniaturization is slowing in 1ynm and 1znm, and investment efficiency appears to be decreasing. It is unclear whether the decision to use EUV is due to delays in 1Anm development, but we will be monitoring the transition to the next generation and the progress of 1Anm development.

DDR5 uptake: likely to expand from spring 2021 models for mobile phone DDR5, 4Q 2021 for server DDR5

LP DDR5 is apparently being used in various companies' flagship models (e.g., Samsung Mobile's Galaxy S20 and Huawei's P40), but DDR5 has not been a particular driver of 5G smartphone demand, and some are starting to take a cautious view on future DDR5 uptake. Currently, no smartphone maker is increasing the use of LP DDR5, as the uncertain demand outlook is not permitting them to aggressively increase costs. At this point, only one company, Samsung Electronics, has been able to mass produce and supply a smartphone with LP DDR5. We think the LP DDR5 price premium is one reason it has failed to gain traction in the market. If other DRAM makers are ready to supply LP DDR5 from 2H 2020, we would expect the price premium to contract and the use of LP DDR 5 in high-end and midrange 5G smartphones to increase. We do not expect this to happen until the spring 2021 models.

Adoption of DDR5 server DRAM is not expected until end-2021 at the earliest (with the Sapphire Rapids CPU, the successor to Ice Lake).

HBM2 demand

Demand for HBM2 for data center voice recognition applications is on the rise in 2020, but data center investment is now peaking out, and we expect GPU accelerator demand to likewise slow. On a 4GB conversion, demand is projected to double YoY in 2020 (to 15mn units) and another 40–50% in 2021. The latter is up from a projected 35% rise in 2021 as of our March survey. This is because next-generation GPU accelerators will be 16GB-ready, and thus are expected to drive demand. The main sources of HBM2 demand (in particular, nVidia's GPUs for data centers and Broadcom's SoCs for high-end switches/routers) are also expected to grow in 2021.

Figure 53: Intel server CPU, the number of channels

Architecture	Product Name	Launch Date	Lithography (nm)	Memory Types	Max # of Memory Channels
Sandy Bridge	Intel® Pentium® Processor 1405	Q2'12	32	DDR3 800/1066	2
Ivy Bridge	Intel® Xeon® Processor E7 v2 Family	Q1'14	22	DDR3 1066/1333/1600	4
	Intel® Xeon® Processor E5 v2 Family	Q3'13, Q1'14	22	DDR3 800/1066/1333/1600/1866	3, 4
	Intel® Xeon® Processor E3 v2 Family	Q2'12	22	DDR3 1333/1600	2
Haswell	Intel® Xeon® Processor E7 v3 Family	Q2'15	22	DDR4-1333/1600/1866, DDR3-1066/1333/1600	4
	Intel® Xeon® Processor E5 v3 Family	Q3'14, Q2'15	22	DDR4 1333/1600/1866/2133	4
	Intel® Xeon® Processor E3 v3 Family	Q2'13, Q2'14	22	DDR3 and DDR3L 1333/1600 at 1.5V	2
Broadwell	Intel® Xeon® D Processor	Q1'15, Q4'15, Q1'16, Q2'16, Q3'17	14	DDR4, DDR3	2
	Intel® Xeon® Processor E7 v4 Family	Q2'16, Q1'17	14	DDR4-1333/1600/1866, DDR3-1066/1333/1600	4
	Intel® Xeon® Processor E5 v4 Family	Q1'16, Q2'16	14	DDR4 1600/1866/2133/2400	4
	Intel® Xeon® Processor E3 v4 Family	Q2'15	14	DDR3 and DDR3L 1333/1600/1866 at 1.5V	2
Skylake	Intel® Xeon® Processor E3 v5 Family	Q4'15	14	DDR4-1866/2133, DDR3L-1333/1600 @ 1.35V	2
	Intel® Xeon® D Processor	Q1'18	14	DDR4	4
	Intel® Xeon® Scalable Processors	Q3'17	14	DDR4-2400/2666	6
Kaby Lake	Intel® Xeon® Processor E3 v6 Family	Q1'17, Q3'17	14	DDR4-2400, DDR3L-1866	2
Coffee Lake	Intel® Xeon® E Processor	Q3'18. Q2'19	14	DDR4-2666	2
Cascade Lake	Intel® Xeon® W Processor	Q3'17, Q4'17	14	DDR4 1600/1866/2133/2400/2666	4
	2nd Generation Intel® Xeon® Scalable Processors (Gold, Silver, Bronze)	Q2'19	14	DDR4-2400/2667/2933	6
	2nd Generation Intel® Xeon® Scalable Processors (Intel® Xeon® Platinum series)	Q2'19, Q3'19	14	DDR4-2933	6, 12
Cooper Lake	Cooper Lake-P	?	14	DDR4	6
	Cooper Lake-SP	Q3'20	14	DDR4-3200	8
Ice Lake	Ice Lake-SP	Q3'20?	10	DDR4-3200	8
Sapphire Rapids		'21?	10?	DDR5	8
Granite Rapids		'22?	7?	DDR5	8

Source: Company data, Credit Suisse estimates

NAND market outlook

Our view based on our survey

As with DRAM, NAND restocking demand appears to have peaked out for Chinese smartphone makers and for hyperscalers. Actual demand is also already being affected by inventory adjustments at Chinese smartphone makers and a correction in Huawei's demand from 3Q, and market sentiment on 2H CY20 has accordingly cooled sharply. With adverse seasonality also in play, we see few catalysts for an upturn in prices through 1H CY21.

Over 2 months' inventory at smartphone makers, over 3 months' at retailers, module makers

NAND inventory is currently an excessive two months' worth at Chinese smartphone makers and we expect three months' worth at retailers and module makers amid weak macroeconomic conditions. NAND makers' inventories have meanwhile largely returned to normal, enabling them to hold wafer inventory and thereby keep a lid on supply–demand. We therefore do not expect prices to deteriorate as much as in CY18.

NAND makers have been raising prices since CY19 regardless of market conditions in an effort to break free of losses and improve profitability, but we think the demand environment from 3Q could make further price hikes difficult. While SSD prices could conceivably rise by as much as 5% in 3Q due to a temporary supply shortage stemming from COVID-19, we expect smartphone and retail prices to turn downward. We expect price declines to be smaller than for DRAM, with ASP down only around 0–5% in 3Q and 5% in 4Q.

Under such conditions, NAND makers will need to cut costs, and we expect next-generation 3D NAND 1XX-layer (112/128-layer) to start receiving customer certification in 2H following industrywide development delays. However, mass production yields are low and performance is unstable, so we do not expect the shift to 1XX technology to accelerate in CY21. In short, we think the environment is not conducive to accelerated capex.

Two longer-term risks

From a longer-term perspective, we are particularly interested in the following two points regarding the NAND industry. The first is a slowdown in NAND storage density in smartphones, the second a delay in take-up of 512Gb chips (64GB). The slowdown in smartphone NAND density reflects end-users' increasing use of cloud storage, which has resulted in weak demand for high-capacity storage (512GB/256GB). Moreover, we think price cuts aimed at stimulating demand are unlikely in view of NAND makers' earnings structures. The second issue has emerged beginning with the 3D NAND 9X layer, with chip demand topping out at 256Gb and making it more difficult for NAND makers to cut costs. NAND makers aim to lower costs by shifting to 512Gb chips for 9X and 1TB chips for 1XX layers, but customers are opting for 256Gb chips in view of their capacity, reliability, and speed. 256Gb is the mainstream for 9X-layer NAND, but NAND makers have been hoping to demand shift to 512Gb for 1XX-layer chips. Assuming this shift does not materialize, NAND makers will be less able to reduce costs through multilayering in what we view as a key threat to their profitability.

NAND pricing trends

Market feedback

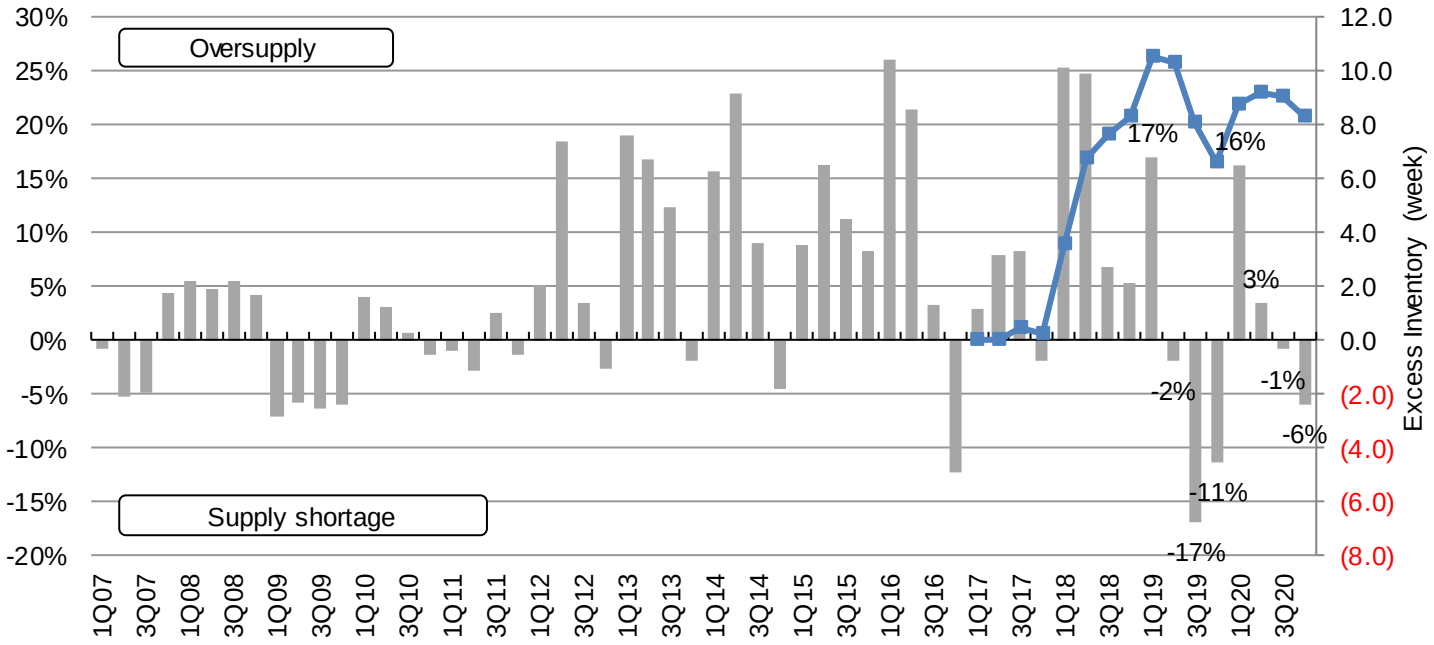
- There is mounting concern over the possibility of a 2–3% NAND supply glut in 4Q 2020. Our sources also see high risk of oversupply in 1H CY21.
- Bit growth in CY21 is expected to be limited to around 20% for both demand and supply.

