12 March 2020
Equity Research
Asia Pacific | Japan

CREDIT SUISSE

Technology sector

Asia Feedback (semiconductor/SPE): Restocking-driven procurement out of sync with real demand: risk of 2H memory slowdown

Technology | Comment

- **Summary:** The COVID-19 outbreak prevented us making our usual visits to China, Korea and Taiwan, but we did conduct our periodical market survey from late February through early March. This did not reveal any particular change in semiconductor and electronic component demand due to COVID-19, but there has been evidence of a downturn in Huawei's smartphone NAND demand since the beginning of March. However, we believe hardware makers are moving to restock components in light of likely disruption to supply chains, including those of Chinese smartphones and of data centers. The stock market consensus is that investment by the US hyperscalers will recover, but we flag the existence of plans that indicate a slowdown in DRAM demand, with demand in 2H CY20 flat at the 1H level. In the near term, however, we expect server DRAM prices to rise 20–40% QoQ in 2Q, so we expect the consensus to remain bullish on data center-related stocks. Meanwhile, we noted restocking for memory demand in our previous December survey. We now see an even greater risk of a slowdown in memory demand in 2H, as weak underlying demand revealed by data center plans for 2H compound a demand pullback following data centers' and smartphone makers' memory restocking demand. The stock market expects memory capex to recover in 2H CY20 but, leaving aside the impact of COVID-19, we see no sign of new concrete investment plans.
- **Investment implications:** The outlook appears positive for the near term but negative over mid to long term. We expect the prices of both DRAM and NAND to rise in 2Q server DRAM makers to push through a steep 20–40% QoQ increase in their prices, so we think the memory market appears positive for the near term. However, procurement volume has diverged from the level of underlying demand for a wide range of semiconductors and electronic components, not just memory. While this entails a risk of adjustment, we expect share prices to gain support from rising memory prices and strong semiconductor and electronic component orders until the adjustment materializes. If expectations of post-readjustment demand and an end to the COVID-19 epidemic increase, we think attention is likely to refocus on 5G-related stocks (Advantest (6857), Anritsu (6754), Lasertec (6920)) as safe plays. We remain cautious on Japanese SPE stocks. A sharp rise in server DRAM prices in 2Q would inflate expectations of further memory investment, but consideration of new memory-related investment in 2H has in fact not started at all, which signals a transition to a downswing in the share price cycle, in our view.
- **Newly confirmed points in our survey:** Refer to pages 6–7.

Research Analysts

Hideyuki Maekawa
81 3 4550 9723
hideyuki.maekawa@credit-suisse.com

Akinori Kanemoto
81 3 4550 7363
akinori.kanemoto@credit-suisse.com

Mika Nishimura
81 3 4550 7369
mika.nishimura@credit-suisse.com

Yoshiyasu Takemura
81 3 4550 7358
yoshiyasu.takemura@credit-suisse.com

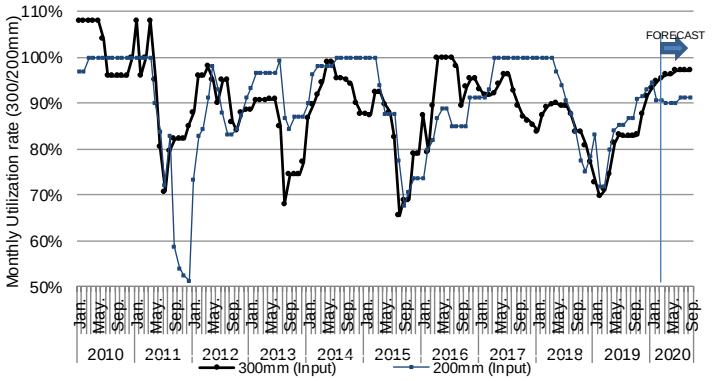
Sayaka Shimonishi
81 3 4550 7364
sayaka.shimonishi@credit-suisse.com

Daisuke Tanimoto
81 3 4550 7371
daisuke.tanimoto@credit-suisse.com

Tailai Qiu
81 3 4550 9984
tailai.qiu@credit-suisse.com

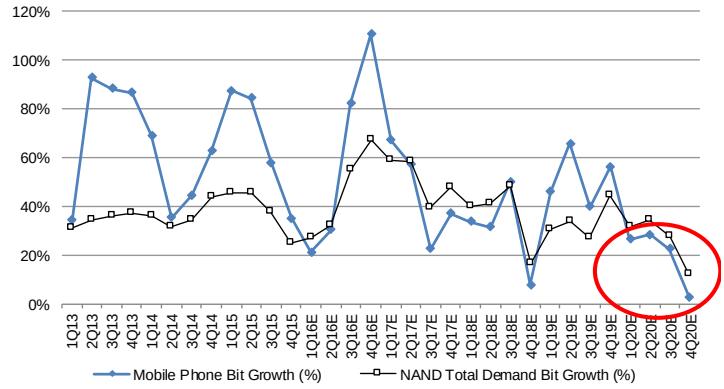
Key charts

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



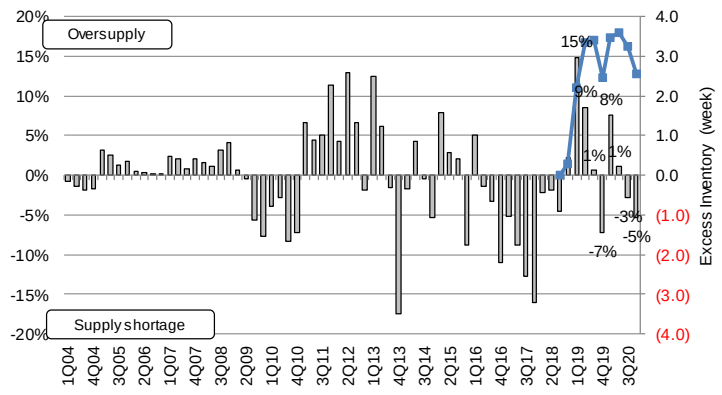
Source: Credit Suisse estimates

Figure 2: Potential growth in smartphone NAND capacity decreasing



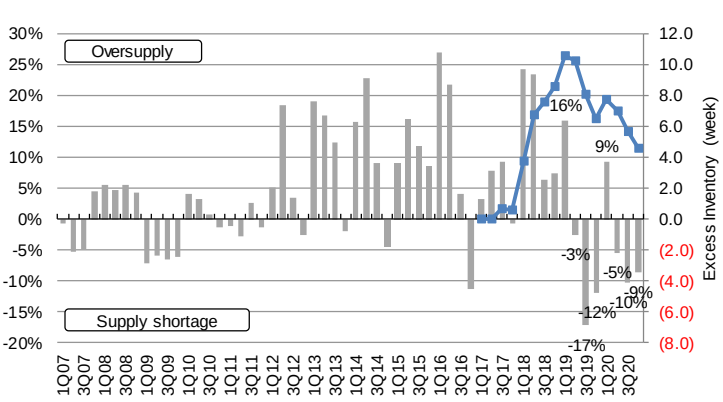
Source: IDC, Credit Suisse estimates

Figure 3: DRAM supply–demand model



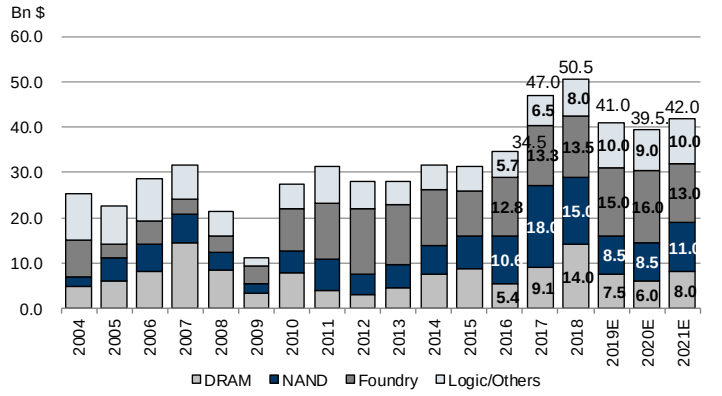
Source: Company data, Credit Suisse estimates

Figure 4: NAND supply–demand model



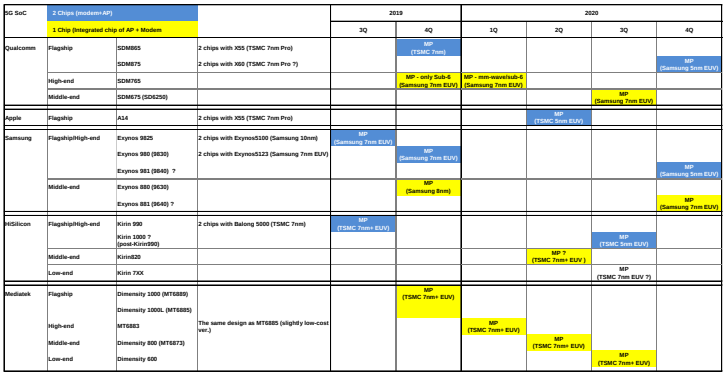
Source: Credit Suisse estimates

Figure 5: WFE capex forecasts (Japan team estimates)



Source: Credit Suisse estimates

Figure 6: Development roadmap – 5G SoC single-chip



Source: SEMI, Credit Suisse estimates

每日免费获取报告

1. 每日微信群内分享7+最新重磅报告；
2. 定期分享华尔街日报、金融时报、经济学人；
3. 和群成员切磋交流，对接优质合作资源；
4. 累计解锁8万+行业报告/案例，7000+工具/模板

申明：行业报告均为公开版，权利归原作者所有，小编整理自互联网，仅分发做内部学习。

手机用户建议先截屏本页，微信扫一扫

或搜索公众号“尖峰报告”

回复<进群>，加入每日报告分享微信群

限时领取“2020行业资料大礼包”，**关注即可获取**

Table of Contents

Key charts 2

Executive summary 5

Semi procurement ahead of underlying demand, risk of correction from 2Q; US data center investment skewed to 1H CY20; no plans for 2H memory investment recovery 5

Investment summary: Risk of demand shortfall despite positives (incl. higher memory prices through 2Q); like 5G-related post-correction; still cautious on SPE 8

Valuation tables 10

Logic/foundry trends 13

Our views based on survey feedback 13

Semiconductor fab capacity utilization 13

5G smartphone trends 18

Our view based on our survey 18

Chipset uptake 18

Mediatek's adoption likely at Samsung Mobile 18

5G chipset development 20

Chipset costs still an issue 20

Others 21

CIS market and production trends 22

Our views based on survey feedback 22

DRAM market trends 25

Our view based on our survey 25

DRAM market outlook 25

DRAM demand outlook 27

DRAM supply outlook 30

DRAM inventory trends 31

DRAM price trends 31

DDR5 uptake 35

HBM2 trends 36

NAND market outlook 38

Our view based on our survey 38

NAND pricing trends 38

NAND demand trends 39

NAND supply outlook 46

NAND inventory trends 46

NAND pricing outlook 47

3D NAND 9X/1XX mass production and development....50
Opportunity for Kioxia to take a lead in cost and mass production in 1XX-layer development51

Front-end SPE market 53

Our view based on channel checks....53
Specific investment projects concentrated in China....54
Cutting-edge memory investment for 1znm DRAM, 3D NAND 1XX layers (112/128-layer); delays due to cost factors....54
Foundry investment could boost 5nm capacity in 2021....55
WFE market forecast....55

Back-end SPE market outlook 57

Our view based on our survey....57

Other 59

Our view based on market survey....59
COVID-19 impacts....59
Automotive, industrial, consumer (air-conditioners)....60
Gaming consoles....60
Displays....60

Executive summary

Semi procurement ahead of underlying demand, risk of correction from 2Q; US data center investment skewed to 1H CY20; no plans for 2H memory investment recovery

Smartphone makers cutting 5G smartphone output plans to realistic levels

Hardware production trends are as stated in our Asia Feedback (Hardware) report issued simultaneously with this report. For the smartphone market, we lower our volume outlook to reflect sluggish demand for LTE models. We understand that 5G smartphone production plans have been lowered from 470–480mn units to 380mn units. Volume outlook at semiconductor and component makers is likely to be 295mn units.

Semiconductors & component orders apparently brought forward due to Covid-19. Risk of downward adjustment in sourcing volume, given it exceeds real demand

We believe that the impact of the COVID-19 outbreak is currently inflating, rather than undermining, semiconductor demand, as (1) there is no sign that OEM customers are reducing their forecasts or procurement in the face of low semiconductor capacity utilization, driven by weak underlying demand and the inability of plant workers to return to work, and (2) we are seeing the beginnings of some front-loading of procurement in anticipation of disruption to the supply chain. That said, there are still signs of weakness, including demand from automotive, industrial and consumer appliances (excluding inverter air-conditioning systems) customers remaining low key and Huawei adjusting its demand for smartphone NAND. We believe that downside risk is likely to outweigh upside risk in the semiconductor supply chain once the full impact of COVID-19 on the supply chain becomes visible, including the risk of adjustment to excess inventory and a reduction in semiconductor demand in the face of weak underlying demand for smartphones and other end products.

Taiwan foundry 300mm wafer capacity utilization remains high; 5G chipset demand plans lowered 11%, but lower game demand offset by HPC demand

With regard to semiconductor output, Taiwanese foundry capacity utilization remains above 90%, with full capacity utilization for the cutting-edge 7nm process. Demand from 5G smartphone AP (application processors), games and HPC (high-performance computing) makers is compensating for 4G smartphone AP inventory adjustment and a seasonal downturn in iPhone production. However, capacity utilization for 200mm and other older processes has fallen as a result of a COVID-19-driven downturn in automotive, industrial, and consumer appliance sector demand. HiSilicon and Samsung LSI have lowered their 5G chipset production schedules for 2020 (we were unable to confirm Qualcomm's and Mediatek's current plans). Although planned 5G chipset production has now been reduced from 520mn to 465mn units, this is having no adverse impact on capacity utilization, as supply–demand for the 300mm cutting-edge process remains tight.

Restocking demand for almost all memory applications; large gap between actual demand and sourcing volume for smartphones; sharp rise in data-center DRAM prices

In memory, overall there is DRAM and NAND restocking demand from Chinese smartphone makers, data centers and PC OEMs. Data center server DRAM demand, in particular, appears to be prioritizing volume over price. However, despite the apparently solid recovery in the DRAM/NAND market, we see a growing risk of future adjustment signaled by a particularly marked gap between purchasing and underlying demand among smartphone customers, the fact that the US hyperscalers' demand forecasts are skewed to 1H, and signs of a decline in storage capacity due to the severe impact of higher cSSD prices on BOM (bill of materials) cost. Nevertheless, memory prices continue to rise, with server DRAM prices expected to increase 20-40% in 2Q, and we see no risk of any significant downturn in the DRAM market through 2Q. That said, the market is likely to drop sharply once customers have finished restocking. In this eventuality, the key question is whether memory makers can weather the storm by building up their own inventories in order to control supply.

No new memory-maker SPE investment plans

In front-end SPE investment, COVID-19 is beginning to hinder new production capacity expansion and the start-up of facilities for process migration in China, as global SPE makers have pulled out their start-up engineers and local engineers are unable to handle this work alone. This also makes it likely that it will take time to resolve any equipment failures, which could result in a decline in capacity utilization. We are aware of no new capex plans and expect investment to be limited to cutting-edge process development lines, such as pilot lines for

Samsung's DRAM 1znm process and TSMC's 3nm process. Even without the COVID-19 factor, there are no concrete enquiries for 2H investment by memory makers, making it increasingly likely that 2H memory investment will fall short of the market's expectations, in our view (in line with our estimates).

For back-end SPE investment, in China it appears that although investment and enquiries by OSAT (outsourced semiconductor assembly and test) service providers remain firm, enquiries from SMEs are slowing. Although some Taiwanese OSATs enjoyed a level of demand higher than the seasonal norm in 4Q CY19, this investment has already dropped out. In 2–3Q, we expect to see back-end SPE investment relating to the production capacity expansion TSMC implemented in 4Q CY19–1Q CY20. We think equipment demand relating to new technologies such as FO-PLP (fan-out panel-level packaging) and chip enlargement will be limited to development projects, and are aware of no projects to drive order growth. Overall, we expect to see nothing more than the seasonal bounce-back in equipment demand. With regard to DDR5 DRAM, while this has started to be used in flagship smartphone models, demand is weak, and we do not expect to see any related capex through the end of CY20.

Newly confirmed points in our survey

Positives include:

(1) Prospects for a 20–40% increase in server DRAM prices in 2Q.

(2) 300mm capacity utilization at Taiwanese foundries remains high, with no impact from COVID-19; cutting-edge processes, in particular, are running at full capacity.

(3) Apple will revert back to its normal, once-a-year iPhone model cycle in 2021 (in the previous survey we noted the possibility of a spring/summer release cycle).

(4) CMOS production is brisk. SK Hynix's 300mm wafer input set to reach 20K.

(5) Server DRAM emerges a supply bottleneck due to growing demand for data center applications.

(6) Demand up sharply for HBM2 at nVidia for voice recognition applications.

Negatives include:

(1) Deterioration in 200mm capacity utilization for automotive, industrial, and consumer applications due to the impact of COVID-19.

(2) 5G chipset production volume has been revised down (from 520mn to 465mn units).

(3) Huawei has lured away entire teams of image processing engineers from two major Japanese camera makers.

(4) Slowing demand for DRAM/NAND restocking from Chinese smartphone makers. Huawei cut its NAND demand outlook.

(5) US hyperscaler demand, which has been solid since 4Q FY/19 including for restocking, slumped to flat growth in 2H.

(6) Server makers are reluctant to adopt Intel's new Cooper Lake CPU (mass production in 3Q 2020).

(7) DDR5 to fails to gain traction in the smartphone market, as its adoption is limited to some flagship models.

(8) In NAND, PC makers are considering shifting to HDDs and low-capacity cSSDs due to rising PC BOM costs; smartphone makers are cutting NAND density on 5G smartphones due to higher BOM costs.