Inventory levels imply supply glut in 2H CY20; prices unlikely to rebound until 1H CY21

In view of recent demand, many NAND makers are now expecting demand to grow just 20–25% (previously 25–30%) and supply +25% (unchanged). There is also a growing view that bit demand growth will remain in the 20% range in CY21. We therefore think capex is likely to remain weak again next year. If bit supply growth continues to be in the low-20% range in

CY21 as a result of curbs on capex, we would expect supply-demand conditions to return to healthy levels once inventory adjustments run their course.

Figure 54: NAND supply–demand outlook: Expecting supply shortage in 2H CY20 excluding inventories, but excess inventories at customers mean that market conditions are unlikely to tighten



Source: Credit Suisse estimates

NAND demand trends

Market feedback

- Hardly any smartphone makers are planning to aggressively increase NAND density per phone.
- Enterprise demand also now appears at risk of slowing in 2H after coming in at more than one-fourth of the expected full-year total in 1Q.
- Huawei has begun informing memory makers of a 30% reduction in demand in 3Q and zero demand for use in flagship models. We also understand that some manufacturers have been sounded out about a cancellation of roughly half of 2H CY20 demand.
- The 2020-model iPhones are expected to feature 6GB of DRAM and 128GB/512GB/1TB of NAND for the high-end Pro series and a respective 4GB and 128GB/256GB/512GB for other models. So it looks like we will be seeing 1TB of storage in at least some of the new iPhones.
- Consensus has enterprise demand peaking in 3Q and data center demand in 2Q.
- Chinese enterprise SSD demand doubled YoY in CY19. The expectation for CY20 is 60–70% growth, with a peak in 2Q followed by a 15% QoQ decline in 3Q. Demand from Alibaba and Tencent looks set to slow in 2H.
- SSD demand from ByteDance could double in CY20 as it constructs multiple new data centers in China and India.
- NAND demand is still dominated by the 256Gb chip even in the 9X-layer generation. NAND makers thus remain unable to benefit from the cost benefits expected from 512Gb

chips. They are hoping that the migration to the 1XX layer will shift demand toward 512Gb chips.

- They face a major problem if this shift does not materialize.
- Regarding in-house SSD assembly by Chinese enterprise/data center makers, Tencent and Inspur are planning to move forward here. Progress on this front could drive increased demand for NAND wafers (raw-NAND) from Chinese data centers.

Uncertain demand outlook for 2H

Starting inventory adjustment for smartphone, but offset for datacenter

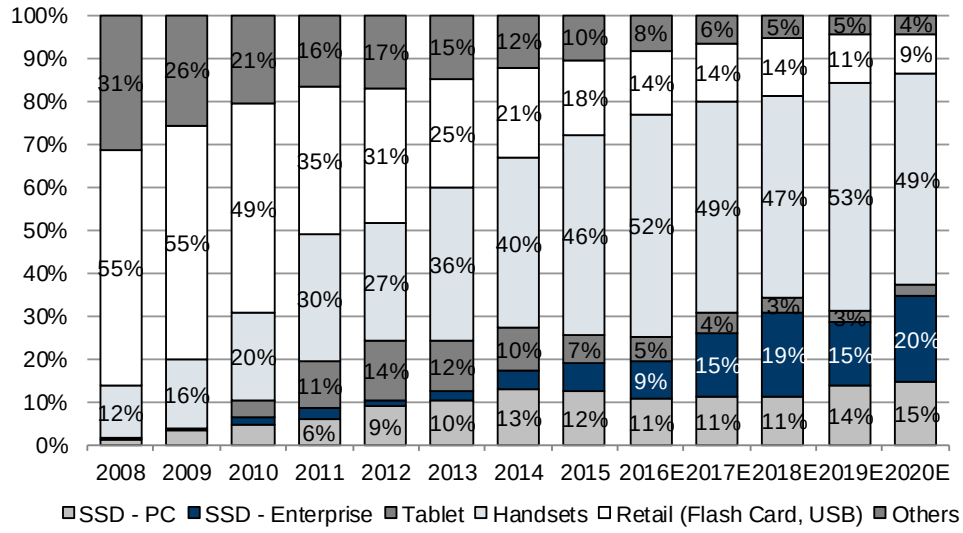
Demand began to correct from the latter half of April, mainly at Chinese smartphone makers. In addition, demand from US hyperscalers and Chinese data center makers peaked in 2Q and is expected to slow in 2H. Huawei is also sounding out memory makers about cutting its 2H demand target by at least 30–40%. Chinese smartphone makers are continuing to adjust inventories, with no sign of demand growth to gain market share in response to tougher Huawei regulations.

Smartphone makers are now holding between two and six months' inventory, and we are seeing a reactionary pullback from the restocking that began in 2H CY19. Just how large an impact these inventory adjustments are having can be gauged from the fact that NAND makers are not expecting any demand boost from the anticipated increase in 5G smartphone production (centered on mid-range models) from 3Q.

In 5G smartphones, we understand smartphone makers are mulling plans to lower memory densities for mass-market models by one level versus current models, in response to higher BOM cost for other components. With COVID-19 also clouding the demand outlook, there are no moves to aggressively increase installed capacity. The 2020-model iPhone is likely to feature 1TB in the high-end Pro series, but we expect the overall impact on NAND demand to be minimal.

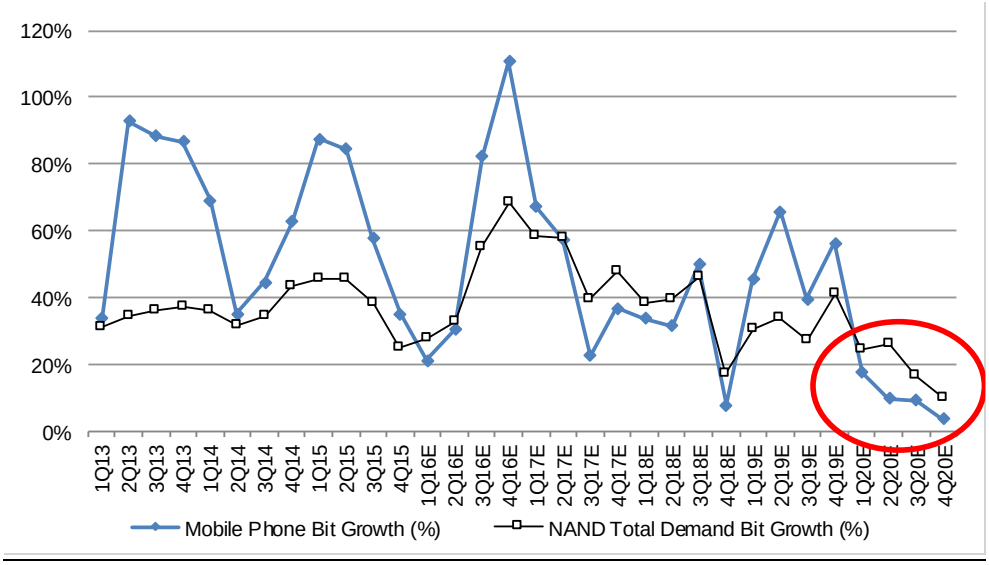
In our previous survey, we reported on NAND makers facing structural risk from increased sales of individual chips and packages, rather than entire eSSD, eUFS, and other systems. We cited Microsoft's procurement of chips for in-house SSDs and Huawei's procurement of individual chips as it transitions to in-house controllers, and we now also note plans by Tencent and Inspur to assemble SSDs in-house. We thus believe NAND makers could see increased demand for lower value-added products, which poses risk of long-term deterioration in their product mix.

Figure 55: NAND demand breakdown



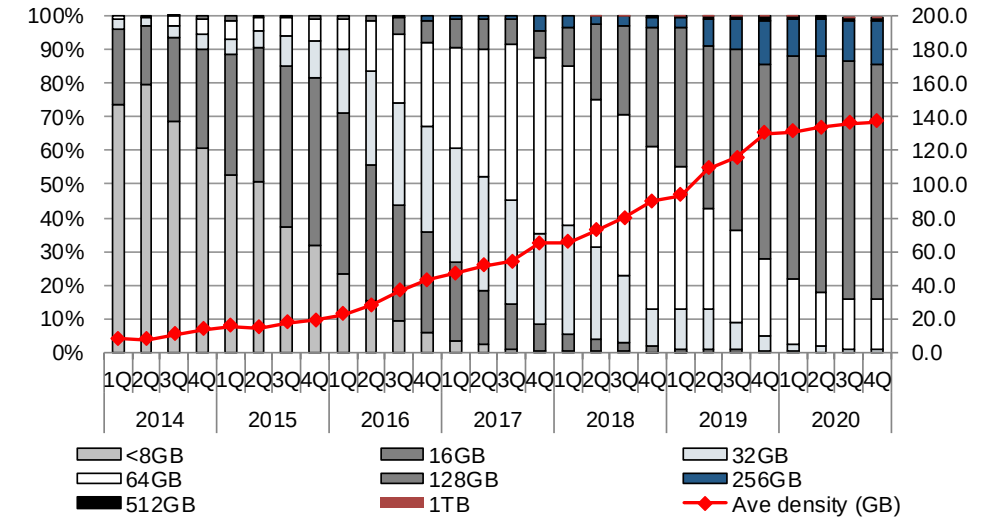
Source: Credit Suisse estimates

Figure 56: NAND total demand bit growth and mobile phone bit growth



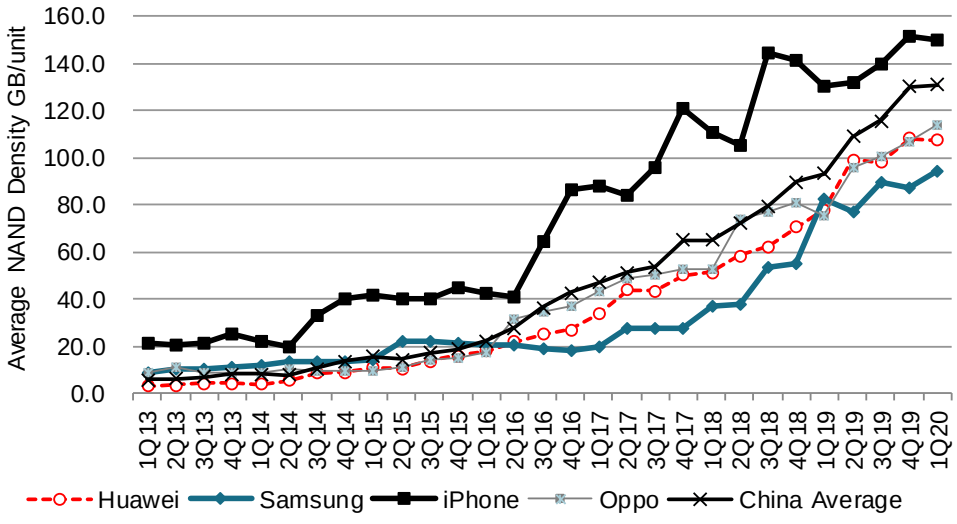
Source: Credit Suisse estimates

Figure 57: Chinese smartphone NAND density ratio trend estimates (including iPhone)



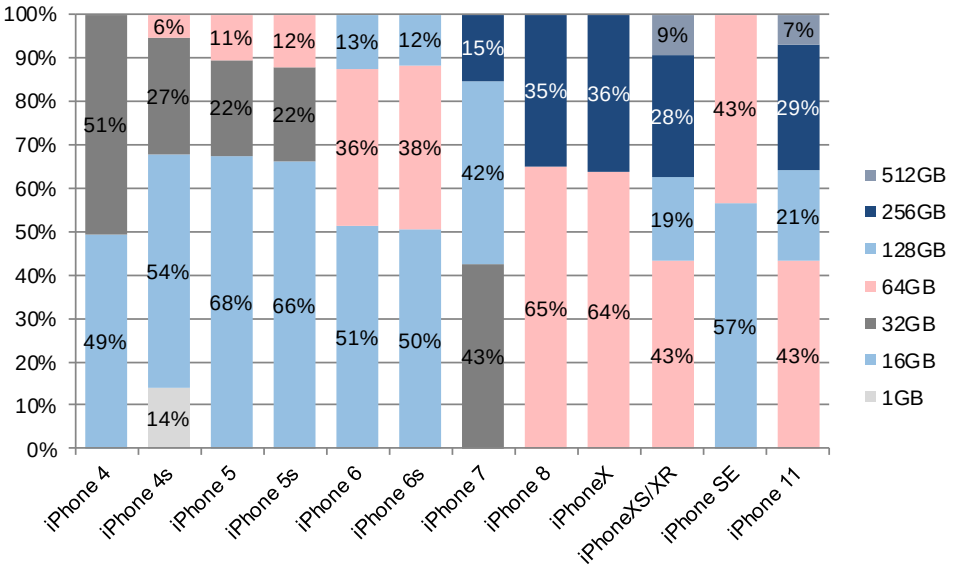
Source: IDC, Credit Suisse estimates

Figure 58: NAND density: iPhone, Samsung, Huawei, Chinese smartphone average



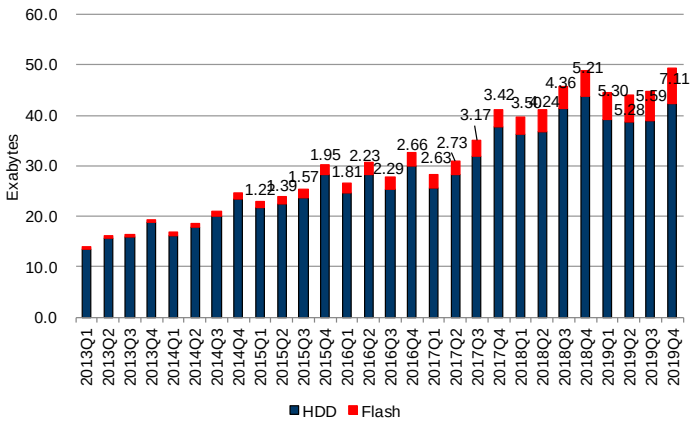
Source: IDC, Credit Suisse

Figure 59: Weighting by iPhone generation, storage option (based on four quarters since launch)



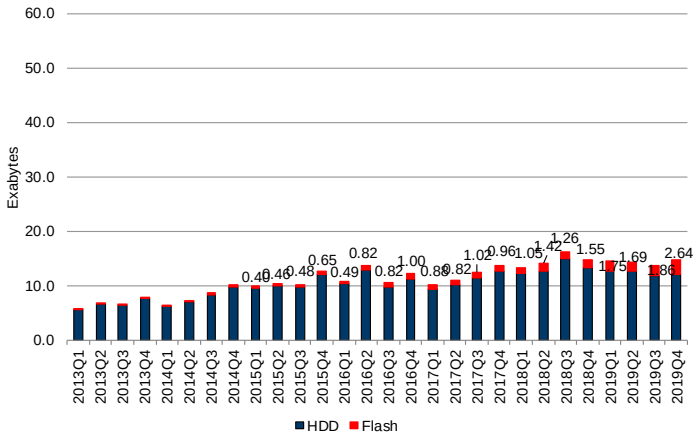
Source: IDC, Credit Suisse

Figure 60: Enterprise storage market (worldwide)



Source: TSR, Credit Suisse

Figure 61: Enterprise storage market (US)



Source: TSR, Credit Suisse

NAND supply outlook

Market feedback

- Several NAND makers are expanding production bases in Thailand and increasing outsourcing to OSAT plants in China and Taiwan because their SSD assembly plants in the Philippines are operating at low capacity.
- Yields on 9X-layer are improving; we understand some makers have achieved 20ppt improvements from last year.
- There is a mismatch between NAND demand and the actual products manufactured; some NAND makers' production systems have not kept up with demand changes such as the sharp decline in smartphone demand and growing demand for enterprise SSDs.
- We understand a number of makers are deliberately reducing their share of the Apple-related market due to its low margins, resulting in additional demand for other makers.
- We also understand that QLC has yet to receive customer approvals for SSDs for enterprise applications. Meanwhile, Xiaomi looks set to use 1TB SSDs for PCs.
- Samsung secured help from SPE makers and swiftly made up lost ground after a two-month delay in installing NAND equipment due to COVID-19. At other companies, equipment installation plans were postponed by up to six months.

COVID-19 impact on SSD supply

NAND suppliers are still struggling with mass production of 9X-layer 3D NAND, with the exception of front-runner Samsung Electronics. Some makers have improved yields by around 20ppt since last year, but yields remain low at the 70% level. COVID-related delays in installing equipment have had a negative impact on bit supply growth (boosting prices), but Samsung has made up lost ground thanks to the back-up system of SPE makers, so its delay is no longer benefiting supply–demand much.

As some NAND makers' SSD assembly facilities are located in the Philippines, we see COVID-19 taking a toll on dSSD/eSSD output in particular, leading to a temporary tightening of supply. As a result, we expect a continuation of price hikes for eSSD applications only in 3Q price negotiations.

QLCs (Quad-level cells), which contribute to cost reductions and bit growth, have yet to receive customer approvals in the enterprise market. Among PC makers, Xiaomi apparently plans to use QLCs for 1TB storage, but we see no evidence yet of uptake by major PC makers.

NAND inventory trends

Market feedback

- Overall inventory surplus of two months at Chinese smartphone makers. Huawei's high-end eMMC/eUFS inventory is 6-months' worth.
- Chinese smartphone makers are expected to reduce inventories in 2H CY20.
- NAND makers' inventory levels seem appropriate, but some makers appear to have accumulated more than one month of post-package inventory due to operating constraints on SSD assembly processes.
- Some enterprise customers are likely to adjust excess inventory in 3Q, impacting demand.

Chinese smartphone makers shifting from restocking to inventory adjustments

We understand restocking by Chinese smartphone makers since July CY19 has pushed up their inventory levels, resulting in a two-month surplus as of end-2Q. Huawei, which had started inventory adjustments according to findings in our previous survey, had likely secured roughly six months' of eMMC/eUFS inventory for its flagship/high-end products before tighter restrictions were imposed on the company. We understand the challenge from here will be switching the ratio of high-end eUFS to midmarket & low-end eMCP (DRAM & NAND hybrid packages) from 3:2 to 1:4. This suggests eUFS demand has essentially dried up.