(9) NAND inventory excessive in downstream supply chain.

(10) Due to the impact of COVID-19, equipment installation plans have been pushed back for Samsung Electronics' Xian Fab2, SMIC/HuaLi, and CXMT.

(11) DRAM 1xnm and 3D NAND 1XX-layer development and sample shipments have been delayed.

(12) Delivery times and air freight costs tracking at 4x usual.

Investment summary: Risk of demand shortfall despite positives (incl. higher memory prices through 2Q); like 5G-related post-correction; still cautious on SPE

Implications for semiconductor-related, network equipment-related plays

Outlook for 5G-related names still reassuring
Bullish on memory market in near term, cautious over medium term

An apparent 11% reduction in Chinese 5G smartphone production plans has had no notable impact on capacity utilization, as cutting-edge process production is operating at full capacity. However, because investors had not necessarily taken the previous production targets on board as their consensus view, we continue to think 5G-related orders at Advantest and Anritsu—both of which correlate closely with chipset and smartphone production volume—are likely to exceed consensus expectations in 1H CY20.

For memory, the gap between strong restocking demand and underlying demand is giving rise to fears of excess inventory, but memory prices—seen as a key lead indicator by the stock market—rose rapidly for both DRAM and NAND in 1Q and continue to do so in 2Q. For server DRAM, in particular, the pace of price increase has risen to 20–40% in 2Q from 10% in 1Q, although the pace of NAND price rise has slowed. Thus, the data support a further rise in stock market expectations especially for memory-related plays through 2Q. However, we expect the pace of growth in DRAM demand at the US hyperscalers to peak in 1Q, with demand remaining flat on the 1Q level in 2Q. This adds another negative to the outlook for the 2H CY20 market on top of the likelihood of post-restocking inventory adjustment.

Semiconductor materials: Growing risk of customer production cuts, but utilization still high at advanced nodes

Downward revisions to smartphone makers' CY20 production schedules are raising concern over capacity utilization adjustments for 300mm wafers, but production remains at full capacity at advanced nodes. We now expect Taiwanese foundries' 300mm lines to operate at 95% of capacity in 1Q CY20 (previously 89%) and 94% in 2Q. This implies that 1Q demand for 300mm wafers will be 40k sheets higher than we anticipated (equating to around 0.8% of total 300mm shipments). We meanwhile perceive no change in memory makers' investment stance since we last reported. Memory makers have refrained from increasing wafer input despite robust restocking demand from Chinese smartphone makers and hyperscalers, indicating that they continue to adjust wafer inventory. We accordingly expect 300mm wafer demand to remain driven by logic and foundries in CY20, with memory-related demand weak.
In smaller-diameter wafers, chipmakers have confirmed lower capacity utilization for ≤200mm, raising risk of price declines for lower-tier makers with little coverage from long-term supply agreements.

We also expect the technological complexity of 9x/1xx-layer (112/128-layer) 3D NAND to slow their adoption to a 1.5–2-year cycle from the one-year cycle needed for 64-layer chips and accordingly see little possibility of development spurring an acceleration in capex. We think this could keep demand for KrF resist for use in thick-film processes short of what Tokyo Ohka Kogyo (4186) expects.

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

Implications for SPE-related plays: No new concrete memory investment plans on the horizon for 2H CY20

Prospects for recovery in memory-maker investment likely to fade soon

Looking at the SPE sector in isolation from the macroeconomic impact of COVID-19, we think share prices will gain support from ongoing expectation of recovery in memory investment driven by continued rise in memory prices in 2Q. However, we have no confirmation that there are any new memory investment plans under negotiation, and sense that memory makers are skeptical about the sustainability of the current market recovery and remain cautious about capex given the low ROI for cutting-edge processes. Capex orders relating to DDR5 SDRAM was a key theme in 2Q CY19 (Oct–Dec), but this capex is already slowing and the next investment cycle is not likely to start until the latter half of CY20.

Foundry investment in CY20 is likely to be limited to development lines for cutting-edge processes. A change in our view from the time of the previous December survey is that we now only anticipate a single new iPhone product cycle in CY21 (three months ago we forecast two annual cycles), leading us to believe TSMC could invest in 5nm process capacity expansion only if it wins new customers.

For back-end SPEs, COVID-19 does not appear to be diminishing the appetite for investment within China, but a slowdown in enquiries from SMEs is something of a concern. The lack of fully embodied technology investment projects offers nothing much to support share prices.

Our short-term order of preference among major SPE stocks over the coming three months or so is: Advantest (potential catalyst: 5G, DRAM price rise) > Tokyo Electron (DRAM price rise) > Disco (DRAM price rise, capacity utilization adjustment) > SCREEN (TSMC 3nm process investment). In December, our order of preference was Advantest > Disco > Tokyo Electron > SCREEN. On a longer-term view, however, we remain cautious, as we expect the complexity of cutting-edge process technology and slowing DRAM/NAND bit growth, and the prioritization of earnings recovery among DRAM makers to suppress memory capex.

Our order of preference for small & mid-cap SPE names is JEOL (6951)/Tokyo Seimitsu (7729)> Lasertec > TOWA (6315)> Micronics Japan (6871)> Ferrotec (6890) (previously JEOL > Lasertec > TOWA > Tokyo Seimitsu > NuFlare Technology > Micronics Japan > Ferrotec). Additional investment in 5nm processes by TSMC would be positive for JEOL and Lasertec. We also see a possibility of additional orders for Lasertec's EUV mask inspection systems (non-pellicle ULTRA), as EUV pellicles are not expected to be ready for mass production during CY20 and EV process yields are showing little improvement.

Valuation tables

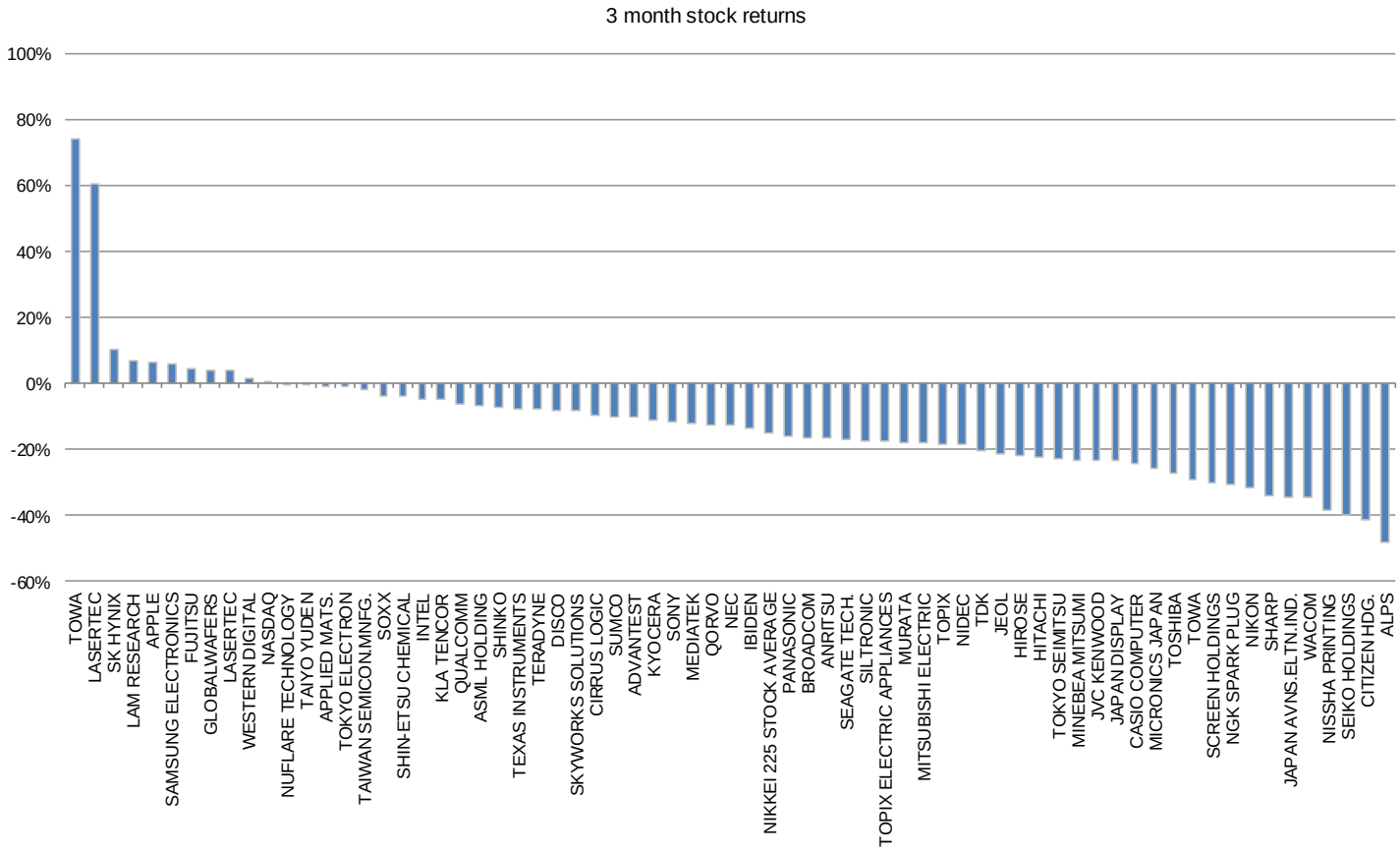
Figure 7: Semiconductor/SPE valuations

Closing Price: 03/11/20

Company	Code	Rating	Mkt Cap	Price			EPS						Dvd Yld	ROE	PBR	EV / Sales	EV / EBITDA	Net D/E	Absolute performance %			Relative performance %		
				Cur	TP	% to TP	CS EPS			P/E, x														
			JPY, bn	JPY	JPY	%	3/19 A	3/20 E1	3/21 E2	3/19 A	3/20 E1	3/21 E2	3/20 %	3/20 %	3/20 x	3/20 x	3/20 x	3/20 %	1M	3M	12M	1M	3M	12M
IEC																								
Hitachi	6501	RESTRICTED	3,143	3,253			230.5	478.3	506.2	6.9	6.8	6.4	3.1	12.1	0.8	0.3	2.4	-0.1	-23.6	-22.4	-6.2	-4.2	-3.2	7.6
Toshiba	6502	NEUTRAL	1,191	2,626	3,150	20.0	1641.9	182.6	176.5	1.9	14.4	14.9	0.0	6.0	0.8	0.2	3.9	-49.5	-28.5	-29.0	-26.4	-9.1	-9.9	-12.7
Mitsubishi Electric	6503	OUTPERFORM	2,685	1,252	2,310	84.6	105.7	129.1		12.7	9.7		2.8	9.1	1.1	0.4	4.2	-21.9	-22.2	-17.5	-8.3	-2.8	1.6	5.4
NEC	6701	OUTPERFORM	992	3,820	4,700	23.0	154.8	308.0	365.8	12.4	12.4	10.4	2.4	9.9	1.0	0.4	4.8	10.6	-22.8	-15.4	-1.2	-3.4	3.7	12.6
Fujitsu	6702	UNDERPERFORM	2,047	10,220	9,340	-8.6	512.5	760.4		13.8	13.4		1.6	11.1	1.6	0.5	5.3	-17.6	-19.0	1.0	33.2	0.5	20.1	47.0
Semiconductor																								
Renesas	6723	OUTPERFORM	872	510	1,290	152.9	30.6	55.4	63.1	16.4	9.2	8.1	0.0	13.9	1.2	1.6	5.8	78.1	-29.6	-31.7	-12.5	-10.1	-12.6	1.2
Network Equipment																								
Anritsu	6754	OUTPERFORM	233	1,693	2,880	70.1	65.2	88.0	115.7	19.2	19.2	14.6	2.1	16.0	2.2	1.6	8.2	-31.8	-19.5	-22.1	-23.3	-0.0	-3.0	-9.6
SPE																								
Tokyo Electron	8035	NEUTRAL	3,250	20,835	19,630	-5.8	1513.6	1101.8	1053.9	10.6	18.9	19.8	2.6	20.4	4.0	2.7	11.3	-36.6	-14.3	-11.4	39.3	5.1	7.7	53.0
SCREEN Holdings	7735	NEUTRAL	225	4,815	5,360	11.3	387.1	162.9	387.9	11.5	29.6	12.4	1.0	4.2	1.2	0.8	12.4	12.6	-24.8	-36.5	9.6	-5.3	-17.3	23.3
Disco	6146	NEUTRAL	740	20,580	22,340	8.6	802.4	656.8	648.5	19.7	31.3	31.7	2.3	10.6	3.3	4.9	17.1	-40.1	-21.5	-16.7	38.8	-2.1	2.5	52.5
Advantest	6857	NEUTRAL	897	4,520	5,310	17.5	302.3	227.1	212.5	8.5	19.9	21.3	1.5	21.0	3.9	2.7	11.8	-74.9	-18.7	-18.3	80.4	0.7	0.9	94.1
JEOL	6951	NEUTRAL	114	2,337	3,000	28.4	123.0	117.2	127.2	19.9	19.9	18.4	0.9	12.9	2.2	1.0	11.8	17.5	-34.9	-25.0	22.7	-15.4	-5.8	36.5
Lasertec	6920	NEUTRAL	437	4,630	4,500	-2.8	65.8	157.4	162.0	32.4	29.4	28.6	1.2	39.8	10.4	8.0	20.4	-41.3	-17.3	-5.1	113.9	2.1	14.0	127.6
TOWA	6315	NEUTRAL	19	742	750	1.1	35.1	39.6	63.6	19.2	18.8	11.7	2.2	3.5	0.7	0.8	10.3	5.0	-35.4	-36.3	8.3	-16.0	-17.1	22.0
Micronics Japan	6871	UNDERPERFORM	30	762	690	-9.4	23.0	56.1	66.4	13.6	13.6	11.5	0.0	9.9	1.1	0.6	4.3	-38.9	-40.1	-32.0	2.8	-20.6	-12.8	16.6
Tokyo Seimitsu	7729	NEUTRAL	123	2,946	3,440	16.8	352.9	222.5	252.5	8.0	13.2	11.7	2.6	8.5	1.1	0.9	5.2	-37.7	-25.5	-28.3	8.0	-6.1	-9.2	21.7

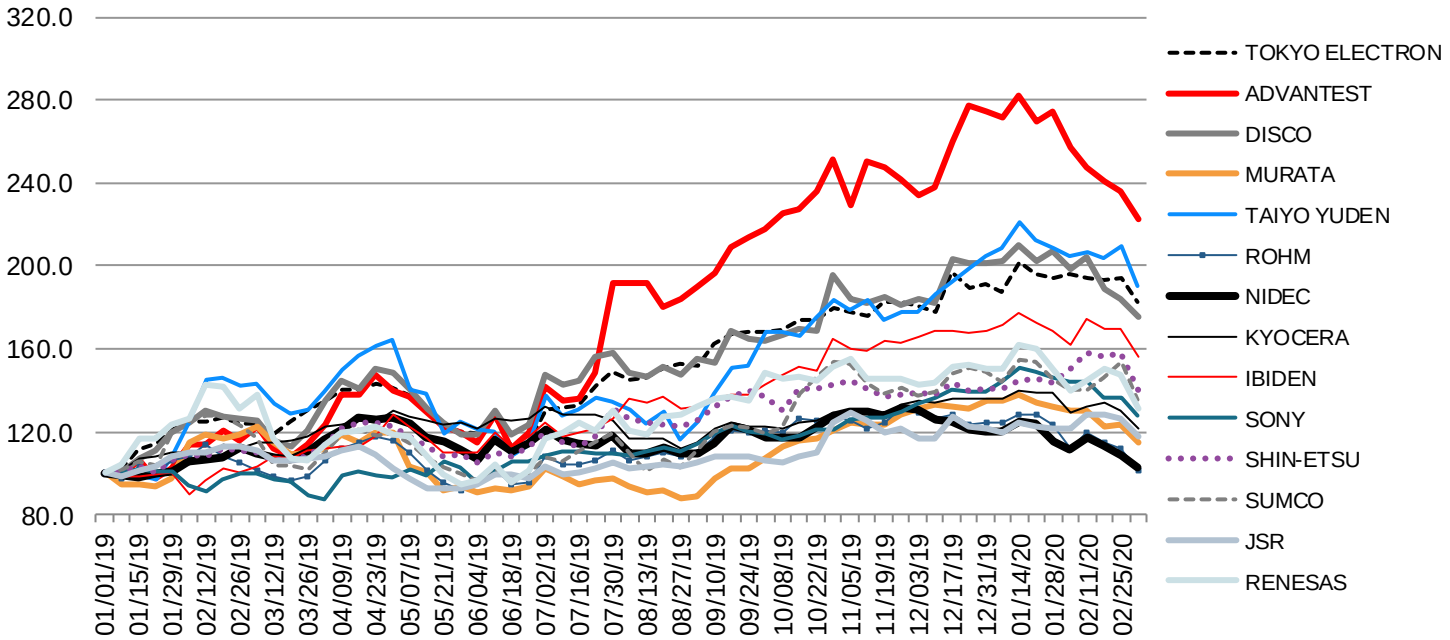
Source: Thomson Reuters Datastream, Credit Suisse estimates