Inventories at US-based hyperscalers look excessive at 4–10 weeks, as with DRAM.

NAND pricing outlook

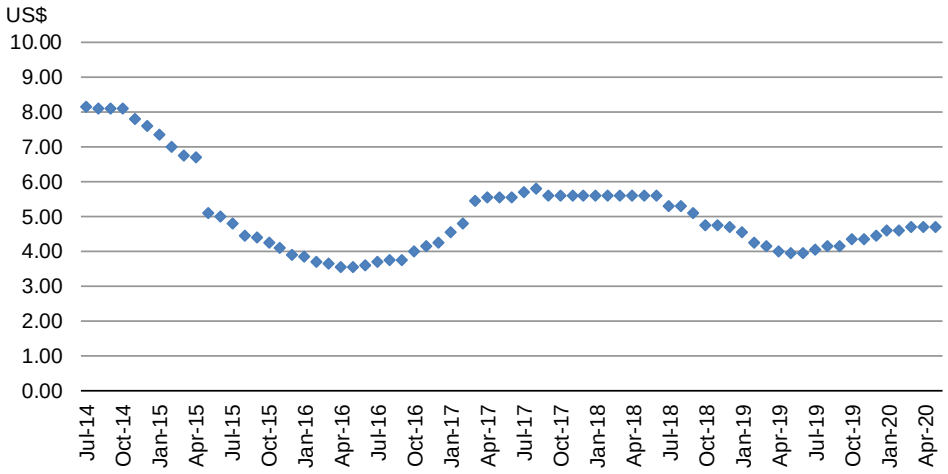
Market feedback

- NAND prices rose 5% QoQ in 2Q and are expected to remain flat or fall in 3Q.
- Prices are likely to flatten QoQ in 3Q and decline 0–5% in 4Q. Depending on future smartphone-related demand, makers are considering aggressive price cuts in 3Q.
- eSSD prices look likely to rise around 5% in 3Q, but prices for other applications are unlikely to hold level.
- There were no signs of strong demand from customers during 3Q price negotiations, with little buying interest.
- As iPhone-related prices are too low, operating losses at sector companies show no improvement; some makers are intentionally reducing their share of the Apple-related market.

Smartphone-related price cuts see unavoidable in 3Q

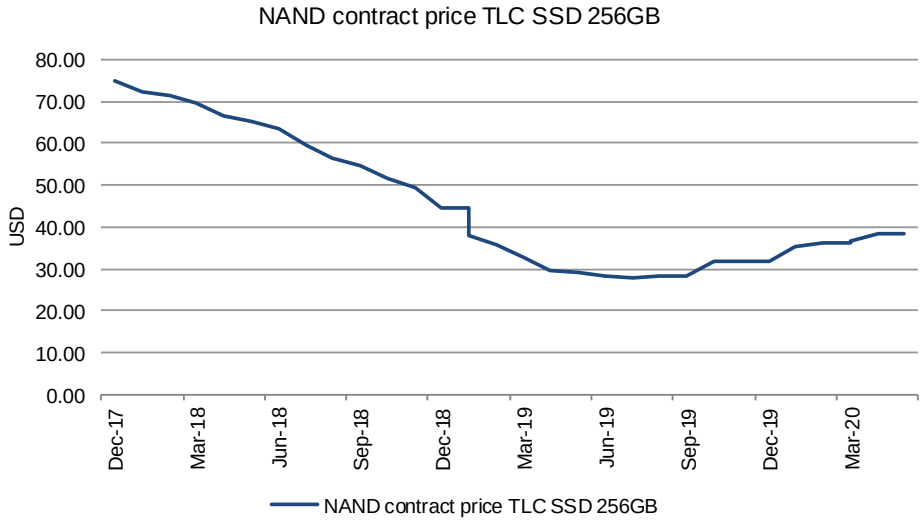
The urgent need for NAND makers to move out of the red likely persuaded their customers to accept the 10–15% price rise in 1Q for almost all applications, as well as the 5% hike in 2Q, but we think price cuts will resume in 3Q. That said, eSSD prices are likely to continue rising in 3Q, so the overall ASP is likely to fall only 0–5% in 3Q and just around 5% in 4Q. We think NAND price will rise less than DRAM ones because low-end NAND makers are still in the red, and even profitable NAND makers have yet to achieve their margin targets, meaning pricing competition is unlikely to pick up among such companies.

Figure 62: 128Gb MLC NAND contract price



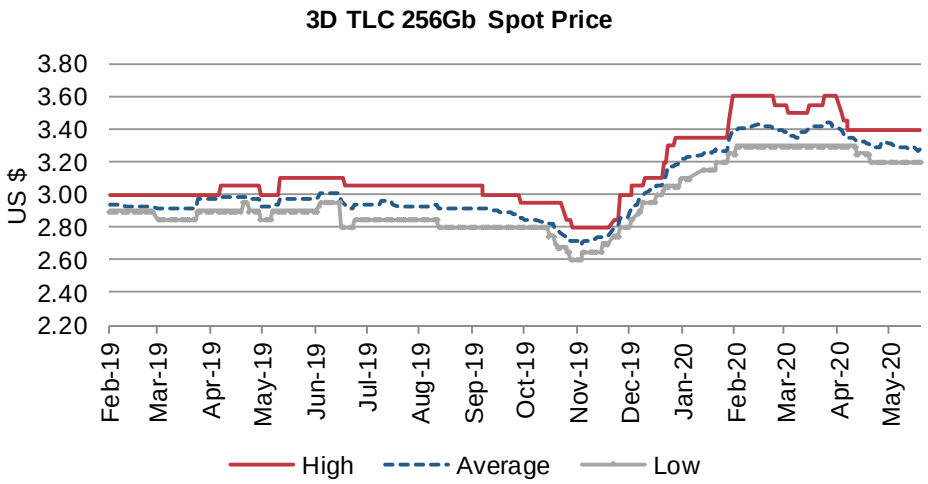
Source: DRAMeXchange, Credit Suisse

Figure 63: 256GB TLC SSD price



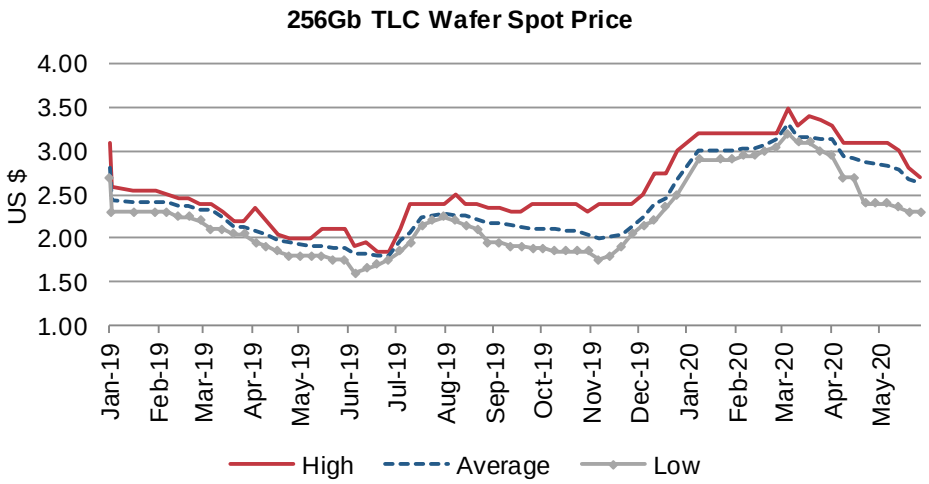
Source: Bloomberg, Credit Suisse

Figure 64: 3D NAND spot price (TLC 256Gb)



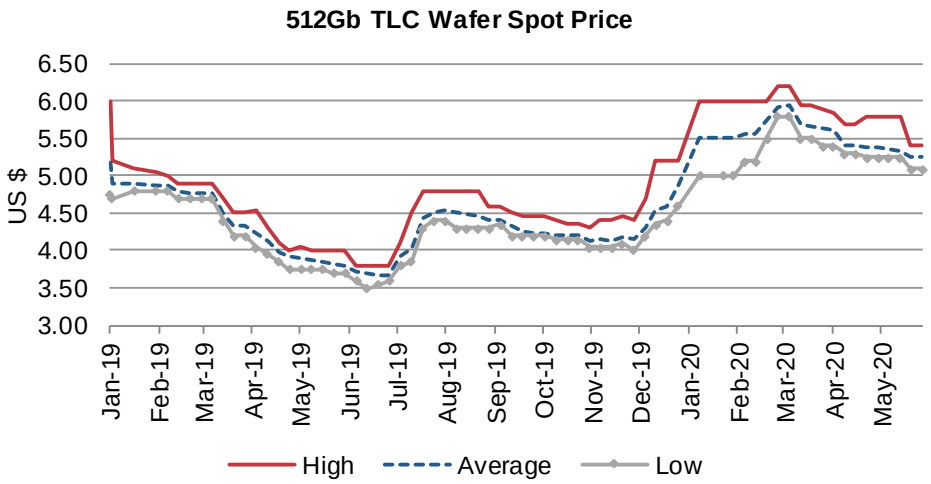
Source: DRAMeXchange, Credit Suisse

Figure 65: Wafer spot price (TLC 256Gb)



Source: DRAMeXchange, Credit Suisse

Figure 66: Wafer spot price (TLC 512Gb)



Source: DRAMeXchange, Credit Suisse

3D NAND 9X/1XX mass production and development

Market feedback

- COVID-19 apparently caused delays in sample evaluations and R&D for next-generation and next-next-generation NAND processes.
- Samsung is struggling to cut costs and ensure product reliability for 1XX-layer (128-layer) NAND. Commercial sample (CS) schedules have been delayed across the board.
- For 1XX-layer NAND, Japanese manufacturers plan to start supplying CS to smartphone makers around July.
- SK Hynix is focusing more on 128 layers than 96 layers; 128-layer NAND has already been shipped to OEMs, with mass production intended to start in 4Q CY20.
- In 1XX-layer NAND, Samsung Electronics is developing 256Gb and 512Gb products, while other makers are focusing on 512Gb. A shift in demand to 512Gb should help lower NAND maker costs.
- The shift to 9X-layer NAND has reduced makers' production capacity by around 10%. Capex to make up for this reduction is being curbed at present.
- The benefits do not currently outweigh the costs of capex for 1YY-layers and above, so technical breakthroughs are needed.
- We understand NAND makers see higher capital intensity for multi-layer 3D NAND investment as a serious impediment to cutting costs, raising questions about the sustainability of such operations.
- For 1YY-layer NAND (successor to 1XX (112/128)-layer NAND), the number of layers vary by maker (160/176 layers), but the chips are likely to feature at least two stacks at all companies.
- YMTC aims for mass production of 128-layer NAND using its Xtacking architecture in CY20. In addition to "Xtacking" two arrays of 64-layer NAND, logic circuitry is also applied, to form a three-level structure. The process has been completed but has yet to be fine-tuned (including in terms of product reliability) for commercialization.

Firms flagging in 1XX-layer NAND development & approvals

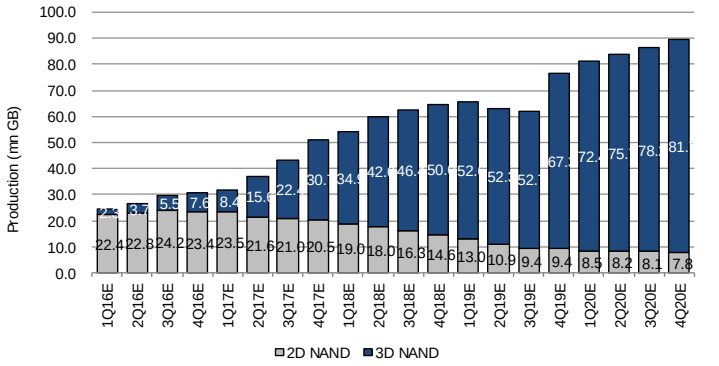
Makers aim to mass produce 1XX layers (112/128-layer) NAND around end-CY20, but development is not going smoothly. We believe Samsung Electronics has gained an overwhelming edge over competitors by achieving much better yield improvements for 9X-layer NAND, but we think the company faces considerable hurdles in developing 128-layer wafers due to its use of a one-stack structure. We understand it has yet to achieve reliable product quality, as evidenced by the pressure it is under to revise prices even after submitting CS. Other companies have also begun shipping CS, and while they plan to start mass production in CY20, they still need to clear numerous hurdles, in our view.

In next-generation 1YY-layer NAND (160/176 layers; successor to 1XX-layer NAND), converting 1XX-layer process equipment would likely reduce production capacity for 1XX-NAND by nearly 40%, meaning more capex would be needed to maintain bit supply growth of 20–30%. We also understand there will need to be further investment in technologies that reduce NAND chip surface area by using periphery circuits and memory cell arrays (such technology is called COP, CUA, PUC, etc., depending on the company). This suggests the capital intensity of multi-layer NAND investment will come under further scrutiny, and cash flow will need to improve if NAND businesses are to remain sustainable.

NAND makers keen to adopt 512Gb chips

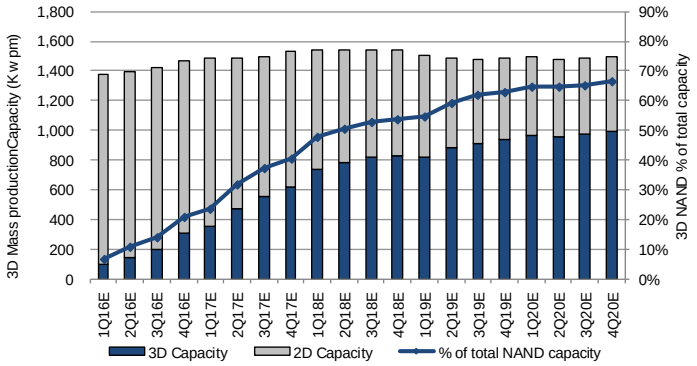
In addition to reducing costs through multilayering, another way of reducing NAND costs is to increase chip density. However, with the advent of 3D NAND, there has been limited uptake beyond 256Gb densities. In the five years since CY15, 256Gb has been the norm, but if this rises to 512Gb, costs could come down (the surface area of the periphery circuits is the same for 256Gb and 512Gb, so higher bits for 512Gb mean lower costs per surface-area unit). 256Gb is the norm for 9X-layer NAND, but makers are prioritizing development of 512Gb chips in the case of 1XX-layer NAND. Their customers, however, are keen to continue using 256Gb chips due to factors including chip size, chip-stacking reliability and firmware assets. We focus on these issues as we believe adoption of 512Gb chips for 1XX-layer NAND will be vital to reducing NAND-maker costs.

Figure 67: 2D/3D NAND supply bit forecasts



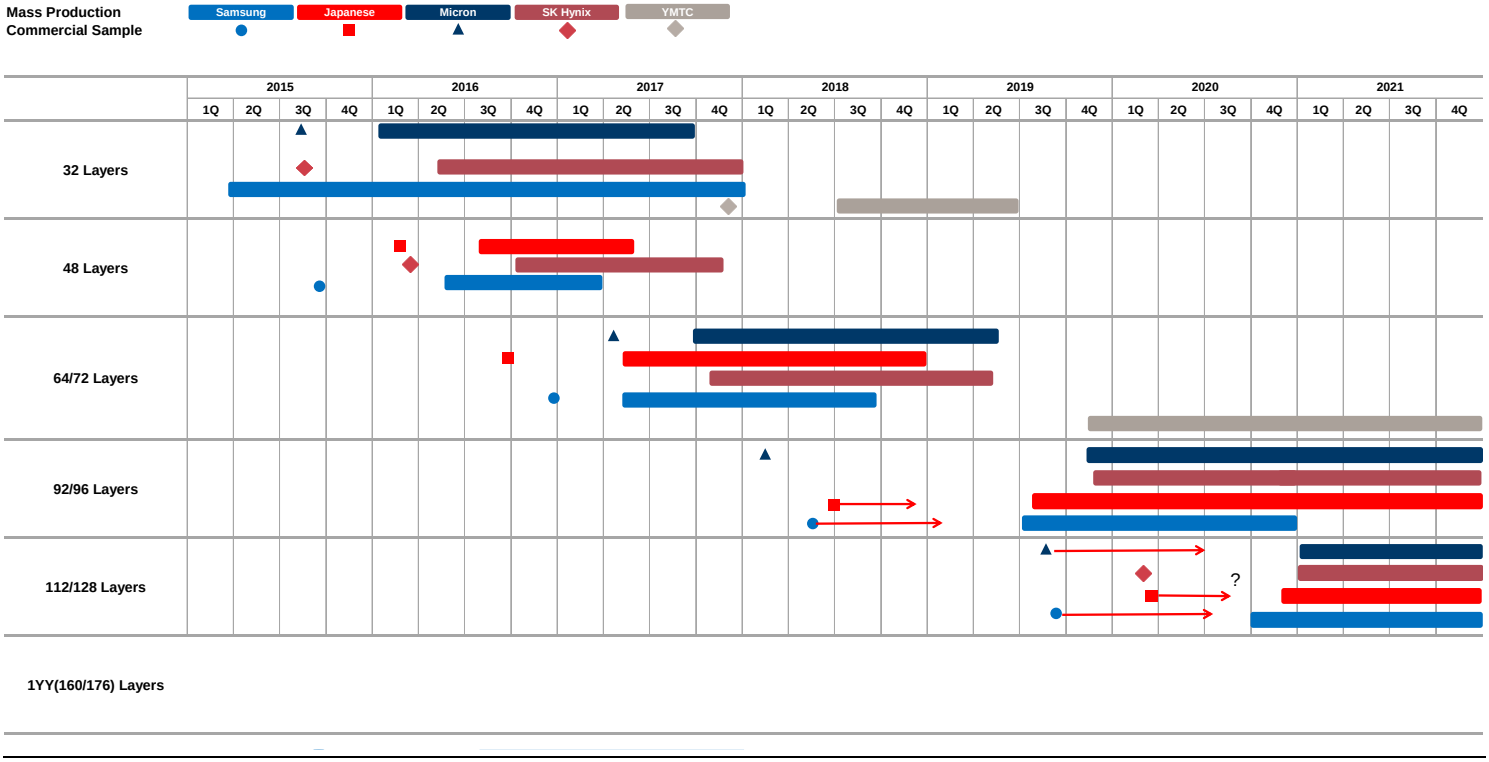
Source: Credit Suisse estimates

Figure 68: D/3D NAND production capacity forecasts



Source: Credit Suisse estimates

Figure 69: NAND makers' 3D NAND technology roadmap



Source: Credit Suisse estimates

Front-end SPE market

Our view based on channel checks

The COVID-19 pandemic has led to delays in the delivery of equipment by forcing engineers at global SPE firms to return to their home countries. However, there is disparity between semiconductor makers. The majors are in receipt of full support but others are running between two and six months behind plans.