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



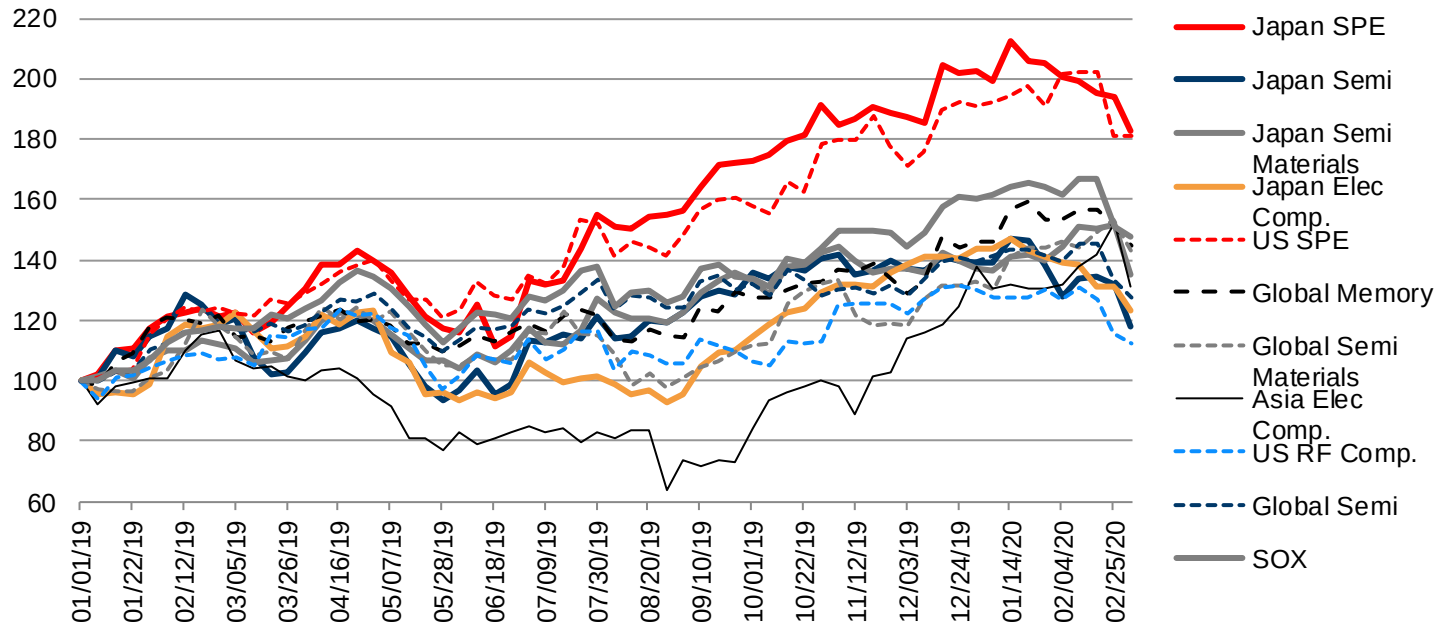
Source: Thomson Reuters Datastream, Credit Suisse

Figure 9: Japanese technology stocks' YTD performance



Source: Thomson Reuters Datastream, Credit Suisse

Figure 10: Global/Japanese technology stocks' YTD market value performance by sub-sector



Source: Thomson Reuters 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	3.1	2.8	13.0	10.8	19.0	15.6	4.0	3.5	21.0%	22.5%	53.0%	-0.9%	-9.4%
	Advantest	3.4	3.1	14.6	12.8	19.4	16.8	4.0	3.5	20.6%	20.6%	89.3%	-10.3%	-13.9%
	SCREEN	1.0	1.0	13.0	8.1	18.5	9.9	1.2	1.1	6.5%	10.9%	17.9%	-30.3%	-19.8%
	Disco	5.7	5.0	19.3	15.0	29.5	23.1	3.2	3.0	10.9%	13.0%	49.1%	-8.1%	-17.9%
Japan Semi	Renesas	2.4	2.3	9.0	8.6	21.7	14.3	1.3	1.2	6.0%	8.3%	-10.2%	-25.0%	-25.6%
	Rohm	1.7	1.6	8.0	6.7	26.4	18.6	0.9	0.9	3.4%	4.6%	-2.6%	-25.5%	-20.8%
Japan Semi Materials	SUMCO	1.9	1.8	6.6	5.7	14.6	11.5	1.4	1.3	9.3%	11.1%	23.4%	-10.0%	-11.1%
	Shin-Etsu Chemical	2.6	2.6	7.5	7.0	14.3	13.7	1.7	1.6	11.8%	11.4%	26.5%	-4.0%	-16.4%
	JSR	1.0	0.9	7.3	6.5	14.0	12.1	0.9	0.9	6.5%	7.2%	2.6%	-8.6%	-16.4%
	Tokyo Ohka Kogyo	1.6	1.5	9.4	8.4	19.1	16.2	1.0	1.0	5.3%	6.1%	21.8%	-8.2%	-19.6%
Japan Elec. Comp.	Murata manufacturing	2.3	2.1	9.3	7.9	19.0	15.8	2.0	1.8	10.5%	11.6%	-7.2%	-17.9%	-16.1%
	TDK	1.1	1.0	5.8	5.1	13.7	11.4	1.3	1.2	9.3%	10.3%	10.0%	-20.3%	-17.3%
	Taiyo Uden	1.6	1.5	6.8	5.9	14.1	11.9	1.6	1.4	11.3%	12.0%	40.6%	-0.7%	-10.3%
US SPE	Applied Materials	3.4	3.2	12.1	11.1	12.6	11.1	4.8	4.0	38.5%	36.0%	48.8%	-0.8%	-10.7%
	Lam Research	4.2	3.7	14.5	12.4	16.7	13.6	8.9	7.3	53.3%	54.0%	70.3%	6.9%	-10.1%
	KLA	4.8	4.6	12.4	11.7	14.1	12.8	8.0	6.7	56.6%	52.8%	35.6%	-4.8%	-8.5%
Global Memory	Samsung	1.0	0.9	3.9	3.3	11.7	8.6	1.3	1.1	10.9%	13.3%	24.7%	6.0%	-8.5%
	SK Hynix	2.1	1.6	4.3	2.9	12.2	5.9	1.2	1.0	9.5%	16.7%	33.6%	10.4%	-9.8%
	Micron Technology	2.9	2.4	7.4	5.0	18.8	7.8	1.3	1.1	6.9%	14.4%	23.8%	0.8%	-16.5%
Global Semi Materials	Siltronic	1.9	1.8	6.1	5.3	10.9	9.1	1.8	1.5	16.2%	16.8%	-16.6%	-17.3%	-28.0%
	GlobalWafers	2.4	2.4	6.2	6.2	11.7	12.2	3.6	3.4	30.9%	28.3%	21.9%	4.1%	-8.6%
	Waferworks					12.2	11.6	1.7	1.7	14.3%	14.3%	-11.3%	-7.6%	4.6%
Asian Elec. Comp.	Yageo	3.5	2.6	11.9	9.3	17.7	12.0	3.0	2.6	16.9%	22.0%	17.2%	7.2%	-5.7%
	SEMCO	1.2	1.1	6.4	5.7	16.6	13.2	1.6	1.5	9.8%	11.0%	29.0%	8.9%	-3.4%
US RF	Qorvo	3.6	3.4	10.4	10.3	14.7	13.6	2.5	2.3	16.8%	17.0%	40.0%	-12.6%	-8.9%
	Skyworks	5.1	4.5	11.9	10.0	14.3	11.8	3.5	3.1	24.4%	26.2%	19.5%	-8.2%	-17.6%
	Broadcom	5.9	5.6	10.9	10.6	10.7	9.7	4.7	3.8	44.1%	39.0%	-0.5%	-16.6%	-16.3%
Global Semi	Texas Instruments	7.9	7.4	17.1	15.4	21.0	18.5	12.3	12.5	58.8%	67.5%	6.9%	-7.6%	-13.5%
	STMicroelectronics	2.3	2.2	9.9	8.5	14.5	11.7	2.3	2.0	16.1%	17.3%	51.6%	-9.7%	-23.4%
	NXP semiconductors	4.2	3.9	12.2	10.7	12.6	10.6	3.1	3.1	24.5%	29.3%	14.7%	-10.3%	-19.8%
	Infineon	2.7	2.5	10.0	8.7	18.6	16.0	2.0	1.9	10.8%	11.6%	-13.2%	-16.8%	-23.8%
	ADI	8.4	7.7	19.1	16.8	19.9	16.6	3.0	2.8	15.0%	16.6%	-2.8%	-10.5%	-9.3%
Index	SOX											25.7%	-3.7%	-12.5%

As of 2020/3/11

Source: Thomson Reuters Datastream, Credit Suisse

Logic/foundry trends

Our views based on survey feedback

As of the first week of March, major semiconductor production adjustments have not occurred due to COVID-19 or weak demand for Chinese smartphones. However, some Taiwanese foundries have started to see changes in their capacity utilization for 150mm wafers associated with industrial, consumer electronics, and automotive applications, with a 10ppt reduction in capacity utilization since February. We think this could impact 300mm wafer capacity utilization as smartphone makers revise down their production plans for 2020.

Smartphone makers have lowered their production plans for 5G smartphones (from 470–480mn units at the time of our December survey to 380mn units on a bottom-up basis). Consequently, HiSilicon and Samsung LSI—the only 5G chipset vendors whose production plans we have been able to confirm—have dropped their production by 11% (from 520mn to 465mn units). At this level, there is still disparity between 5G chipset and smartphone production, but this is not particularly worrying given that there is usually a gap of around 15–20% due to the existence of inventory and production lead times.

Heading into 2H, however, we expect cutting-edge processes (5nm, 7nm) to remain at full capacity ahead of new product cycles in 5G chipsets, APs (A14) for 2020 iPhone models, AMD processors for the PlayStation 5, and NVidia GPU, where demand is growing for voice recognition applications.

Capacity utilization at Samsung Electronics' CIS lines had fallen by 20–30ppt in 4Q 2019 due to production bottlenecks for CIS stacked with logic, but CIS production has now returned to full capacity thanks to the outsourcing of logic production.

We see no major changes overall, but the growing risk of 300mm capacity utilization adjustments is a concern.

Semiconductor fab capacity utilization

Market feedback

- Capacity utilization rates at Taiwanese foundries are still high, as the impact of COVID-19 has yet to be felt. By 300mm process category, 90/65nm process capacity is relatively low due to weak demand related to home appliances and industrial applications, but other lines are running at full capacity (e.g., 40/28/16/7nm).
- Capacity utilization for 200mm wafers is close to 100% due to stronger demand for 5G PMICs and wireless charger-related demand from Apple and Huawei. However, capacity utilization (input basis) for 200mm wafer lines that have not tapped into this demand has deteriorated by 10ppt since February due to the impact of COVID-19.
- Samsung Electronics' 300mm wafer lines are operating at full capacity. This is an improvement from conditions three months ago, when the company was unable to produce CIS (i.e., bottlenecks in production capacity for CIS stacked with logic).
- Capacity utilization in the assembly process is down 20–30% due to resource shortages as a result of COVID-19, so wafers are backing up after finishing front-end processing. As a result, HiSilicon and MediaTek have apparently started to talk about front-end production adjustments (final decisions pending).

Slump in Chinese smartphone demand yet to have an impact

We forecast Taiwanese foundries' capacity utilization (input basis) for 300mm wafers will be around 88% in 4Q and 95% in 1Q 2020, and for 200mm wafers to be 92% in 4Q, and 92%

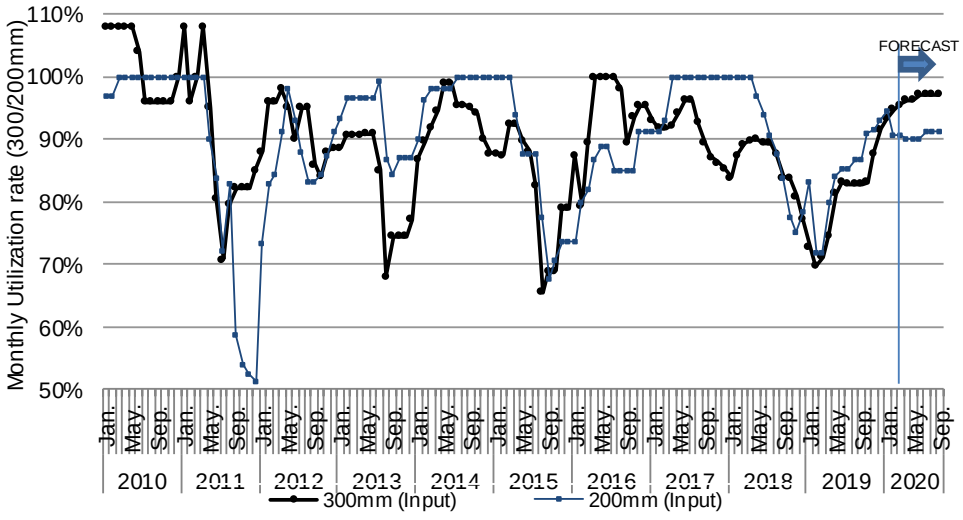
in 1Q 2020. In 2Q, we expect a temporary adjustment on processes older than 16nm, with capacity utilization of 94% for 300mm wafers and 90% for 200mm wafers, due to inventory corrections for LTE smartphones in China and a general slump in demand due to COVID-19. We expect 300mm wafers to remain at full capacity utilization on 5nm and 7nm+ processes as production ramps up for 5G chipsets. In addition, AMD processors for the Sony PlayStation 5 should have a noticeable impact on TSMC's overall 7nm process production capacity of 110–120K wafers because input will expand to 15K wafers per month at its peak.

Cutting-edge foundry processes likely to run at full tilt even amid smartphones-related adjustments

Looking at utilization rates by process, utilization remains at full capacity for 16nm processes, and we see risks emerging for capacity utilization going forward as 16/12nm processes shift to the 7nm process, but without a shift from 28/22nm processes to the 16nm process. Production of PMICs and WiFi6-related chips is brisk on the 28nm process, and since the personnel volume of PMICs used in 5G smartphones is double that of current models, more may be produced on 200mm lines. We think the 40nm process has also been running at full capacity, including CIS stacked with LSIs and OLED driver ICs.

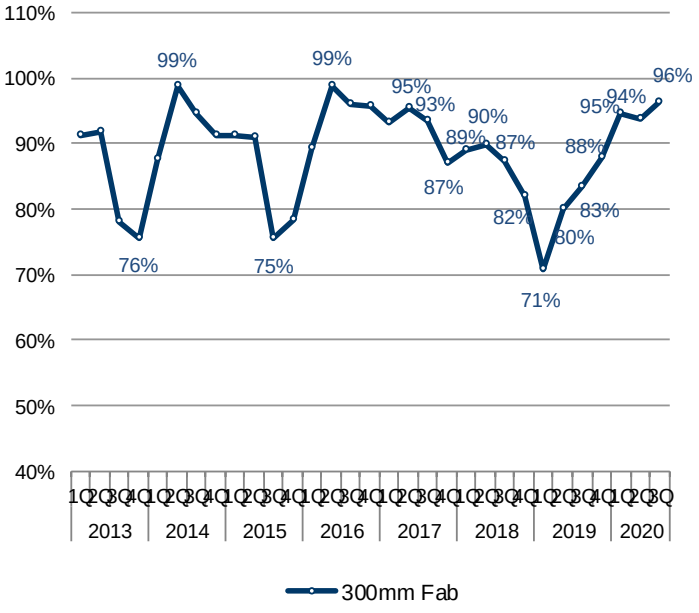
We have also heard that capacity utilization at OSATs has failed to recover after the Lunar New Year, and that wafer inventories have bloated after the front-end processing stage. However, we see no particular cause for concern, as we expect capacity utilization to return to levels prior to the Chinese New Year in April.

Figure 12: Projected capacity utilization for Taiwanese foundry 300mm/200mm lines (input basis)



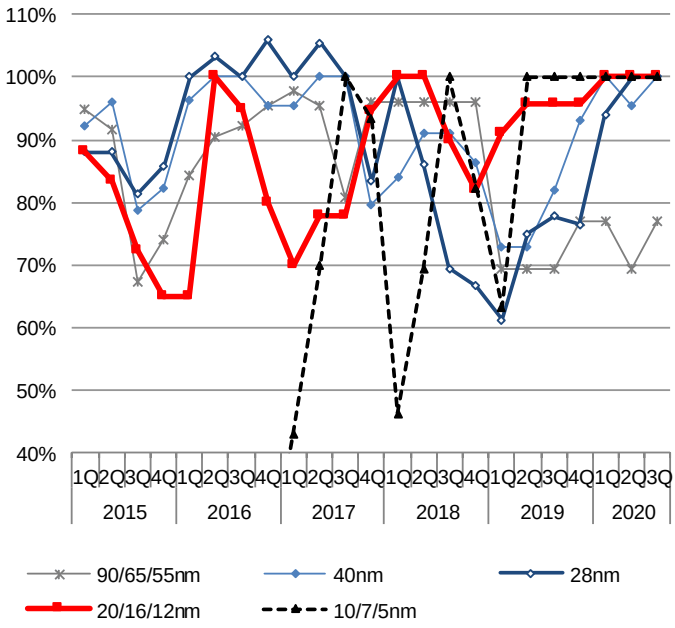
Source: Credit Suisse estimates

Figure 13: Projected quarterly utilization rates for major Taiwanese foundry 300mm lines (input basis)



Source: Credit Suisse estimates

Figure 14: 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

- Production of AMD GPUs for the PS5 has begun at TSMC. Input is around 15K wafers on the 300mm 7nm Pro process
- The iPhone's cycle of new products every year should remain in place in 2021
- TSMC plans to introduce a pilot line for its 3nm process in mid-2020
- We understand TSMC is also considering increasing production on the 7nm process (by 20K wafers) (with the exception of the Nanjing Fab, no signs of specific negotiations for equipment with Taiwan suppliers)
- Yields on Samsung LSI's EUV processes remain very low

iPhone's cycle of new models every year to continue in 2021

New/expansionary investment in 5nm process could pick up if CY21 iPhone models mark return to one-year product cycles

Capacity utilization for cutting-edge processes (5nm/7nm) at Taiwanese foundries and South Korean LSI makers remains at 100%. We expect full capacity utilization to continue as mass production ramps up in earnest for 5G chipsets, as well as the launch of CPUs and GPUs for the Sony PlayStation 5. Although we were unable to get an update related to TSMC foundries for Intel GPUs, if moves are made on this front, we would increasingly expect cutting-edge processes to remain at full capacity and potentially create a need for expanding output, including for the 7nm process.

In our survey three months ago, we heard that the new product cycle for the iPhone would change to twice a year (summer/autumn), but for unknown reasons, Apple apparently changed plans back to a once-a-year new product cycle in September every year. Accordingly, if TSMC wins new customers other than Apple and HiSilicon, and HiSilicon increases chipset production volume for 5nm processes, we think TSMC would need to expand production capacity for the 5nm process.

There has not been any significant improvement in yields on EUV processes, with yields on 7nm processes at Korean firms in particular apparently in the 30–40% range. Accordingly, it seems input is higher than 20K on 7nm processes (around 10K seems appropriate based on real demand). If yields do not improve for both 5nm and 7nm processes, we expect demand for testing to remain firm as production capacity expands.

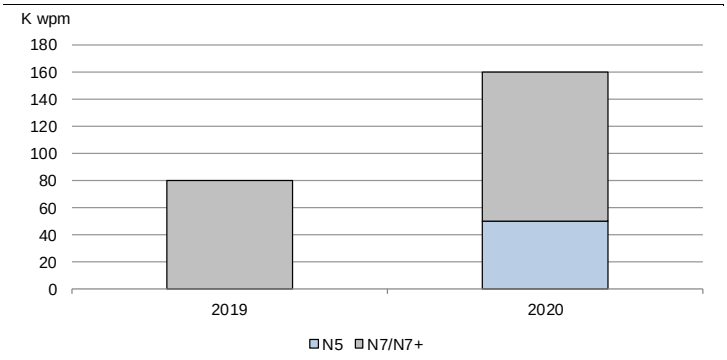
The development of EUV mask pellicles, which we expect to contribute to yield improvement, is unlikely to finish in time for mass production during 2020, and TSMC's switch to in-house mask production has not progressed on schedule from the standpoint of ASML EUV equipment certification. Accordingly, we do not expect yields to improve significantly in 2020. If yields look likely to improve in 2021, capex may be curtailed, so we think it will be necessary to take a comprehensive view of the potential need for additional capacity in the 5nm and 7nm processes mentioned above.

Figure 15: Smartphone application processor maker technology roadmap

5G SoC	2 Chips (modem+AP) 1 Chip (Integrated chip of AP + Modem			2019		2020			
				3Q	4Q	1Q	2Q	3Q	4Q
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)			
	Middle-end	SDM675 (SD6250)						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 981 (9840) ?							MP (Samsung 5nm EUV)
	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 (TSMC 7nm EUV ?)	
Mediatek	Flagship	Dimensity 1000 (MT6889)			MP (TSMC 7nm+ EUV)				
		Dimensity 1000L (MT6885)				MP (TSMC 7nm+ 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							

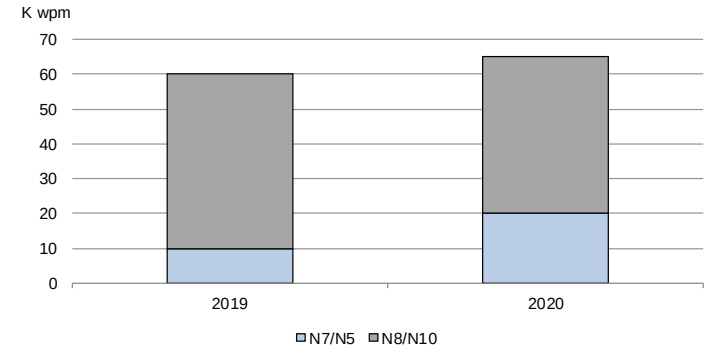
Source: Credit Suisse estimates

Figure 16: TSMC N7/5 process production capacity estimates



Source: Credit Suisse estimates

Figure 17: Samsung Electronics' N7/5 process production capacity estimates



Source: Credit Suisse estimates

5G smartphone trends

Our view based on our survey

5G smartphone makers cut planned output to 380mn units
5G chipset production volume has been revised down (from 520mn to 465mn units).

In September 2019, we stated that 5G chipset vendors planned to produce a total of 515mn units in 2020 and in December, we reported that smartphone makers had raised their production plans to 470–480mn units. Our current Asia feedback (hardware) report indicates that smartphone makers have dropped their production plans to 380mn units but that the consensus among suppliers is below 300mn units. Chipset vendors have lowered their production schedules from 520mn to 465mn units. We believe the cut to HiSilicon's plan reflects a reduction in TSMC's output capability due to controls on its production capacity. The decrease in Samsung's production plan is likely due chiefly to low-key sales of its flagship models. However, because cutting-edge process supply–demand is tight, TSMC and Samsung LSI have not adjusted production for 5G chipset-related cutting edge processes. If there is any impact on capacity utilization from adjustment in 5G chipset production volume, it is likely only to emerge from 3Q CY20, once high-end and midrange 5G smartphones have started to hit the market and the actual level of demand becomes apparent.

In terms of costs, smartphone makers are targeting chipset costs of $30–40 for midrange smartphones, but we understand that it difficult to maintain margins at this price level. In addition, Samsung Electronics is apparently facing development difficulties. It adopted Qualcomm (QCOM) for the Galaxy S20 in the South Korean market, its home turf, instead of the company's own Exynos due to performance issues. Accordingly, while each company releases new 5G chipset products each quarter, there could be some delays in development and costs, which could lead to changes in market share.

Chipset uptake

Market feedback

- 5G chipset production plans lowered from 135mn to 110mn units at HiSilicon, from 65mn to 35mn units at Samsung, from 520mn to 465mn units overall
- Uptake appears limited for Samsung Electronics LSI's Exynos9830 (Samsung Electronics LSI 7nm EUV) which has performance issues. Samsung's flagship models for the Korean market typically use its own chips, but the Galaxy S20 will unusually feature Qualcomm's SDM865 (TSMC 7nm Pro).
- In 5G chipsets, MediaTek set a high price for the Dimensity 1000 (TSMC's 7nm EUV process) while Qcom cut its price for SDM 7250 (Samsung's 7nm EUV), and thus received more orders. MTK intends to make up lost ground with the Dimensity 800 (TSMC's 7nm EUV) slated for mass production in 2Q CY20.
- Huawei will rely on HiSilicon for 80–90% of 5G smartphone chipsets and MTK for the remainder.
- Samsung Mobile expects to use MTK for some low-end models.
- We understand HiSilicon wanted to use Samsung LSI as the foundry but the offer was rejected.

Mediatek's adoption likely at Samsung Mobile

We note price competition in 5G chipsets since the very beginning, but MTK, which has gained market share in flagship products, is aiming to regain market share in midrange smartphones with its Dimensity 800. In addition to Huawei and other Chinese makers, MTK is also likely to be adopted by Samsung Mobile. We also note an increase in the number of MTK customers since our last survey three months ago.

We estimate that 5G chipset market share will remain at around 45-50% for Qualcomm in CY19-20, increase from 32% in CY19 to 26% in CY20 for HiSilicon, contract from just over 20% in CY19 to just over 5% in CY20 for Samsung LSI, and grow from zero in CY19 to 15–20% in CY20 for Mediatek.

Figure 18: Production plan by 5G smartphone supplier and 5G chipset adoption forecast

As of Dec.2019

5G Production Plan (mn units)		QCOM	HiSilicon	Samsung LSI	Mediatek
Apple	90	90			
Samsung	60	15		45	
Huawei	170		150		20
OPPO	60	25			35
Xiaomi	45	25			20
vivo	40	20		15	5
Others	10	10	0	0	0
Total	475	**185**	**150**	**60**	**80**

As of Mar.2020

5G Production Plan (mn units)		QCOM	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	**190**	**100**	**25**	**70**

Consensus among device makers as of Mar.2020

5G Production Plan (mn units)		QCOM	HiSilicon	Samsung LSI	Mediatek
Apple	80	80			0
Samsung	45	20		20	5
Huawei	90		80		10
OPPO	25	15			10
Xiaomi	25	15			10
vivo	25	15		5	5
Others	10	10	0	0	0
Total	300	**155**	**80**	**25**	**40**

Source: Credit Suisse estimates

Figure 19: 5G chip supplier production forecast

5G SOC, BB+AP production forecast				2019	2020 as of Dec.19	2020 as of Mar.20	
AP/BB/SOC	Product name	Process	Foundry	mn units	mn units	mn units	Customer
Hisilicon	Balong 5000(+Kirin 980/985/710)	7nm Pro	TSMC	5	15		Huawei
	Kirin 990	7nm EUV	TSMC	17	70	110	Huawei
	Kirin 820	7nm EUV	TSMC	1	50		Huawei
	Kirin 1000 (3Q20)	5nm EUV	TSMC	NA	NA		Huawei
Qualcomm	X50(+SDM855)	8nm	Samsung	4	0		Mainly China, Samsung, LG
	X55(+SDM865)	7nm Pro	TSMC	11	60		Mainly China, Samsung, LG
	X55(+Apple A13/14)	AP5nm/7nm Pro+BB7nm Pro	TSMC	0	90		Apple
	SDM765 (7250)	7nm EUV	Samsung	4	90	NA	Mainly China, Samsung, LG, others
	SDM7350 (3Q20 MP)	5/7nm EUV	Samsung	NA	NA		
	SDM675 (6250) (3Q20 MP)	8nm?7nm?	Samsung	NA	NA		Mainly China, Samsung, LG, others
	SDM4350 (3Q20 MP)	8nm	Samsung	NA	NA		
Samsung LSI	Exynos 980 (9630)	8nm	Samsung	3	50		Samsung, Lenovo, Xiaomi, vivo
	Exynos 9650 (4Q20 MP)	7nm	Samsung	NA	NA	35	Samsung, etc
	5G Modem + AP	7nm EUV/5nmEUV	Samsung	0	15		Samsung Flagship
Mediatek	Total	7nm EUV	TSMC	1	80		Mainly China
	Dimensity 1000L (MT6885) 4Q19			-	-		OPPO, Xiaomi and Huawei
	MT6883 1Q20 ($48)			-	-	NA	
	Dimensity 800 (MT6873) 2Q20			-	-		
	Dimensity 600			-	-		
Total				46	520	465	
Hisilicon				23	135	110	
Qualcomm				19	240	240	not updated since Dec.2019
Samsung LSI				3	65	35	
Mediatek				1	80	80	not updated since Dec.2019
			Samsung	11	155	125	
			TSMC	35	365	340	

Source: Credit Suisse estimates

5G chipset development

Market feedback

- Makers seem more upbeat on middle-market and low-end 5G chipsets, owing to the poor performance and steep costs of the Dimensity 1000 and Kirin 990 chipsets.
- The companies target costs of $30–40 for midmarket 5G chipsets (such as SDM 6250, Dimensity 800); they will likely struggle to mass-produce and ship products at such price levels while maintaining margins.

Chipset costs still an issue

As noted above, performance-related issues are starting to have direct impact on Samsung Electronics' market share as the company is unable to use its Exynos 5G chipsets for its flagship models in South Korea. In addition, we believe it will be extremely difficult for smartphone makers to achieve their $30-40 cost targets for midrange and lower chipsets (development for which was brought forward in May–Jun last year due to strong demand) without sacrificing the profitability of chipset makers. We think EUV process yields are also a factor, but we are still not optimistic. Full-scale mass production of midrange and smaller chipsets is due from 2Q 2020, but we will be monitoring development trends as progress in the development of these chipsets and the gap with the cost target will directly affect 5G smartphone production and sales.

Cost issues for middle-end 5G chipsets

Figure 20: 5G single chip technology roadmap

5G SoC	2 Chips (modem+AP) 1 Chip (Integrated chip of AP + Modem			2019		2020			
				3Q	4Q	1Q	2Q	3Q	4Q
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)			
	Middle-end	SDM675 (SD6250)						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 981 (9840) ?							MP (Samsung 5nm EUV)
	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 (TSMC 7nm EUV ?)	
Mediatek	Flagship	Dimensity 1000 (MT6889)			MP (TSMC 7nm+ EUV)				
		Dimensity 1000L (MT6885)							
	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)	

Source: Company data, Credit Suisse estimates

Others

Market feedback

- Assembly of Antenna-in-Package (AiP) for 5G mmWave applications is likely to be handled by former Siliconware Precision Industries (SPIL) for Qcom and by ASE for Apple.

CIS market and production trends

Our views based on survey feedback

5G smartphones look increasingly likely to use higher-resolution CIS than LTE smartphones, which is prompting Sony and Samsung to shift production toward higher-resolution CIS (24MP/48MP and above). As a result, we believe this will lead to expansions of in-house capacity and Sony possibly tapping TSMC for help with production, because high-resolution CIS feature larger chip sizes, which reduces the number of chips possible per wafer. Sony has yet to make a final decision on whether to outsource production to TSMC, but development projects appear to be progressing ahead of schedule.

Since September 2019, there has been a supply shortage for Samsung's CIS due to production capacity bottlenecks in CIS stacked with logic, but this problem has been resolved with Samsung outsourcing production to foundries. CIS makers continue to operate at full capacity, and there is not enough production capacity for CIS stacked with logic at Samsung, TSMC and other suppliers, which has promoted sourcing from UMC, SMIC and HuaLi.

We were also told that Huawei has hired teams of image processing-related engineers from major Japanese camera makers, and we get the impression that it is taking steps to internalize CIS production and improve camera quality.

Market feedback

- In addition to TSMC, Sony relies on SMIC and HuaLi for CIS stacked with logic. This is because TSMC's 40nm process is operating at full capacity, but unable to meet Sony's demand.
- Samsung Electronics' LSI lines outsource production of CIS stacked with logic to UMC and SMIC, while securing in-house production capacity for strengthening the foundry business.
- OmniVision is also doing very well.
- Huawei has lured away entire teams of image processing engineers from major Japanese camera makers.
- Samsung Electronics' 300mm CIS production volume fell to 35–40K/month in Nov–Dec last year, but this has recently risen to 50–55K, and 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.
- TSMC is bringing forward its foundry project for Sony's CIS. The company is working on the assumption that production will start in 2H 2020, but we understand it has yet to make a final decision.

Unchanging trend toward multiple cameras, higher resolutions on 5G smartphones

- Raising our multiple camera smartphone assumption, driven by increase in quadruple camera phones

In Oct–Dec, multiple cameras were installed in 75% of smartphones, a higher installation rate than we anticipated. The weighting of smartphones with quadruple cameras reached 13%. On a full-year basis, the multiple camera installation rate leapt from 40% in CY18 to 67% in CY19 (40% dual camera, 12% triple, 6% quadruple).

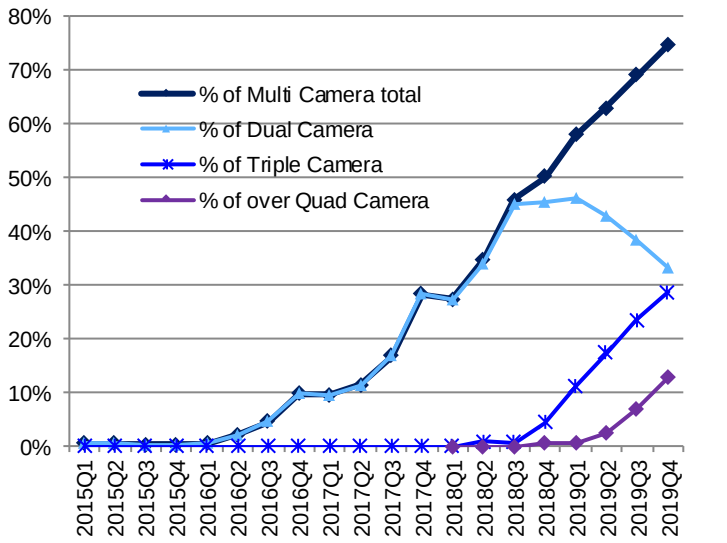
The Oct–Dec data has prompted us to update our estimates. We now forecast that 80% of smartphones will feature multiple cameras in CY20 (25% dual, 35% triple, 20% quadruple) and 90% in CY21 (22% dual, 40% triple, 28% quadruple). Our estimate for CY21 is new, and our previous (December 2019) estimate for CY20 was 75% (28% dual, 30% triple, 7% quadruple).

Triple or quadruple cameras are no longer a feature of high-end smartphones alone and are increasingly being installed in midrange phones priced at $200–400. Quadruple cameras including a ToF camera (time-of-flight camera which uses infrared for depth measurement) are a feature of many 5G smartphones that recently started to hit the market. We expect this to be a feature of (two out of four of) Apple's 2020 iPhone models, and that the installation rate will rise from now on as smartphone camera picture quality continues to improve.

- Ongoing shift to higher resolution smartphone cameras

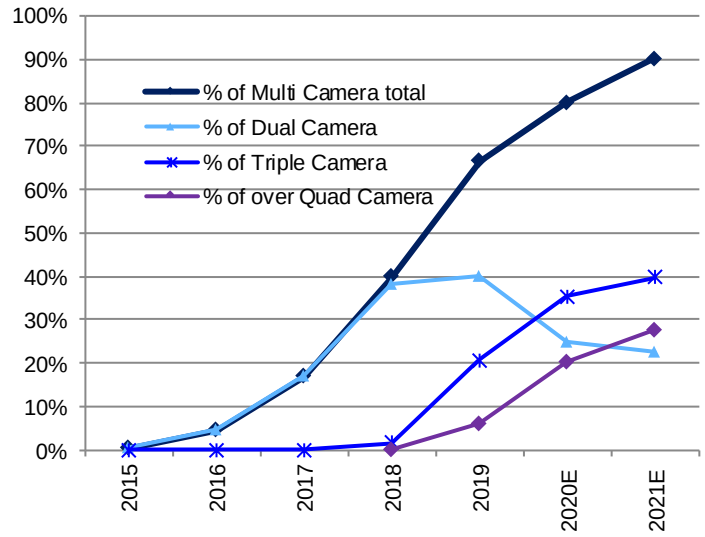
The weighting of smartphones featuring a main camera with a megapixel count of at least 20MP continued to increase in Oct–Dec, rising to 28% (10% in Oct–Dec 2018, 26% in Jul–Sep 2019). There is a trend for 5G smartphones to feature a main camera pixel count one size larger than 4G models with the same specs (for example, a 5G model with the same specs as a 4G model with a 48MP main camera will feature a 64MP main camera). The vast majority of 5G smartphones recently announced by Chinese and Korean makers feature a main camera with at least 40MP, including some with 108MP, and we assume a shift towards higher pixel count among 20MP-plus class smartphones too. This shift to higher pixel count is likely to entail a shift to larger CIS, thereby fueling a rise in unit price.