Memory makers unlikely to adopt bullish CY21 capex plans amid 2H CY20 market downturn

Contrary to the expectations of SPE makers, semiconductor firms' capex plans have not changed much since the start of the year. Meanwhile, memory makers continue to invest in process migration and multiple layers (DRAM 1znm, NAND 9X layers). We could not find evidence that even one memory maker was considering stepping up capex in response to the upturn in memory prices. With memory market conditions likely to worsen in 2H, we also do not expect any memory makers to commit to accelerating capex in 2021. Accordingly, we do not foresee a dominant set of investors taking the view that investment in the WFE market is poised to rebound in 2021.

We currently assume investments to expand production capacity will include Samsung Electronics' DRAM 1znm pilot line at its Pyeongtaek Fab2 (+20–30k wpm) and new 96-layer 3D NAND production line at its Xian Fab2 (+40–45k in 2020), a Japanese NAND maker's Kitakami Fab1 (+12.5k in 2020), YMTC's Fab1 (+20k), and CXMT (+20k).

Regarding TSMC's investments in cutting-edge processes, we expect the firm (1) to tone down capex plans to expand the 5nm/7nm process and not plan any additional investments until 1H 2021, and (2) to have equipment delivered in 2H 2020 as a part of investments in a pilot line for 3nm process development. We therefore believe capex peaked from 4Q 2019 into 1Q 2020 and do not expect any major investments until 3nm process mass production lines are expanded in 2022.

As for decisions to invest in logic and foundry projects in 2H, we anticipate Intel moving on investments in 7nm process mass production and Samsung Electronics LSI investing in new 5nm process lines at its Pyeongtaek Fab2. Among plants currently under construction, we look for equipment deliveries to start in 1Q 2021 for the new building at Sony's Nagasaki Technology Center, but see the possibility of Sony changing its investment plans.

We forecast the WFE market at $400bn in 2020 (–4% YoY, $39.5bn previously) and $380bn in 2021 (-5% YoY, $42.0bn previously). The major cut to our CY21 forecast reflects a possible delay in CIS investment and a review of DRAM/NAND investment plans. Over the next few months, we expect to see a significant gap between SPE makers' projections and memory makers' investment plans, as well as a downward revision to market consensus. For 2021, our Japan Technology team forecasts the WFE market (per device) will increase 7% for memory on expectations for higher investment in 1XX-layer NAND, but 12% decline in logic/foundry orders due to lower capex at TSMC.

Our reasons for not expecting a full-fledged recovery in capex at memory makers are four-fold: (1) Smartphone makers and the hyperscalers restocked both DRAM and NAND in 4Q 2019 and 1H 2020 owing to the risk of tight supply-demand conditions in 2H 2020 and 2021, and memory manufacturers are thus cognizant of demand risk in 2H. (2) Memory manufacturers are placing top priority on raising DRAM and NAND profit margins to appropriate levels (30% for DRAM, 20% for NAND), and management is withholding FID approval until then. (3) DRAM manufacturers are reluctant to invest because of delays to 1znm-process development and low ROI. (4) With low yields on 96-layer NAND, manufacturers are limiting their investments in mass production of 96-layer NAND.

Market feedback

- Samsung Electronics' Xian Fab2 expansion plan (from 20k wpm at end-2019 to 60–65k at end-2020) had been delayed by more than two months due to the impact from COVID-19, but we now understand the company has been able to catch up to its original plan with

help from SPE makers. Although Lam Research and Tokyo Electron were unable to establish a framework in the end, the shortage of launch engineers has recently been resolved.

- Japanese semiconductor makers' delivery plans also appear to be behind launch schedules due to insufficient resources at US and European SPE makers.
- In South Korea, the largest player in memory plans to slightly reduce investment YoY in 2021, while the second-largest player plans to expand investment. The largest player plans to cut DRAM and increase NAND investment. The second-largest player will increase investment after cutting back in 2020.
- Looking at the next year, we see that Samsung Electronics plans to invest in expanding Xian Fab2 and ramping up to 128-layer NAND, and also to invest in expanding the 1znm DRAM process.
- Samsung Electronics LSI has temporarily shelved plans for its Austin Fab2. The company does plan to expand capacity at Pyeongtaek Fab 2.
- TSMC has put on hold its plans to expand the 5nm/7nm process because demand from HiSilicon is unlikely to materialize.
- Sony's CIS capex plans at the new Nagasaki Technology Center building (equipment is scheduled for delivery in 1Q 2021) are likely to be revised in light of construction delays due to COVID-19 and market trends.
- Higher capital intensity has caused investment efficiency to worsen significantly with each generation of multilayer NAND. Apparently, doubts have begun to form about whether the market truly needs next-next-generation NAND (1YY layer) and the 2XX-layer generation after that, and whether this presents NAND makers with the value they require to continue operations.

Cutting-edge memory investment for 1znm DRAM, 1XX-layer (112/128-layer) 3D NAND; delays due to cost factors

Cautious stance on investment likely across the board

Given the slowdown in DRAM and NAND bit demand growth, there are virtually no plans for output expansion capex in 2020, as investment aimed at expanding capacity would only lead to oversupply. NAND output capacity at major NAND makers has fallen by more than 10pp due to the shift to 9X layers, and NAND makers are investing wholeheartedly to offset this decline in output.

Memory makers are adopting ROI as a useful benchmark for capex plans. For both DRAM and NAND, next-generation processes (DRAM 1znm, NAND 96/1XX-layers) are unlikely to result in cost reductions, given the high technological barriers and the low yields associated with the rise in capital intensity. This makes it increasingly hard for makers to push forward with capex plans.

Global SPE makers expect a recovery in memory prices to lead to a recovery in investment spending, but in this cycle, it is the memory makers who are skeptical of prospects for a demand recovery for reasons including the aforementioned technological difficulties. These memory makers are thus more likely to take a cautious stance on investment decisions. We think smartphone makers and data center operators are likely to adjust their inventories in 2H, making it difficult to justify capex with this type of outlook for demand.

We still see a significant disconnect between SPE makers' expectations for a recovery in memory investment and memory makers' cautious investment stance. While the timing of a capex recovery has been pushed back to 2021, SPE makers have not changed their expectations and memory makers remain cautious on capex in 2021.

Foundries shelve plans to invest in 5nm/7nm process expansion due to lost demand from HiSilicon

In the report on our previous survey, we noted that Apple will stick with its fall-only releases instead of splitting its flagship iPhone releases into separate spring and fall cycles starting in 2021. If TSMC wins new customers, we think it may need to invest in new production capacity for the 5nm process. However, TSMC lost anticipated demand from HiSilicon as a result of the US Department of Commerce tightening sanctions on Huawei in May—a move that eliminated the need for additional investment in 5nm processes (10–20k wpm) and 7nm+ processes (20–30k). We therefore see potential for surplus capacity in both the 5nm and 7nm processes. As a result, TSMC is likely to delay by at least six months any investment decisions to expand its cutting-edge process.

MediaTek will serve as a backup supplier of application processors for Huawei smartphones. However, we do not believe MediaTek's premier application processor will be the best solution for Huawei's flagship and high-end models, and we expect a gap to emerge between MediaTek's roadmap and Huawei's required specifications. Since MediaTek's technology is at least six months behind HiSilicon's, TSMC probably does not need to make any additional investments over the next 12 months or so. On the other hand, if Huawei adopts Qualcomm's Snapdragon or Samsung Electronics LSI's Exynos application processor, Samsung Electronics LSI would have to invest in new production capacity on the 5nm/7nm process. We await developments.

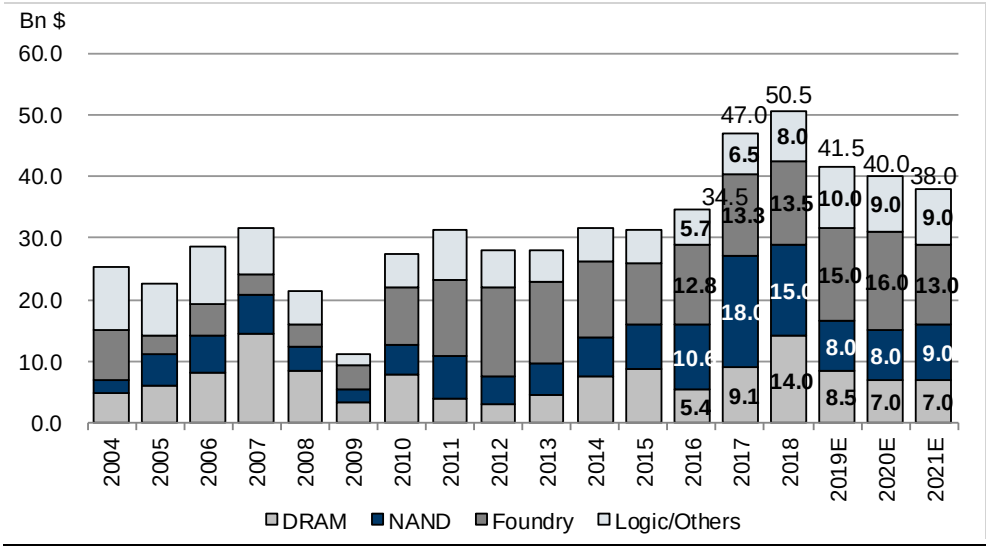
Chinese foundries starting to invest in mass-production 14nm-processes

Chinese foundries are currently investing in 14nm processes. Regarding 14nm process investment in China, we believe SMIC has the lead in 14/16nm process development thanks to its hiring of former development executives at Samsung and TSMC. Meanwhile, HuaLi has hired UMC's 14nm process development team, which together is likely to lead to 14nm process investment in 2Q 2020. We look for SMIC to take over production on the 14nm process of base station ASICs for HiSilicon; they had been produced on TSMC's 16nm process. The US Department of Commerce imposed restrictions on HiSilicon's designs that prohibit production using US-made EDA tools and manufacturing equipment, but some observers have voiced doubts about these actions' effectiveness in China. As a result, there are still needs for 14nm process production capacity, so capex plans are unlikely to be canceled or delayed in our opinion.