Figure 21: Multi-camera smartphone quarterly sales weightings



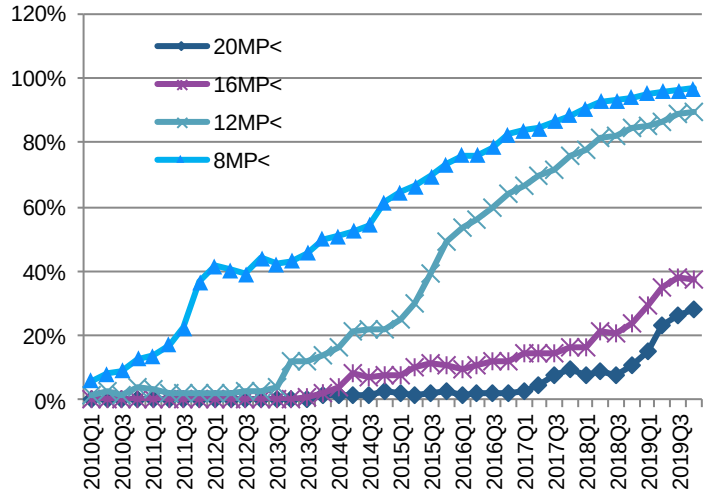
Source: IDC, Credit Suisse

Figure 22: Multi-camera smartphone weightings



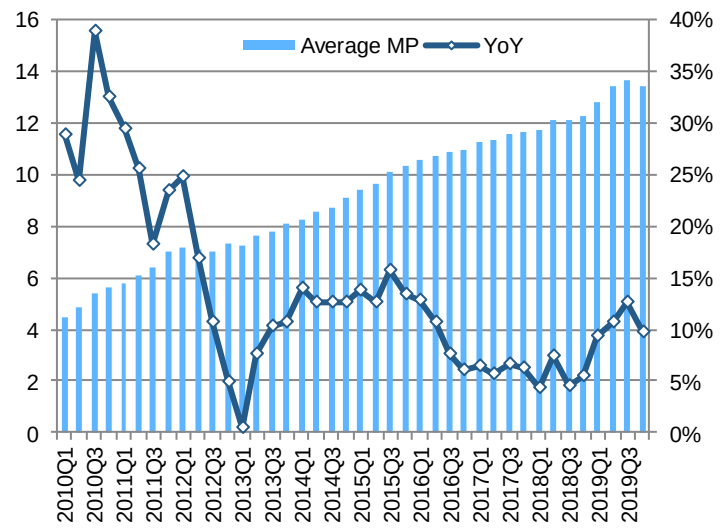
Source: IDC, Credit Suisse estimates

Figure 23: Smartphone shipments by camera resolution (units)



Source: IDC, Credit Suisse

Figure 24: Smartphone shipments by camera resolution (%)



Source: IDC, Credit Suisse

DRAM market trends

Our view based on our survey

DRAM prices have rebounded across all applications in 1Q CY20, but DRAM makers have nonetheless refrained from turning bullish amid multiple concerns including (1) restocking by Chinese smartphone makers and US hyperscalers in excess of actual demand, (2) COVID-19's likely impact on 1H CY20 smartphone demand and demand for Android flagship models, and (3) a likely slowdown in demand from US hyperscalers in 2H CY20. We expect a major improvement in DRAM prices in 1H, including a 20–40% rise for server DRAM in 2Q that might ordinarily signal a recovery in data center investment.

However, we expect prices to soften in 2H in reaction to 1H's restocking demand. Our view differs from the market consensus in that we think (1) 1H is seeing temporary support from restocking in excess of actual demand and (2) 2H demand from US hyperscalers will likely be only flat HoH.

We are accordingly bullish overall on DRAM prices in 1H CY20 and cautious on 2H. We think supply–demand could tighten in CY21 if CY20 capex curbs continue as we expect.

In terms of technology, DDR5-related investment was seen in 4Q CY19, but demand for DDR5-equipped phones has been weak and additional uptake slow, making this a rare instance of demand/investment for a new product slowing immediately after launch. We think DDR5 demand/investment could pick up from 2H CY20 premised on adoption in 5G smartphones. In addition, we think development of 1xnm processes has been delayed due to their high level of technological complexity and expect mass production of 1xnm/1ynm processes to continue for the time being. We therefore see price increases as DRAM makers' sole option for boosting profit margins.

We think the divergence between our forecasts and the market consensus is due to (1) a sharp rise in 2Q prices, (2) a skew in US hyperscalers' server DRAM demand toward 2H rather than to a sustained uptrend, and (3) cautious outlook across the board on capex aimed at increasing supply to data centers, as data center demand is volatile and difficult to predict even if the DRAM environment improves.

Gap between consensus and our view on DRAM market

DRAM market outlook

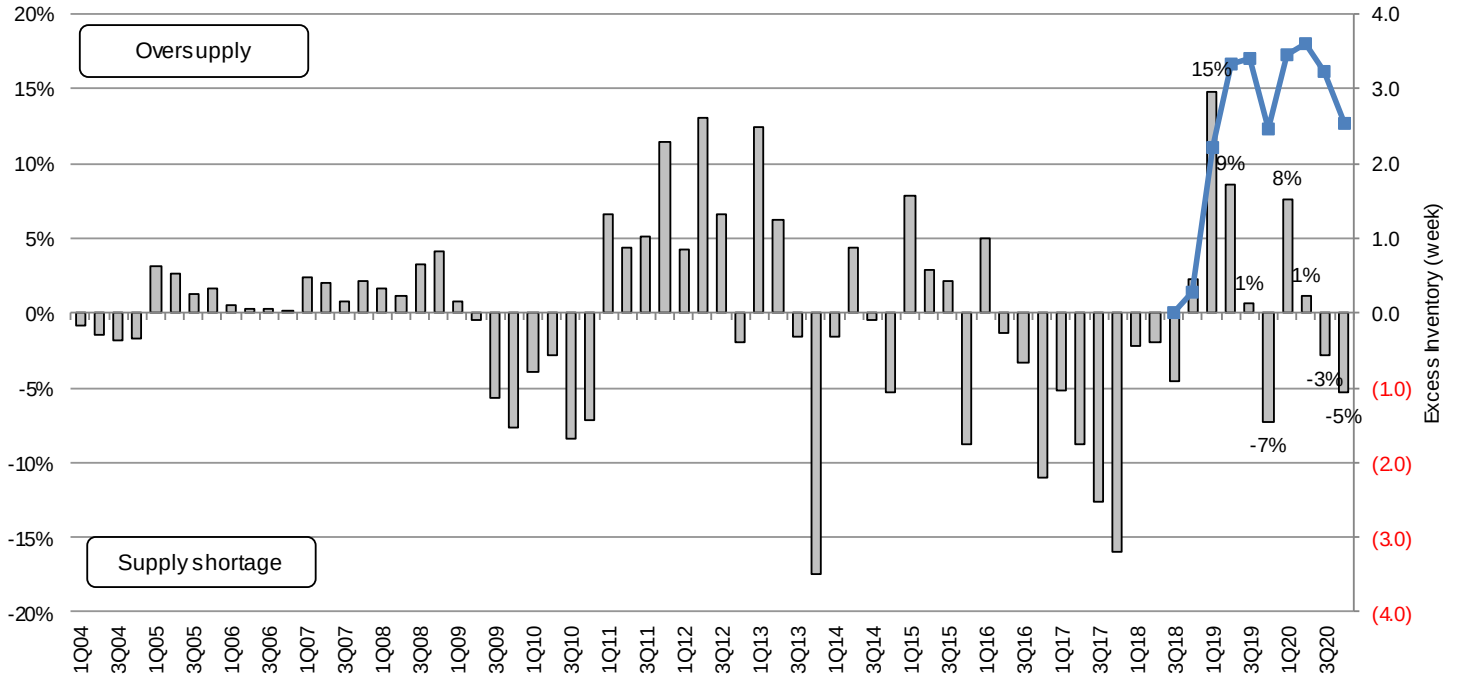
Market feedback

- Visibility on demand in 2H CY20 has declined. Specifically, there are concerns about demand slowing in reaction to recent aggressive restocking by smartphone and server/data center customers ahead of price increases.

Current price increases do not reflect actual demand

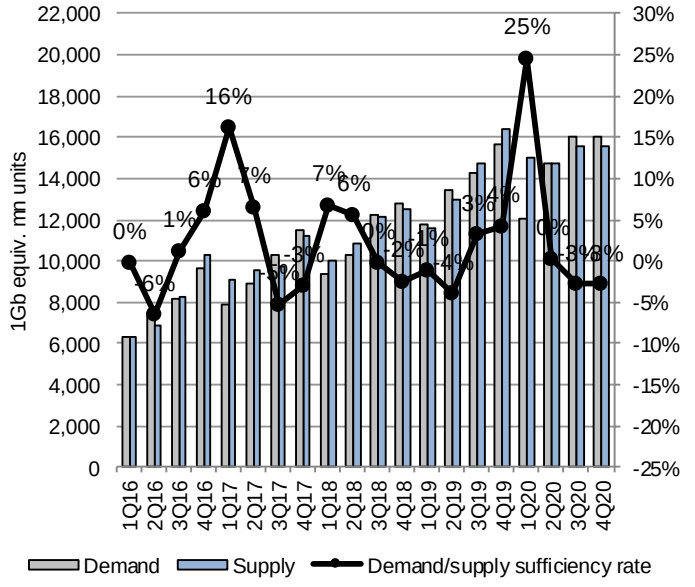
Based on hardware unit production, our DRAM supply–demand model, which assumes DRAM demand based on production and supply volumes that do not take into account inventories, assumes 4-5% oversupply in 1H and 4% undersupply in 2H. However, as we discuss below, DRAM prices are in fact showing signs of an upturn amid heavy restocking by Chinese smartphone makers and US hyperscalers and changes in DRAM makers' product mix. We have nonetheless been unable to confirm any real bullishness among DRAM makers in response to this improvement. In particular, we sense growing caution on the possibility of demand slowing in reaction to the current restocking.

Figure 25: DRAM supply–demand model



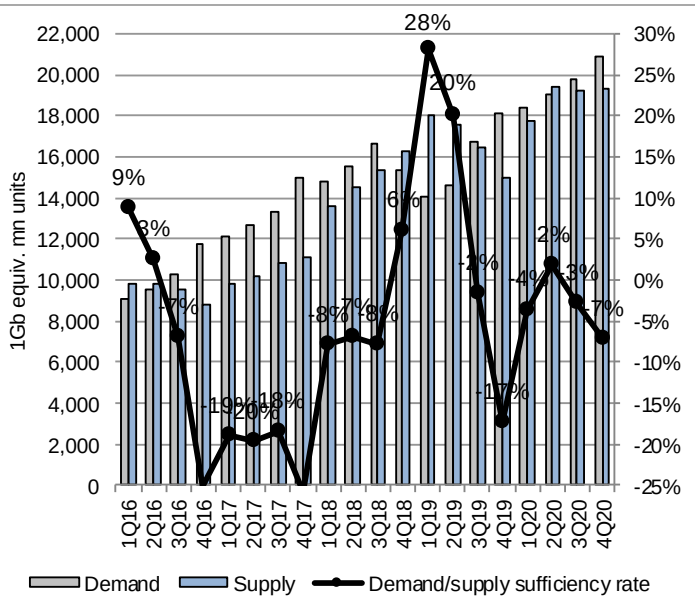
Source: Credit Suisse estimates

Figure 26: Mobile RAM supply–demand model



Source: Credit Suisse estimates

Figure 27: PC/server DRAM supply–demand model



Source: Credit Suisse estimates

DRAM demand outlook

Market feedback

- Based on demand forecasts for Chinese smartphone makers, we expect 1Q and 2Q CY20 to see restocking of mobile RAM in excess of actual demand. Restocking has been underway since 2Q CY19 and had accordingly begun to slow slightly. However, it has now picked up again as price increases have begun taking hold.
- For server DRAM, we expect demand to recover at a modest +10% QoQ in CY20 with bit growth of 30–40%.
- Within this, we expect demand from US hyperscalers to rise 50% YoY. The 1H/2H split initially looked to be 60%/40%, but supply bottlenecks for CPU and memory (DRAM, SSD) now have it at 50%/50%. On a quarterly basis, we expect flat QoQ growth.
- US hyperscalers are concerned about a supply glut in 2H CY20 and are restocking before it materializes.
- Demand for data center applications looks especially strong in 1H CY20, with CPUs and memory in short supply and DRAM a particular bottleneck.
- China is also seeing a flurry of data center investment from the likes of ByteDance, Alibaba, Tencent, and China Mobile.
- US hyperscalers are prioritizing volume over price.
- With server DRAM in booming demand for use in Chinese datacenters, customers are willing to pay whatever DRAM makers ask in order to secure sufficient volume.
- Intel's Cooper Lake CPU is expected to be supplied only to hyperscalers and certain other specific customers. We think enterprise (server) makers are likely to skip Cooper Lake in favor of Ice Lake.
- Intel's server CPU roadmap has not changed over the past three months. Cooper Lake (14nm) is expected to be mass-produced from 3Q CY20 and Ice Lake (10nm) from 4Q CY20.
- Amazon and Google plan to make system changes across the board in response to Cooper Lake and Ice Lake's support for eight-channel memory.

US hyperscaler DRAM demand likely to be flat HoH in 2H CY20

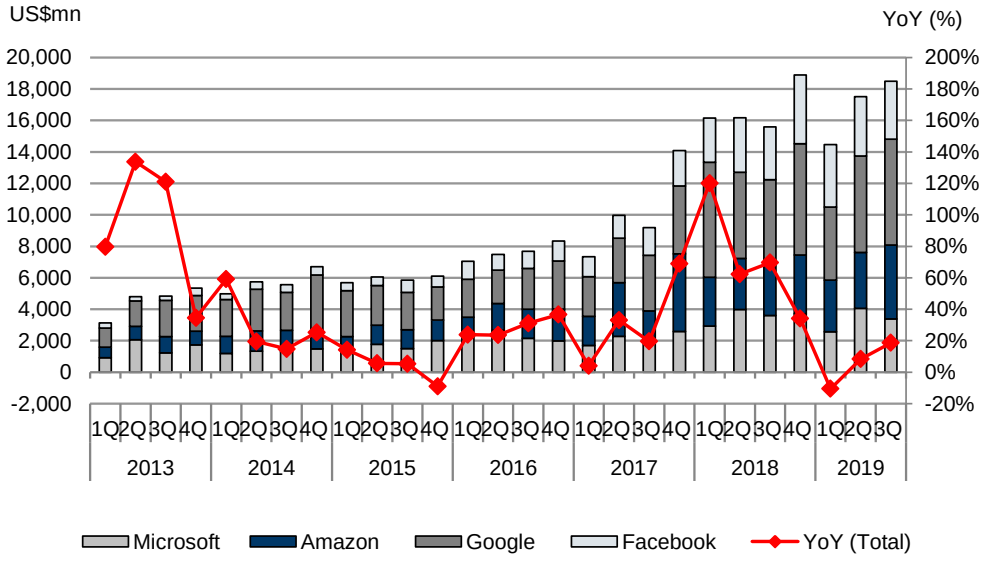
US hyperscaler plans point to 2H demand slowdown

Chinese smartphone makers and US hyperscalers had been restocking since 4Q CY19 in expectation of supply–demand tightening in 2H CY20, but the recent upturn in DRAM prices has them now clearly prioritizing volume over prices. In addition, COVID-19 has yet to impact smartphone makers' demand forecasts and related procurement. US hyperscalers' CY20 demand forecasts initially had demand coming 60% in 1H and 40% in 2H, but supply bottlenecks now have a 50%/50% split looking more likely and quarterly growth essentially flat.

Expect boost from 8-channel CPUs in CY21

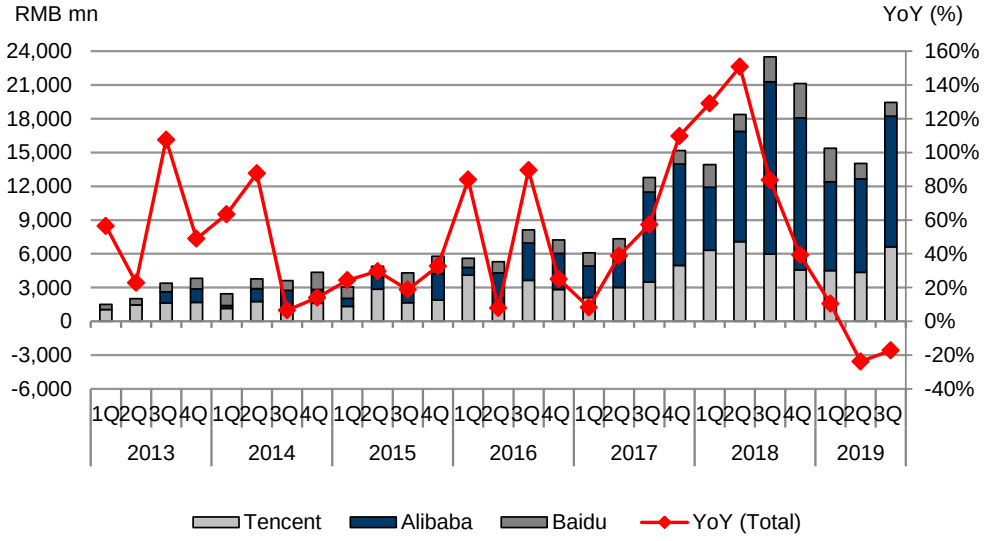
Timing on mass-production of Intel's new Cooper Lake and Ice Lake CPUs is unchanged, and while Amazon and Google's plans to overhaul their systems in response to the new CPUs' support for eight-channel DRAM could boost DRAM demand, this looks likely to be pushed back to CY21. The fact that DRAM demand forecasts do not anticipate any boost from the start of Cooper Lake shipments has us concerned about the high level of inventory.

Figure 28: US hyperscale capex



Source: Company data, Credit Suisse

Figure 29: BAT capex



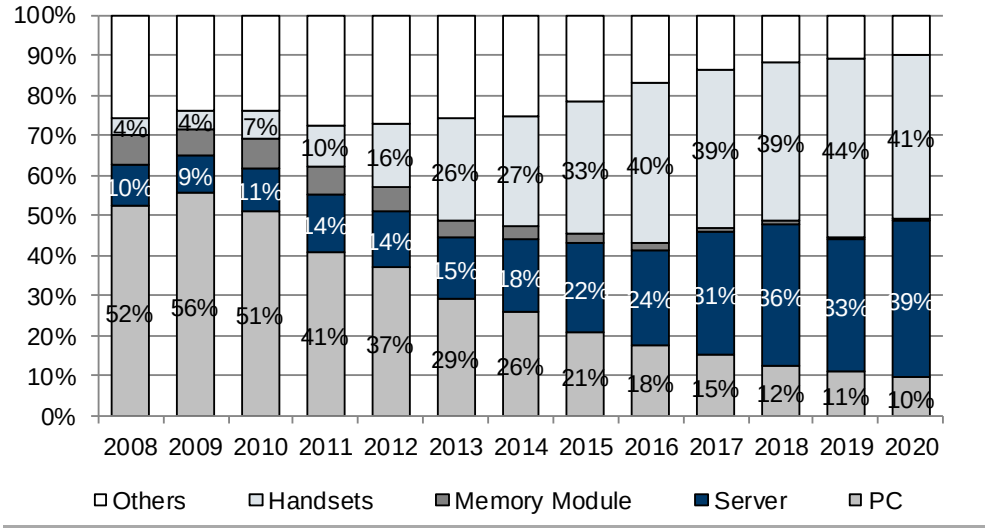
Source: Company data, Credit Suisse

Figure 30: 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 : 1Q20~~ → MP : 3Q20	→ 2H20

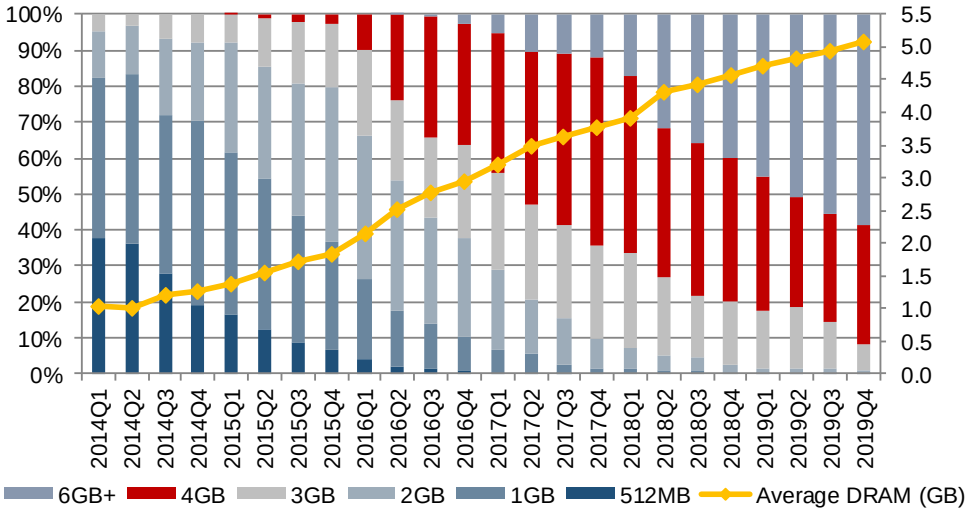
Source: Company data, Credit Suisse estimates

Figure 31: DRAM bit demand breakdown by application



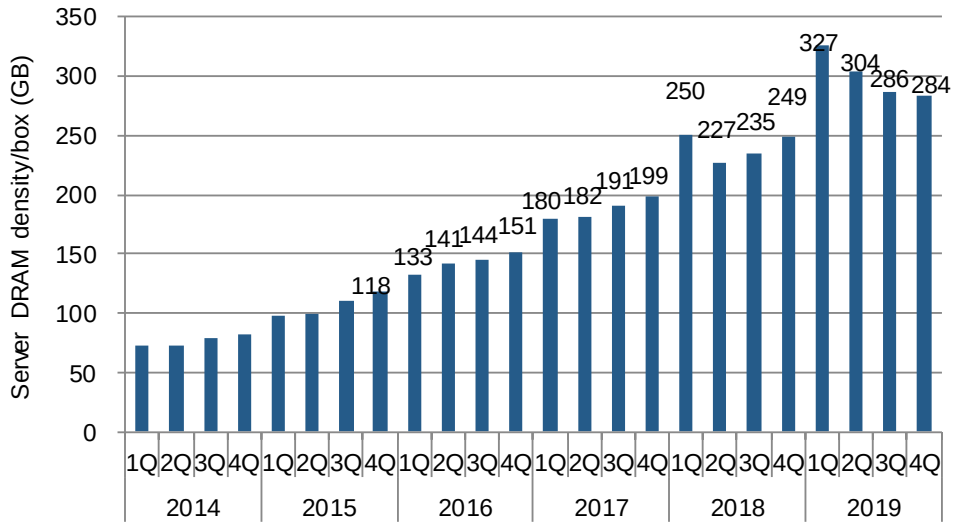
Source: Credit Suisse estimates

Figure 32: Chinese smartphone DRAM density



Source: IDC, Credit Suisse

Figure 33: Server DRAM average density



Source: DRAMeXchange

DRAM supply outlook

Market feedback

- DRAM makers plan to increase production of server DRAM (mainly for data centers) in 1H CY20 and compensate with mobile DRAM in 2H as server DRAM demand likely pauses.
- We understand that Korean DRAM makers have yet to ship 1znm evaluation samples. Yields remain poor, and the technology appears to be still unready for mass production.

Plans to increase production ratio for server DRAM in 1H CY20

Output shift from mobile RAM to server DRAM

On the supply side, there are signs of a shift in the production mix toward server DRAM, based on concerns about a downward revision to smartphone maker demand due to COVID-19, and on the assumption that demand from US hyperscalers will be weighted toward 1H. This has led to a mismatch in DRAM makers' inventory mix. We expect the production mix to revert to normal in 2H as demand from US hyperscalers slows and 5G smartphones drive demand for mobile RAM.

We see no indications that DRAM makers will accelerate capex beyond current plans and believe they have instead made higher OPM their key management priority in CY20.

DRAM inventory trends

Market feedback

- DRAM makers had 1-2 weeks of excess inventory at end-2019; changes in the production mix in 1Q 2020 and rising demand have temporarily disrupted the product mix and inventory balance (i.e., supply–demand for server DRAM is tight owing to a lack of inventory)
- US hyperscalers such as Google and Microsoft held 6–8 weeks of excess inventory at end-2019, and it appears that inventories are currently either at the same level or slightly higher
- Chinese smartphone makers also appear to have excess inventories, although the exact level is unclear

Excess inventories at both Chinese smartphone makers and US hyperscalers

Given the lack of technological advances in DRAM (i.e., there is little risk associated with inventories of current mass-produced products since 1znm-process products will not arrive anytime soon) as well as the uptrend in prices, we think US data centers in particular are carrying out further restocking despite their excess inventories.

We also think Chinese smartphone makers have 2–3 weeks of excess inventory of over 2 to 3 weeks, owing to weak real demand in 4Q and lower-than-expected production volume in 1Q.

We anticipate a slowdown in restocking demand among US hyperscalers and Chinese smartphone makers from the latter half of 2Q through 3Q.

DRAM price trends

Market feedback

- DRAM prices are rising across all applications.
- With server DRAM prices likely to rise sharply in 2Q, DRAM makers have announced aggressive price increases.
- Server DRAM prices are expected to rise 5–10% in 1Q 2020 and 20–40% in 2Q; the projected price of a 32GB module is just over $140. DRAM makers look for a 5–10% increase in 3Q as well.
- The price of mobile RAM is projected to rise by several percent in 1Q and 5–10% in 2Q.
- Some DRAM makers are thinking of resuming investment if the price of server DRAM stays at USD150–160 or higher; however, we understand that some companies are not in a position to ramp up investment because of low reliability on fluctuations in data center demand.

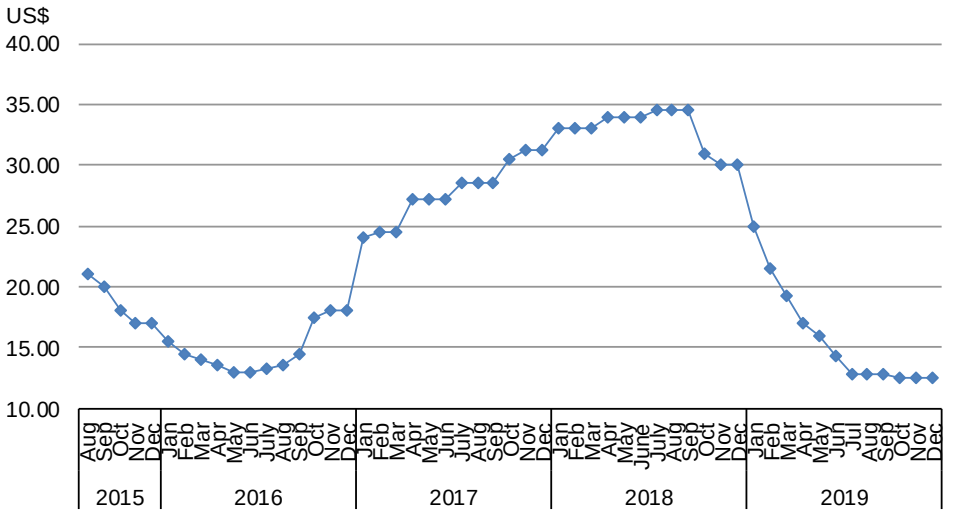
Server DRAM prices projected to rise 20–40% in 2Q

Prices likely swung upward in 1Q, expected to rise 20–40% for server DRAM in 2Q

DRAM prices, and in particular the size of the expected rise in server DRAM prices in 2Q, are a positive surprise. Specifically, server DRAM prices have returned to positive growth in 1Q, rising 5–10%, and DRAM manufacturers expect prices to rise by 20–40% in 2Q. We have already factored an increase of this magnitude into our forecasts. US hyperscalers appear to be prioritizing volume over price in their procurement. Chinese data centers, whose demand is less than 20% that of the US hyperscalers, are purchasing DRAM at manufacturers' asking prices.

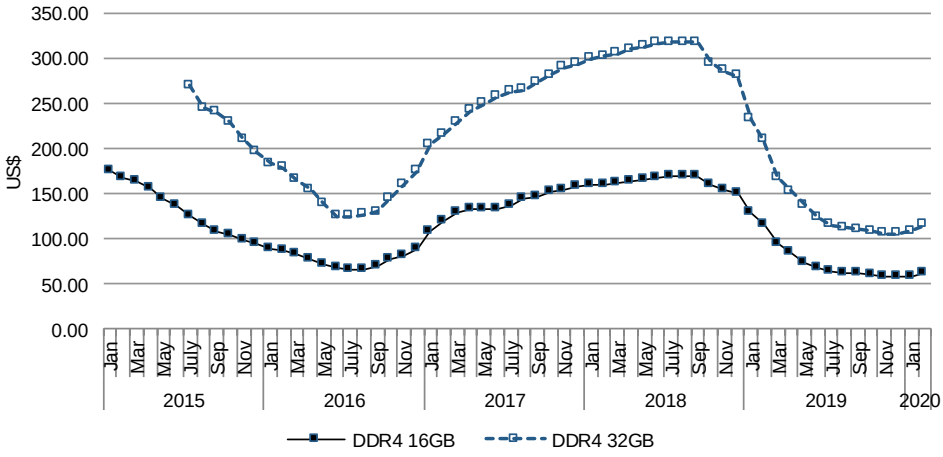
This price trend confirms that a relationship of mutual trust absolutely does not exist between DRAM makers and customers. When DRAM makers are in a position to raise prices, they raise prices by as much as they can, and when customers perceive that prices are going to continue trending higher, they accelerate their procurement as much as possible. DRAM makers in particular are skeptical about data center DRAM demand given the severe oversupply and slump in data center demand that followed the period of data center demand in CY17–18. Although the stock market evidently has high hopes regarding memory demand in the data society of the future, in our discussions with DRAM manufacturers we sensed that they have absolutely no intention of conducting aggressive capex (e.g., investing in new manufacturing capacity) in response to data center demand.

Figure 34: DDR4 4GB module large lot price



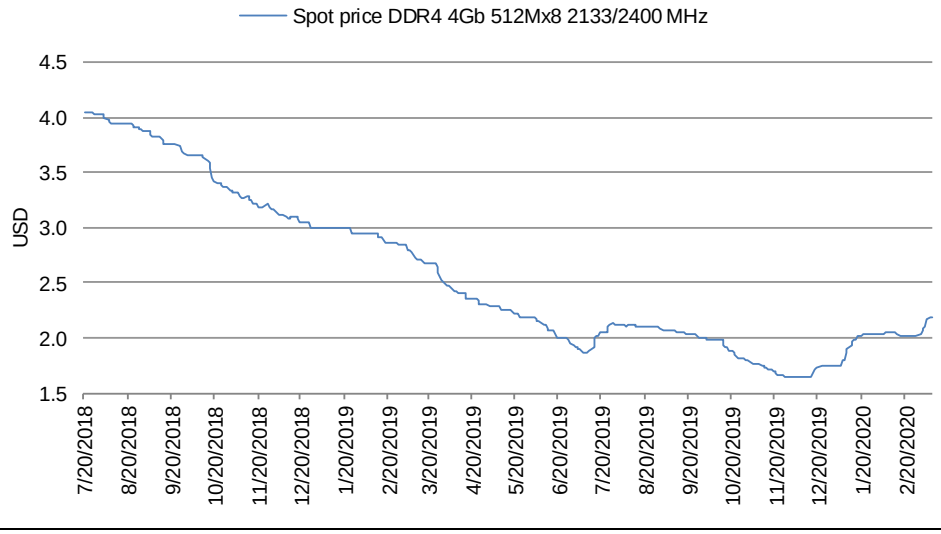
Source: DRAMeXchange

Figure 35: Server DRAM contract price (16/32 GB RDIMM)



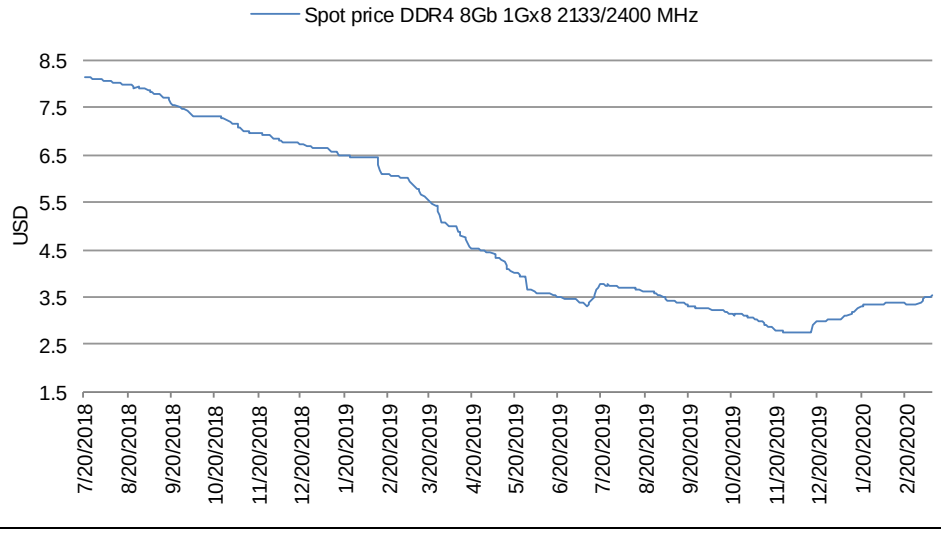
Source: DRAMeXchange

Figure 36: DDR4 spot price (4Gb)



Source: Bloomberg, Credit Suisse

Figure 37: DDR4 spot price (8Gb)



Source: Bloomberg, Credit Suisse

DDR5 uptake

Market feedback

- DDR5 server DRAM is expected to be adopted in Intel's Sapphire Rapids CPU, which is due to be released at the end of 2021
- Adoption of DDR5 in smartphones in 2020 is expected to be limited to some flagship models

Low DDR5 demand, likely to be used as server DRAM from end-CY21

Limited uptake of LP DDR5
Likely to be used as server DRAM from end-CY21

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. Adoption of DDR5 server DRAM is not expected until end-2021 at the earliest (with Sapphire Rapids).

As a result, we do not expect a steady, consistent shift in demand to DDR5 of the kind seen with DDR3 and DDR4 in the past. We think several factors are keeping demand from increasing. For one, with the BOM cost of 5G smartphones on the rise, the price premium for LP DDR5 is around double digits % over the price of LP DDR4. For another, users have yet to be convinced about the advantages of DDR5.

With this in mind, we expect a temporary slowdown in DDR5-related investment, which was brisk in 4Q 2019.