WFE market forecast

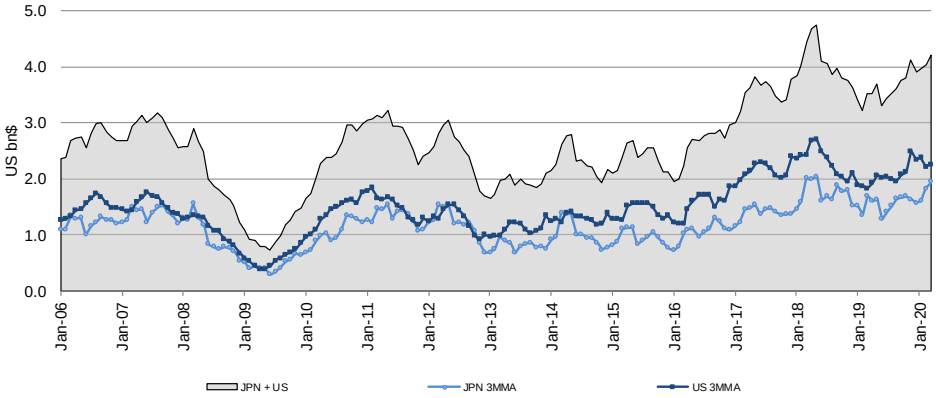
In light of the above, our Japan Technology team forecasts the wafer fabrication equipment (WFE) market will decline 4% YoY to $400bn in 2020 (prev. $39.5bn) and fall 5% to $380bn in 2021 ($42.0bn).

Figure 70: WFE market forecast (Japan team estimate)



Source: Credit Suisse estimates

Figure 71: SPE sales



Source: SEMI, SEAJ

Back-end SPE market outlook

Our view based on our survey

In contrast to seasonal factors through 2019, starting in 4Q 2019, we saw additional investment centered on memory in order to build supply chains. However, we expect the back-end SPE market to slow in 2H 2020 in line with regular seasonality.

Memory investment set to lose momentum from 4Q; Large Chinese OSATs likely to postpone or cancel investment plans

In memory investment, COVID-19 is having a positive impact on NAND-related capex as a way of diversifying risk at each company's production bases. In particular, Japanese and US NAND makers have shifted orders from manufacturing bases and subcontractors in Malaysia and the Philippines to OSATs in China and Taiwan. We believe this has led to related investments. On the other hand, Chinese memory makers, which had been driving SPE demand in assembly and testing processes, appear to have started revising their somewhat bullish DRAM-related investment plans. Korean DRAM makers have continued to invest in DRAM testers to ensure quality in server DRAM. However, their investment plans may change due to the uncertain outlook for demand from Huawei in the wake of stronger sanctions on the company.

In logic-related business, we see signs of change in investment plans, centered on OSATs in China, from late May due to the stronger sanctions on Huawei. China's mid-tier and smaller OSAT firms continue to invest in tandem with the Chinese government's "Made in China 2025" plan. Chinese electronics makers and other companies are still holding onto their own assembly operations, albeit on a small scale, mainly for power semiconductors.

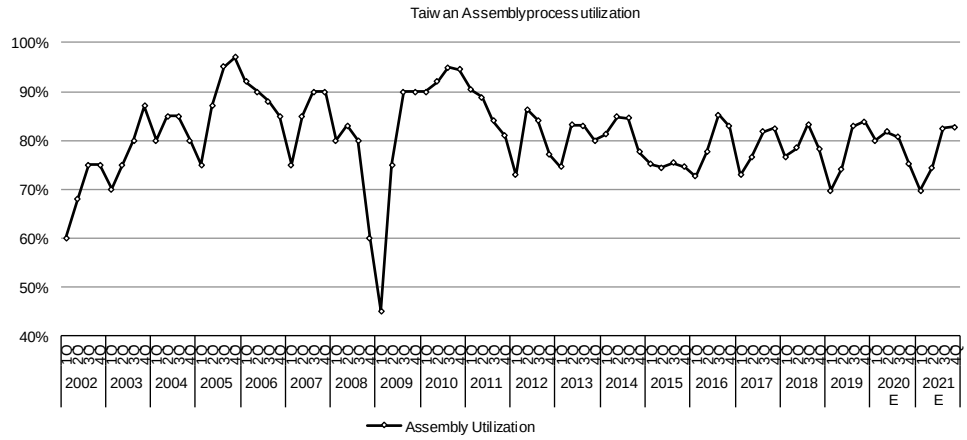
We were unable to find evidence that any new projects that would boost expectations over the next 1–2 years for the development of new package technology. Development is progressing on panel level packages (PLP) for use in PMICs, but the cost-benefit analysis does not look promising for the investment. We do not expect mass production to begin until 2H 2021 at the earliest. We have found evidence of favorable trends in the development of bump-less package technology for logic, CIS, and NAND applications, and we will periodically check back in on progress being made on this front as an exciting development for the next 3–4 years.

Market feedback

- COVID-19 restrictions on travel due in Malaysia and the Philippines have prompted memory makers to outsource their back-end processes to Taiwan and China. OSATs plan to invest in additional equipment for delivery around Jun–Oct.
- Investment in back-end processes at Chinese memory makers is continuing in stages, in both assembly and testing. At YMTC, testing-related demand appears to be outpacing production capacity due to poor testing efficiency.
- OSATs that anticipate receiving orders for assembly and testing processes from local Chinese DRAM maker CXMT are planning to invest in their assembly process in Jun–Jul. However, we understand these investment plans were pushed back to 3Q or later.
- Although inquiries about assembly equipment in China have been strong despite COVID-19, major OSATs started to cancel orders and request postponement of deliveries from late May. Meanwhile, mid-tier OSATs continue to invest.
- Malaysian back-end semiconductor processing plant returned to full capacity utilization in mid-May.
- Major Chinese electronics makers are accelerating investment in their in-house back-end production lines. Gree and Midea have already built assembly lines for power semiconductors. Konka also plans to build its own memory assembly line. BYD has been developing back-end power semiconductor processes, and plans to start mass production. Even at the mass production stage, it seems that investment in production lines is likely to be at a minimal level at most companies.
- Investment in assembly lines and testers for APs and PMICs is slowing.

- Operating rates at OSATs in China are around 60–70%. Export-related demand has declined since the end of 2019.
- ASE is preparing mass production for AiP (antenna-in-package) for the iPhone, and looks likely to ship a large volume of sample products in June. However, demand for new equipment is limited due to the reuse of existing equipment.
- Qualcomm plans to use PLP processes in PMICs for the Samsung mobile Galaxy series. Costs have not come down as much as expected, and the company continues to struggle with mass production. Mass production of PMICs using PLP looks likely to be pushed back to 2H 2021 at the earliest.

Figure 72: OSATs: Assembly capacity utilization forecasts



Source: Company data, Credit Suisse estimates

Other

Our view based on market survey

Of great concern was news that FA-related demand in China again lost momentum and orders started to be cancelled from late May. Given that Chinese data centers are making moves to reduce 2H memory procurement on concerns of a macro slowdown, we will be keeping a close eye on demand trends in areas such as capex.

Production of inverter air-conditioners, game consoles, TVs, and smart poles is relatively strong.

Chinese FA-related order cancellation a new concern

Market feedback

- We understand that order cancellations started emerging from late May for FA-related areas in China. We surmise that this is a reaction to the post COVID-19 production recovery, and that weakness in the real economy and concerns of soft external demand sparked reviews of capex plans.
- Demand for automotive semiconductors was down 20% in 2Q versus 1Q. It is declining every month and forecast to bottom out in May–Jun, so 3Q is likely to see a QoQ fall.
- In analog/discrete semiconductors, demand from server power supplies, telecommunications networks, and computers should offset the slump in automotive to some extent.
- Air-conditioner production: Demand slumped in 1H 2020, exports from China are at a standstill, and there are signs of excess inventory. Starting from July, China will only allow manufacture of products that meet new energy saving standards, prompting a recovery in demand for semiconductors used in inverter air-conditioners from Gree and Midea from June.
- Chinese automobile dealer inventories are not declining, and they appear to be discounting heavily.
- In game consoles, Nintendo forecasts production of 25mn Nintendo Switch units in 2020 and Sony plans for 7–7.5mn PS5 units (6mn in the survey three months ago). The volume of components procured will be larger, driving extremely strong component demand moving into 4Q.
- TV demand in Europe is solid.
- Hopes for the Chinese market in 2H 2020 center on smart poles, 5G, and installation in surveillance cameras and monitors, with installation at 200m intervals on highways and progress on installation for ordinary roads as well.