Figure 38: Intel server CPU, 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

HBM2 trends

Market feedback

- Demand for HBM2 is growing rapidly as the use of nVidia HBM2 in data centers increases; demand for HBM2 for voice recognition applications appears to be growing particularly rapidly
- HBM2 demand fell 35–40% YoY in CY19, to 7–8mn units (4GB equivalent), but is projected to double in 2020, to 15mn units; it is expected to top 20mn units in 2021
- The price premium for HBM2 is around 50% over the price of server DRAM (as of 1Q)
- HBM3 is expected to be adopted in CY22

Market finally expanding

Expectations regarding high-band memory (HBM2) have been high for several years, but the market is expected to expand in 2020. The market contracted temporarily in CY19, but is expected to be 2x greater in size in CY20 (and 25% larger than in CY18). Adoption of nVidia HBM2 for voice recognition applications is evidently increasing among data centers. The market is expected to grow by at least 35% YoY in 2021.

Although HBM2-related capex is under way, some portion of this investment was already made by the end of 2018, so we do not think the amount invested will be that notable in terms of total back-end SPE investment.

Sharp growth in demand for HBM2s for GPUs in voice recognition applications

NAND market outlook

Our view based on our survey

Unfavorable conditions, including potential pullback in restocking demand, and possible end-maker switch to lower memory densities due to rising prices

NAND prices rose since July CY19 due to restocking demand driven by customer concerns about supply, particularly in retail and distributor channels, following the power outage at Kioxia's Yokkaichi power plant and Japan-Korea export restrictions. We understand prices continued rising in 1Q CY20. Underlying demand slowed for 4G smartphones in China in 4Q CY19 and was pushed down further by COVID-19 in 1Q CY20. Underlying NAND demand remains weak, particularly for smartphones, which account for just over 50% of such demand. Demand for high memory densities such as 512GB and 256GB is weak. We think growth in smartphone memory density will slow further, as end-users now tend to save data on the cloud rather than their devices.

We expect NAND prices to continue rising in 1–2Q CY20, supported by ongoing restocking demand from Chinese smartphone makers, data centers, and PC makers.

NAND inventories healthy at makers, but excessive at customers

The overall NAND market had excess inventory of about three months at end-1Q CY19 (roughly one year ago). Subsequent underlying demand in CY19 did not exceed expectations. In fact, smartphone demand slowed in 2H, so we see insufficient demand to absorb surplus inventory. NAND makers said inventory levels have normalized, but we expect market inventory surpluses to persist and we see a risk of NAND prices deteriorating again as restocking demand slows. That said, we think excessively large surpluses are avoidable if NAND makers hold inventories at wafer banks, as in CY18. This should prevent the sharp price declines seen in CY18-19.

Adoption of cutting edge technologies is likely to slow from the one-year cycle needed for 64-layer chips to a 1.5–2-year cycle for 9X & 1XX-layer chips, given NAND maker prioritization of margin improvement and the technical challenges in 96-layer and 1XX-layer (112 & 128-layer) 3D NAND. We therefore doubt current development will spur an acceleration in capex.

Gap between consensus and our view on NAND market

We think our NAND market outlook differs from the consensus' because we believe (1) smartphone maker restocking is sustaining current demand, (2) the industry's inventory surplus has not shrunk; it has merely shifted from NAND makers to their immediate customers, and (3) makers have yet to step up capex given slow development progress and no clear prospect of yield improvement for 9X & 1XX-layer chips, (4) moves to reduce installed density in PC-use SSDs and smartphones due to raised price.

NAND pricing trends

Market feedback

- Bit demand is expected to grow 25–30% in CY20, with supply up roughly 25%.

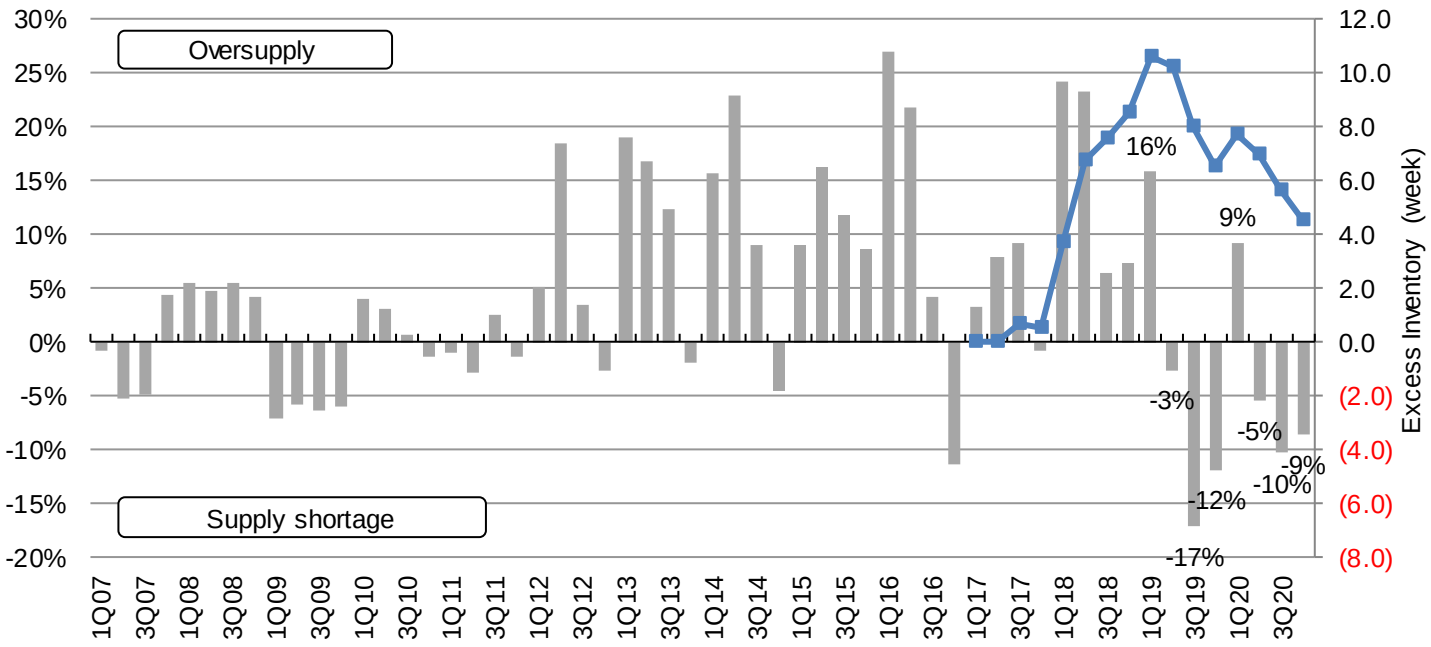
Bit demand expected to grow only 25–30% in CY20

In view of recent demand, many NAND makers apparently expect demand to grow 25–30% with supply up 25%. They have lowered their long-term forecasts for bit demand growth from 40% to 20–30%, boding poorly for capex.

However, we see little room for underlying growth, given that CY20 demand hinges partly on restocking, and that the cSSD installation rate for PCs has already risen considerably since 2H CY19 due to price sensitivity/lower prices (some major PC makers now plan to install cSSD in 90% of their models in CY20). We also expect the uptrend in smartphone memory densities to slow due to greater end-user reliance on the cloud. Such issues pose a risk of slower demand growth, particularly from 2H CY20.

That said, we expect a return to favorable supply–demand conditions in CY21 if capex curbs continue.

Figure 39: NAND supply–demand model



Source: Credit Suisse estimates

NAND demand trends

Market feedback

- Smartphone maker NAND procurement has not changed from before the COVID-19 outbreak, but we understand there is an increasing risk they will adjust this, in light of underlying demand.
- By contrast, Huawei has apparently cut its demand outlook already, as NAND restocking demand winds down. We understand the company is in talks to reallocate some of its projected NAND order volume to cSSD and eSSD, where demand is strong.
- We sense strong demand for cSSD and eSSD among customers seeking to secure supply.
- In PCs, we highlight a significant impact on BOM costs due to price hikes, and note moves to revert to HDDs and reduce cSSD capacity.
- More survey respondents now see poor visibility for 2H demand. Although final demand for smartphones is weak, demand for NAND remains firm, with no downward revisions. Data center demand is not as strong as DRAM demand, and is growing gradually.
- For 5G smartphones, BOM costs preclude increases in NAND densities, which actually show signs of falling.
- Smartphone maker demand for 1TB NAND seems negligible. The CY20 iPhone model may use it, but NAND makers have little expectation of this.
- Samsung Mobiles' approach to installed NAND density seems the most conservative of the major smartphone makers.
- Demand from US hyperscalers and Chinese data centers is solid; we see signs of moves to secure capacity for 2Q CY20.

- Among other things, we expect additional demand for eSSD, given rising capacity utilization at Tencent and other companies.
- Microsoft is moving away from SSD procurement to the sourcing of chips for assembly in-house.
- As with Apple, Huawei apparently seeks to use its own controllers.

Smartphone demand starting to correct

Smartphone demand starting to adjust but offset by datacenter-related demand

February saw a continuation of across-the-board restocking demand including from Chinese smartphone makers, PC makers and data centers. However, we understand that Huawei, which had been restocking since last May, began to lower its demand projections in March. Huawei has started negotiations to reallocate some of its order volume to SSDs for PCs and servers. Depending on the outcome, NAND makers may have to lower their outlooks.

Despite the slowdown in smartphone demand from 4Q CY19, other smartphone makers continued to source NAND in line with unrevised demand forecasts, so NAND makers are becoming concerned about a possible adjustment in such demand. NAND makers had pushed excess inventory into retail and distributor channels in 2H CY19, and therefore now appear increasingly concerned about an adjustment in demand— particularly a slowdown in 2H when they had previously assumed tight supply–demand.

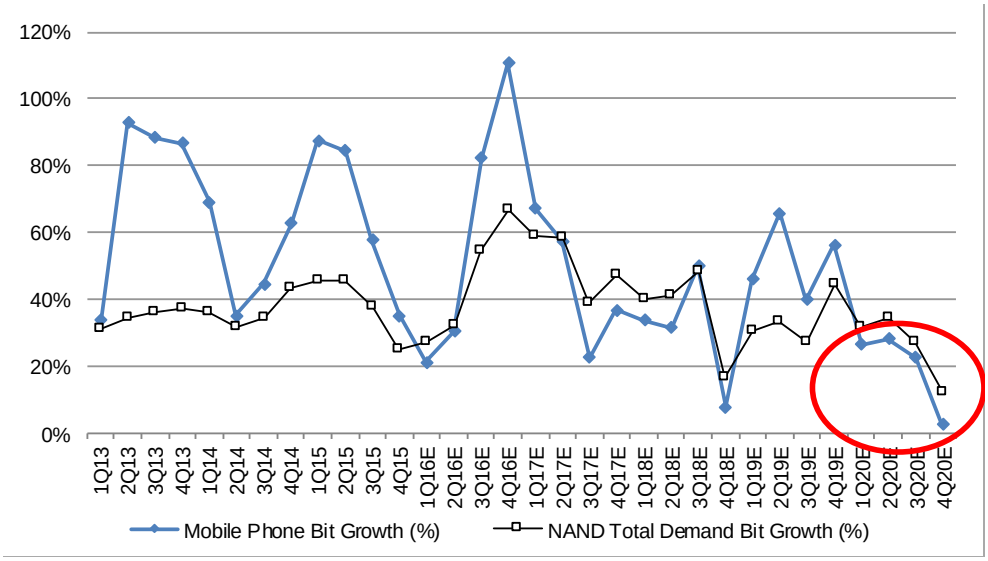
Smartphone and PC makers leaning toward lower memory densities as BOM costs rise

In 5G smartphones, we understand smartphone makers are mulling plans to lower the installed memory densities for mass-market models by one level vs. current models, in response to higher BOM costs for other components. The new iPhone CY20 model is likely to feature 1TB, but if three memory densities are offered as in past launches, there may be insufficient demand for the 1TB and other two versions. For example, faced with a selection of 1TB, 512GB, or 256GB, many users would likely see no need for the 512GB or 256GB version. If there are only two versions: either 1TB and 512GB or 256GB and 128GB NAND, we would expect limited impact on NAND demand. We think 1TB memory densities will be limited to a few Pro series models.

In PCs, we highlight a significant impact on BOM costs from raised price and note moves to revert to HDDs and reduce cSSD capacity.

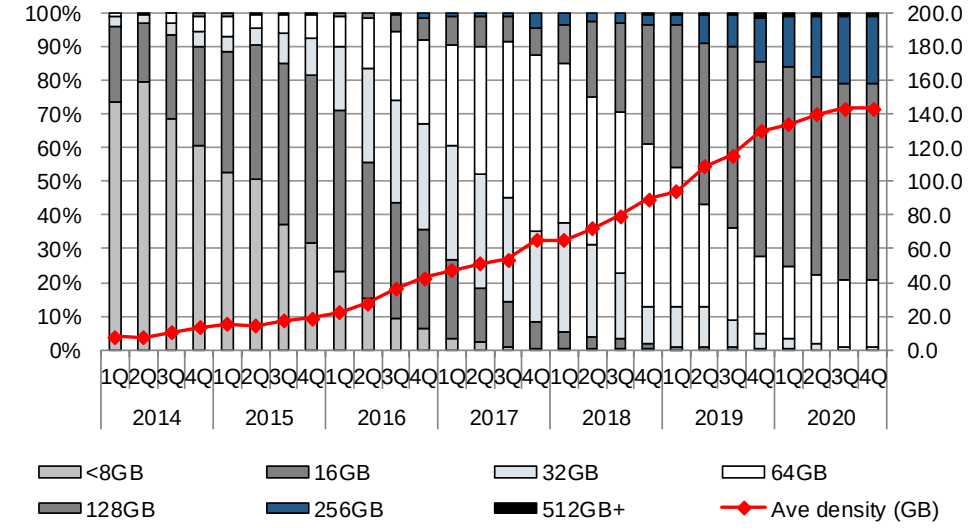
Risks to the earnings structures of NAND makers include increased sales of individual chips and packages, rather than entire eSSD, eUFS and other systems, given the prospect of Microsoft sourcing chips for in-house SSDs and Huawei potentially procuring individual chips as it transitions to in-house controllers. We thus believe NAND makers are now more likely to see increased demand for lower added value products. Given this, the risk of long-term product mix deterioration seems unavoidable.

Figure 40: NAND total demand bit growth and mobile phone bit growth



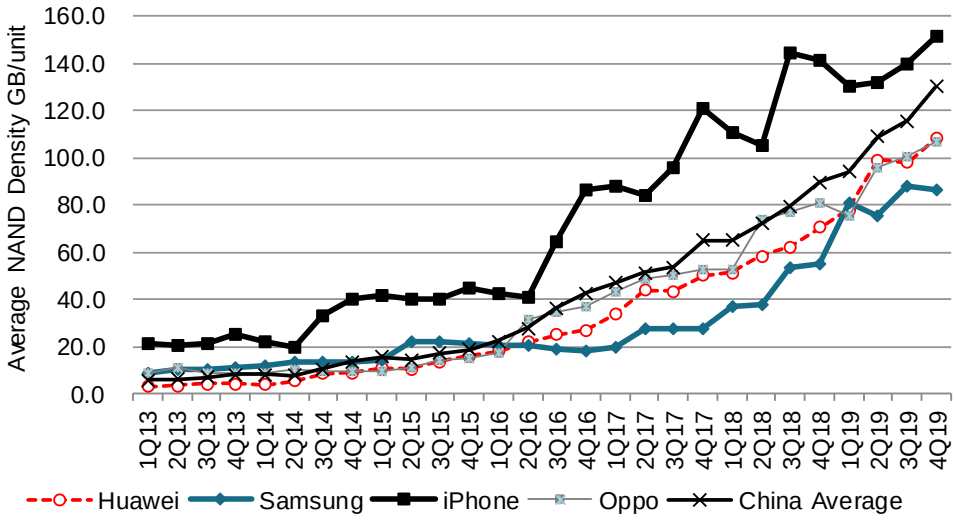
Source: Credit Suisse estimates

Figure 41: Chinese smartphone NAND density ratio trend estimates (including iPhone)



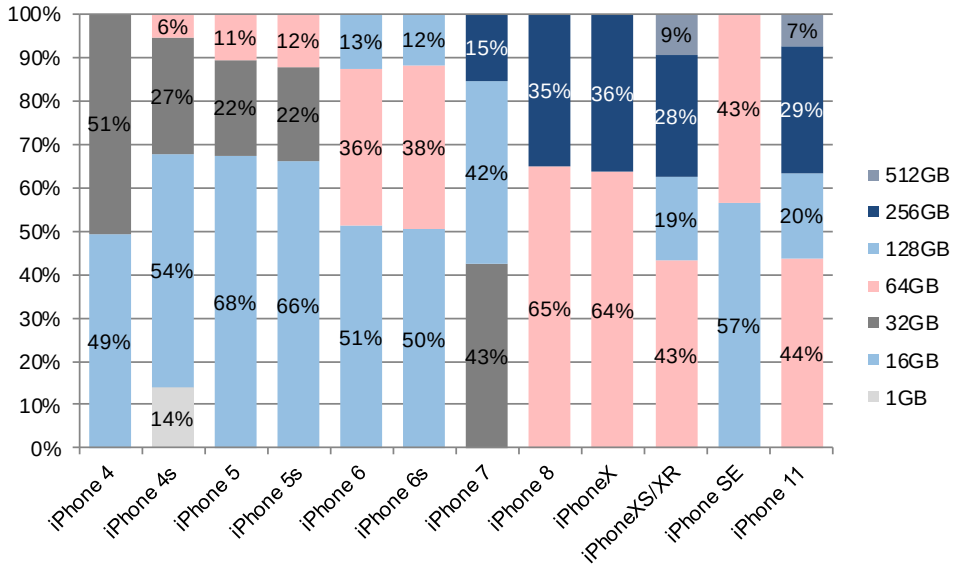
Source: IDC, Credit Suisse estimates

Figure 42: NAND density: iPhone, Samsung, Huawei, Chinese smartphone average



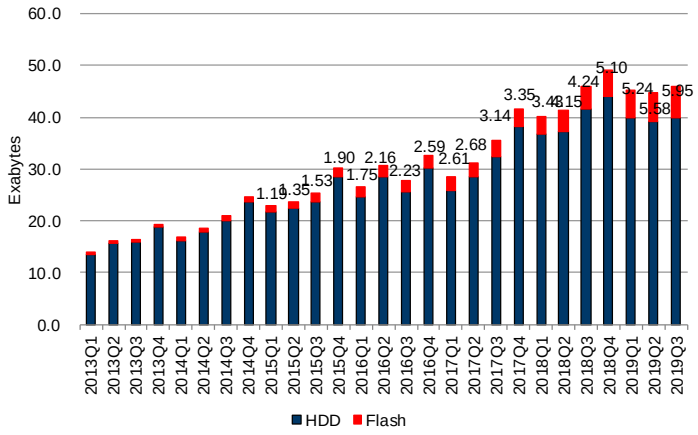
Source: IDC, Credit Suisse

Figure 43: Weighting by iPhone generation, storage option (based on four quarters since launch)