Companies Mentioned *(Price as of 10-Jun-2020)*

ASE Industrial Holdings (3711.TW, NT$68.0)
Advantest (6857.T, ¥6,070, UNDERPERFORM[V], TP ¥3,890)
Alibaba Group Holding Limited (BABA.N, $223.68)
Alibaba Group Holding Limited (9988.HK, HK$215.6)
Alphabet (GOOGL.OQ, $1464.7)
Amazon com Inc. (AMZN.OQ, $2647.45)
Anritsu (6754.T, ¥2,403, OUTPERFORM, TP ¥2,880)
Apple Inc (AAPL.OQ, $352.84)
BYD Co Ltd (1211.HK, HK$52.15)
BYD Co Ltd (002594.SZ, Rmb61.05)
ByteDance (Unlisted)
CXMT (Unlisted)
DISCO (6146.T, ¥26,730)
Facebook Inc. (FB.OQ, $236.73)
Ferrotec (6890.T, ¥785)
Gree Electric (000651.SZ, Rmb61.33)
HiSilicon (Unlisted)
HuaLi (Unlisted)
Huawei (Unlisted)
Inspur (0596.HK, HK$2.3)
Intel Corp. (INTC.OQ, $63.87)
JEOL (6951.T, ¥2,929)
JSR (4185.T, ¥2,018)
KONKA GROUP (000016.SZ, Rmb7.13)
Lam Research Corp. (LRCX.OQ, $301.3)
Lasertec (6920.T, ¥9,690)
Lenovo Group Ltd (0992.HK, HK$4.38)
MediaTek Inc. (2454.TW, NT$500.0)
Micron Technology Inc. (MU.OQ, $52.47)
Micronics Japan (6871.T, ¥1,120)
Microsoft (MSFT.OQ, $196.84)
Midea Group (000333.SZ, Rmb60.32)
NVIDIA Corporation (NVDA.OQ, $374.67)
Nintendo (7974.T, ¥45,340)
QUALCOMM Inc. (QCOM.OQ, $91.01)
SCREEN (7735.T, ¥5,490)
SK Hynix Inc. (000660.KS, W90,800)
SMIC (SMI.P^F19)
SMIC (SMI.P^F19)
SUMCO (3436.T, ¥1,683)
Samsung Electronics (005930.KS, W55,400)
Samsung Mobile (Unlisted)
Shin-Etsu Chemical (4063.T, ¥12,770)
Sony (6758.T, ¥7,496)
TOWA (6315.T, ¥1,244)
Taiwan Semiconductor Manufacturing (2330.TW, NT$322.5)
Tencent Holdings (0700.HK, HK$446.2)
Tokyo Electron (8035.T, ¥23,880)
Tokyo Ohka Kogyo (4186.T, ¥5,020)
Tokyo Seimitsu (7729.T, ¥3,745)
United Microelectronics (2303.TW, NT$16.6)
Xiaomi (1810.HK, HK$13.14)
Yangtze Memory Technology Corporation (Unlisted)
ZTE (0763.HK, HK$21.75)
ZTE (000063.SZ, Rmb38.54)

Disclosure Appendix

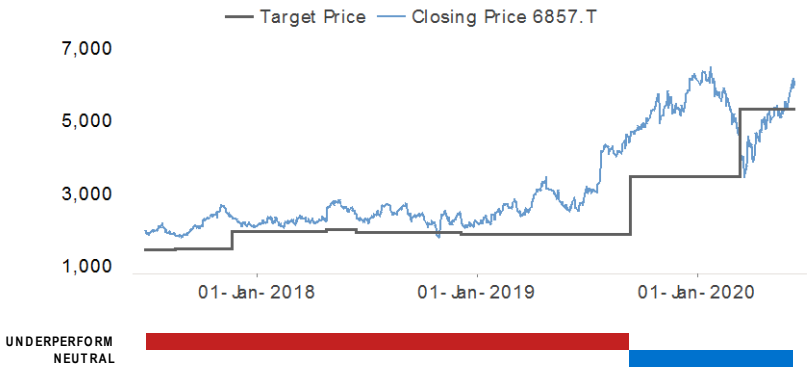
Analyst Certification

Hideyuki Maekawa, Akinori Kanemoto, Mika Nishimura, Yoshiyasu Takemura, Sayaka Shimonishi, Daisuke Tanimoto and Tailai Qiu each certify, with respect to the companies or securities that the individual analyzes, that (1) the views expressed in this report accurately reflect his or her personal views about all of the subject companies and securities and (2) no part of his or her compensation was, is or will be directly or indirectly related to the specific recommendations or views expressed in this report.

3-Year Price and Rating History for Advantest (6857.T)

6857.T	Closing Price	Target Price	
Date	(¥)	(¥)	Rating
29-Jun-17	1,964	1,440	U
18-Aug-17	1,840	1,470	
20-Nov-17	2,335	1,960	
25-Apr-18	2,249	2,010	
14-Jun-18	2,424	1,930	
05-Dec-18	2,300	1,860	
12-Sep-19	4,610	3,460	N
12-Mar-20	4,285	5,310	

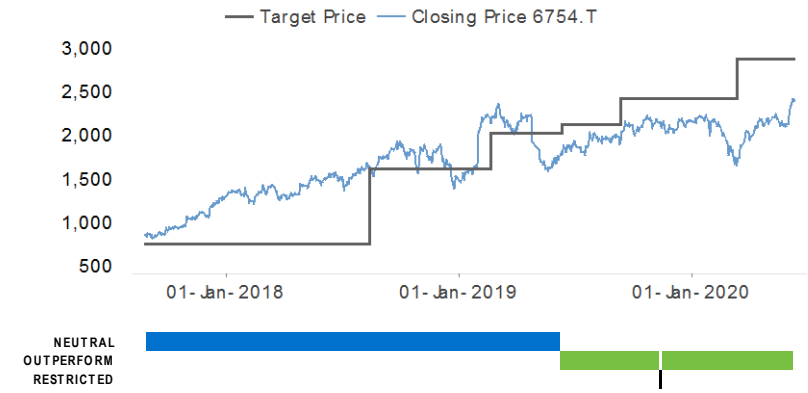
** Asterisk signifies initiation or assumption of coverage.*



3-Year Price and Rating History for Anritsu (6754.T)

6754.T	Closing Price	Target Price	
Date	(¥)	(¥)	Rating
28-Aug-17	852	750	N
15-Aug-18	1,619	1,620	
21-Feb-19	2,142	2,020	
12-Jun-19	1,781	2,120	O
12-Sep-19	1,950	2,420	
14-Nov-19	2,111		R
18-Nov-19	2,156	2,420	O
12-Mar-20	1,657	2,880	

** Asterisk signifies initiation or assumption of coverage.*



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Outperform (O) : The stock's total return is expected to outperform the relevant benchmark* over the next 12 months.

Neutral (N) : The stock's total return is expected to be in line with the relevant benchmark* over the next 12 months.

Underperform (U) : The stock's total return is expected to underperform the relevant benchmark* over the next 12 months.

**Relevant benchmark by region: As of 10th December 2012, Japanese ratings are based on a stock's total return relative to the analyst's coverage universe which consists of all companies covered by the analyst within the relevant sector, with Outperforms representing the most attractive, Neutrals the less attractive, and Underperforms the least attractive investment opportunities. As of 2nd October 2012, U.S. and Canadian as well as European (excluding Turkey) ratings are based on a stock's total return relative to the analyst's coverage universe which consists of all companies covered by the analyst within the relevant sector, with Outperforms representing the most attractive, Neutrals the less attractive, and Underperforms the least attractive investment opportunities. For Latin America, Turkey and Asia (excluding Japan and Australia), stock ratings are based on a stock's total return relative to the average total return of the relevant country or regional benchmark (India - S&P BSE Sensex Index); prior to 2nd October 2012 U.S. and Canadian ratings were based on (1) a stock's absolute total return potential to its current share price and (2) the relative attractiveness of a stock's total return potential within an analyst's coverage universe. For Australian and New Zealand stocks, the expected total return (ETR) calculation includes 12-month rolling dividend yield. An Outperform rating is assigned where an ETR is greater than or equal to 7.5%; Underperform where an ETR less than or equal to 5%. A Neutral may be assigned where the ETR is between -5% and 15%. The overlapping rating range allows analysts to assign a rating that puts ETR in the context of associated risks. Prior to 18 May 2015, ETR ranges for Outperform and Underperform ratings did not overlap with Neutral thresholds between 15% and 7.5%, which was in operation from 7 July 2011.*

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Market Weight : The analyst's expectation for the sector's fundamentals and/or valuation is neutral over the next 12 months.

Underweight : The analyst's expectation for the sector's fundamentals and/or valuation is cautious over the next 12 months.
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Rating	Versus universe (%)	Of which banking clients (%)
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Underperform/Sell*	12%	(23% banking clients)
Restricted	1%	

**For purposes of the NYSE and FINRA ratings distribution disclosure requirements, our stock ratings of Outperform, Neutral, and Underperform most closely correspond to Buy, Hold, and Sell, respectively; however, the meanings are not the same, as our stock ratings are determined on a relative basis. (Please refer to definitions above.) An investor's decision to buy or sell a security should be based on investment objectives, current holdings, and other individual factors.*

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Target Price and Rating
Valuation Methodology and Risks: (12 months) for Advantest (6857.T)

Method: We base our ¥3,890 target price for Advantest is based on end-FY3/22E BPS (¥1,496) and a P/B of 2.60x (TOPIX-relative P/B of 2.30x for the period above and current TOPIX P/B of 1.13x). We use the average P/B for the 12 months from September 2018, a period of memory price deterioration. We expect a revision to valuations and think now may be a good time to take profits. Our UNDERPERFORM rating is based on a comparison of the company's 12-month potential total return versus our coverage universe.

Risk: Risks to our ¥3,890 target price and UNDERPERFORM rating for Advantest include a recovery in Huawei smartphone production (approval of Qualcomm license), an upturn in memory prices, and continued large-scale SLT orders.

Target Price and Rating
Valuation Methodology and Risks: (12 months) for Anritsu (6754.T)

Method: Our ¥2,880 target price for Anritsu is based on our FY3/21 diluted EPS estimate of ¥115.57 and a fair P/E of 24.9x, referencing the stock's TOPIX-relative P/E of 1.78x over the past year of the 5G cycle and the current TOPIX P/E of 14.0x. Given the recent stock market turbulence, we see an opportunity to buy on weakness, particularly with the favorable 5G growth story. Our Outperform rating is based on a comparison of the company's 12-month potential total return versus our coverage universe.

Risk: Risks to our ¥2,880 target price and Outperform rating for Anritsu: upside catalysts include strong sales of 5G smartphone models launched this spring and quarterly test & measurement equipment orders staying above ¥20bn. Risks include Rohde & Schwarz moving into 5G or weak 5G smartphone demand.

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