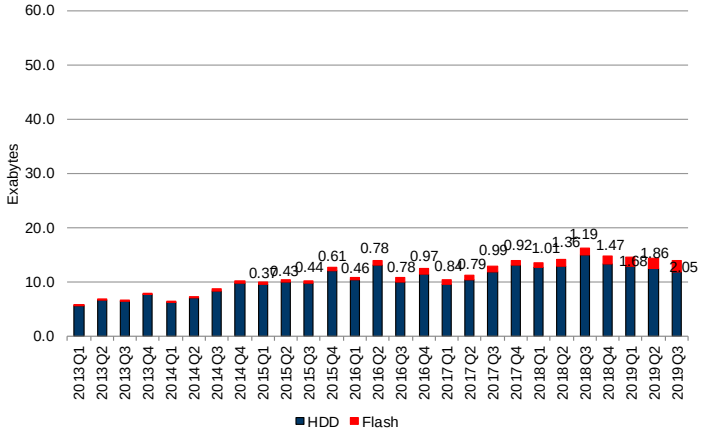
Source: IDC, Credit Suisse

Figure 44: Enterprise storage market (worldwide)



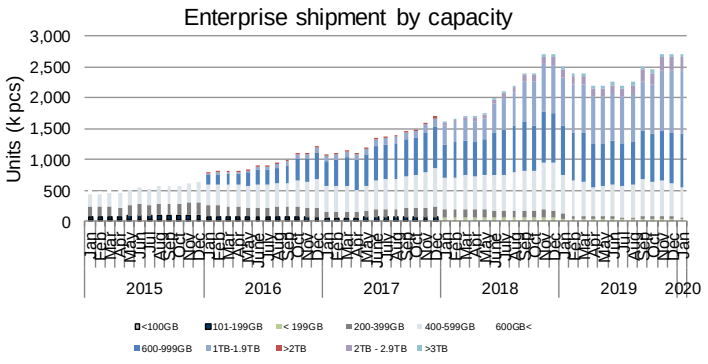
Source: TSR, Credit Suisse

Figure 45: Enterprise storage market (US)



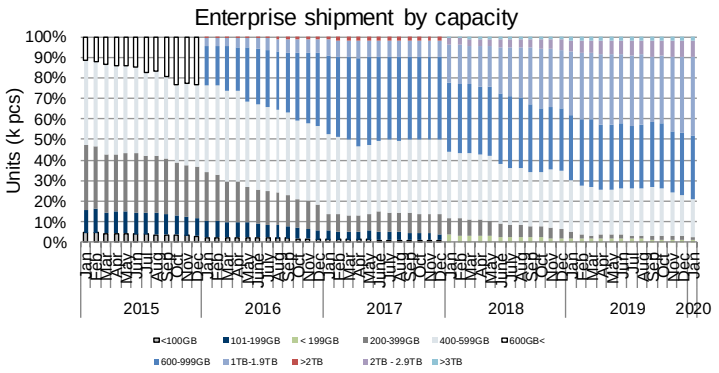
Source: TSR, Credit Suisse

Figure 46: Enterprise SSD shipments by capacity



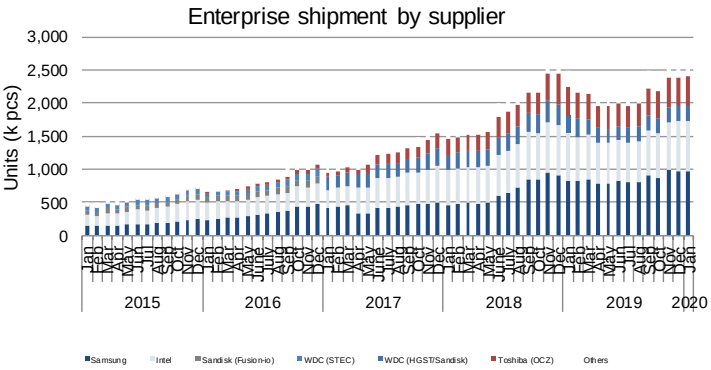
Source: TSR, Credit Suisse

Figure 47: Enterprise SSD shipment mix by capacity



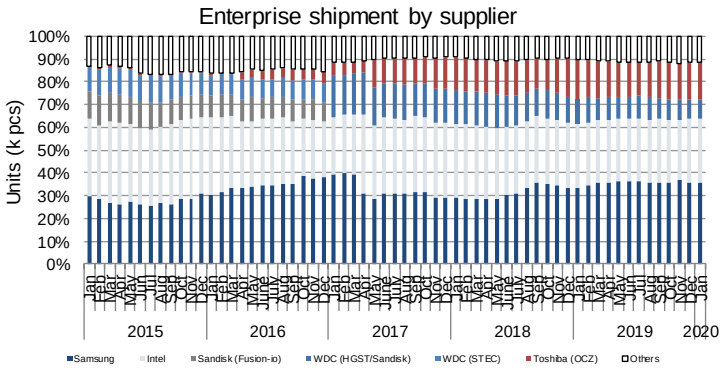
Source: TSR, Credit Suisse

Figure 48: Enterprise SSD shipments by maker



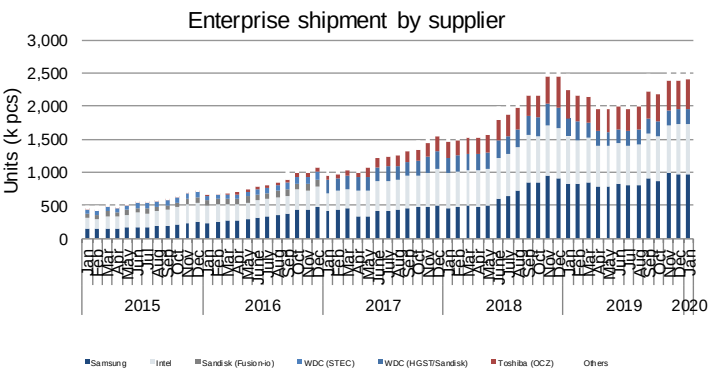
Source: TSR, Credit Suisse

Figure 49: Enterprise SSD share by maker



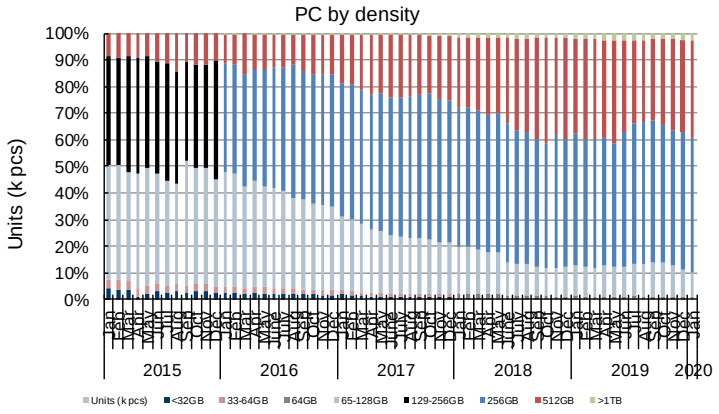
Source: TSR, Credit Suisse

Figure 50: PC SSD shipments by density



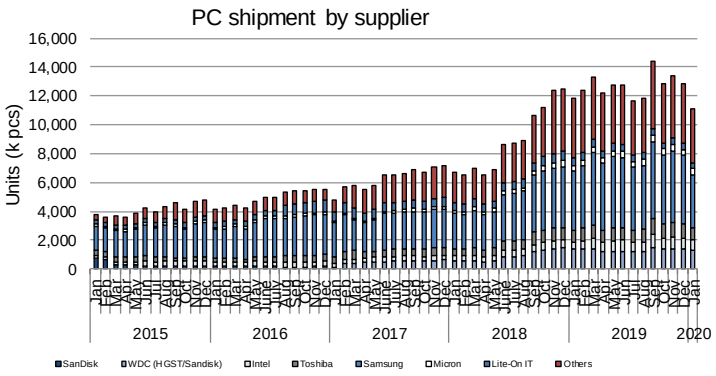
Source: TSR, Credit Suisse

Figure 51: PC SSD shipment mix by density



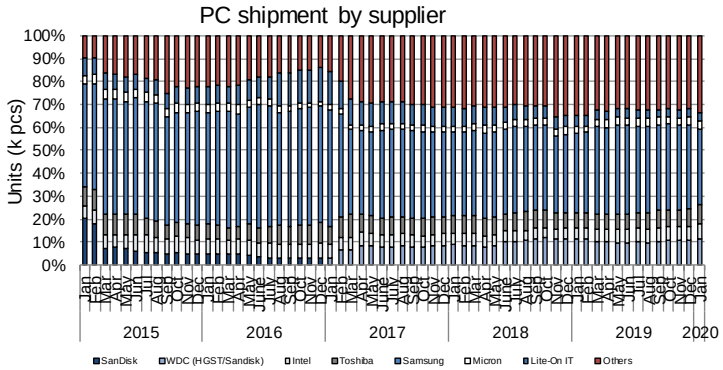
Source: TSR, Credit Suisse

Figure 52: PC SSD shipments by maker



Source: TSR, Credit Suisse

Figure 53: PC SSD share by maker



Source: TSR, Credit Suisse

NAND supply outlook

Market feedback

- We understand several NAND makers plan to curb capex to maximize cost leverage, if bit demand looks likely to grow 20–30% over the longer term.
- The NAND technology cycle has lengthened from one year to 1.5–2 years, so NAND cost structures should improve as the investment cycle become longer.
- SSD supply shortages have apparently occurred due to trouble shipping PCB substrates from the Wuhan facilities of Meiko Electronics and Tripod Technology. At Kioxia, SSDs accounts for less than 20% of shipment volume, but we understand that it sources most of its SSD PCBs from Wuhan, and that this is starting to impact customer SSD procurement.
- The start-up of production facilities at Xian Fab 2 appears over one month behind schedule, as SPE makers lack the resources to rollout the required systems. This could weigh on bit supply growth in CY20.

Potential for cost structure improvements

In our survey, we discovered little of interest regarding CY20 bit supply growth. Owing to COVID-19, the supply of SSD PCBs produced in Wuhan has halted, impeding the supply of Kioxia SSDs, which rely heavily on such PCB sources. As a result, Kioxia customers appear to switching to other suppliers. We estimate that Kioxia's SSDs account for 15–20% of the company's shipment volume, and that its production of cSSDs for PCs and eSSDs for servers has suffered. However, we do not expect a severe SSD shortage, as its customers for these products have been restocking inventories since 3Q CY19 and/or have their own SSD assembly lines.

COVID-19 is a factor pushing down supply as it appears to be delaying SPE deliveries in China, and impacting Samsung's Xian Fab 2 and YMTC expansion plans. However, we see no particular issues with underlying demand and therefore do not expect much impact on prices.

From the standpoint of NAND maker margins, we note the adoption cycle for cutting-edge processes seems to be lengthening from one year for 64-layer 3D NAND to 1.5–2 years for products with 9X or more layers. This could help improve cost structures at NAND makers.

NAND inventory trends

Market feedback

- Excess inventory of three months held by NAND makers in 1H CY19 has now moved to OEMs, retail trade, and distributors, but it appears that NAND makers do not know their exact levels at present; however, all NAND makers agreed that there was insufficient demand in CY19 to eliminate excess inventory of three months
- Some NAND makers continue to hold excess post-wafer process inventory; we understand these makers hold more than three weeks of excess inventory
- Some NAND makers still hold excess inventory of three to four weeks

None of the NAND makers were in position to track actual excess inventory levels in downstream

Demand over past year below that which eliminated 3-month inventory surpluses one year ago; suggests surpluses are likely at downstream customers

Since the upswing in NAND prices in July CY19, the consensus view in the equities market is that NAND prices have entered a recovery phase. However, our discussions with NAND makers show that there were retailers and distributors buying NAND at the time as well as a sales push by NAND makers since 2Q CY19, but no underlying demand to eliminate the level of excess inventory. Chinese smartphone makers also appear to be actively restocking. Since

4Q CY19, demand for Android OS smartphones has been weaker than expected, and we believe smartphone makers hold excessive inventory. Against this backdrop, the start of a correction in NAND demand by Huawei, which faces the risk of tighter sanctions in the future after being placed on the Entity List, suggests that excess inventories have reached a limit.

None of the NAND makers were able to explain how three-month excess inventory was handled a year ago and how this excess inventory was subsequently reduced, and merely stated that their own inventory levels were healthy. We think the supply–demand environment warrants concern over excess inventory at users. Looking at the NAND supply chain as a whole, we expect excess inventory to total eight weeks at end-1Q CY20.

NAND pricing outlook

Market feedback

- Prices continue to rise steadily, rising 10–15% in 1Q for all applications (outlook for a 10% rise in 2Q)
- In cSSDs, higher SSD prices have led to an excessive rise in PC BOM costs, and we understand that PC makers are considering reducing installed density per PC. cSSD prices bottomed at below $30 for 256GB but rose to $40 in 1Q; 512GB bottomed at around $45 but rose to $60–70.

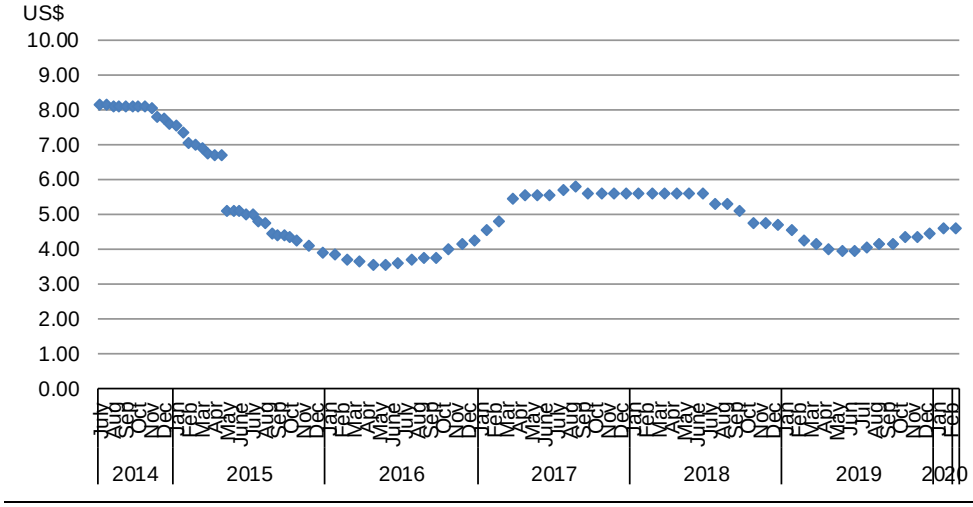
Price increases to continue in 2Q

NAND makers continue to raise prices

Given the urgent need for NAND makers to move into the black, we expect a 10–15% rise in 1Q for nearly all applications and a 10% price increase in 2Q.

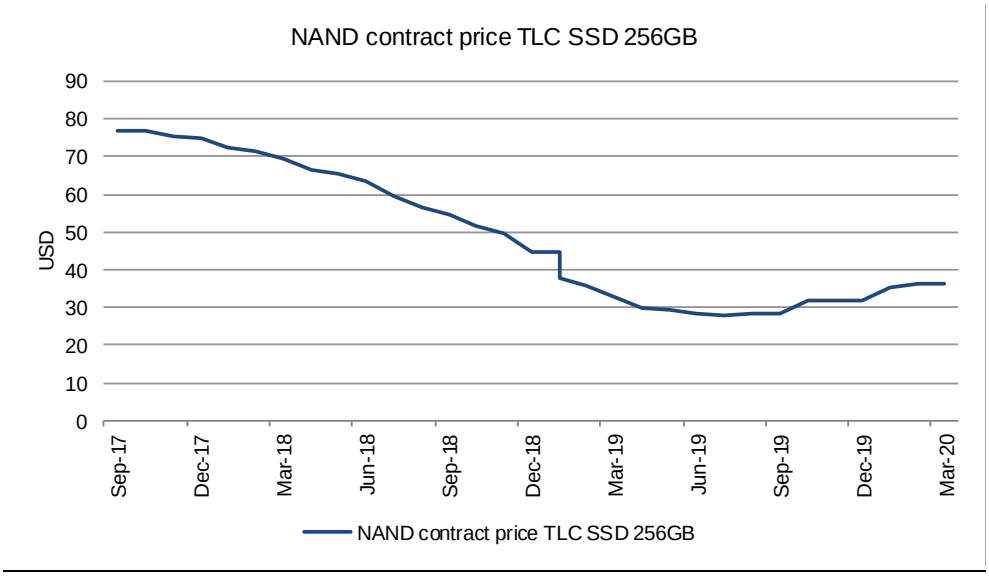
However, the adverse effects of price increases are starting to emerge, and PC makers have begun to consider reducing SSD capacity, even though they are unlikely to switch storage back to HDDs, given the excessive rise in BOM costs. We estimate a roughly 2% cost increase in selling prices as the price rises from the bottom by over $10 for 256GB and by around $20 for 512GB.

Figure 54: 128Gb MLC NAND contract price



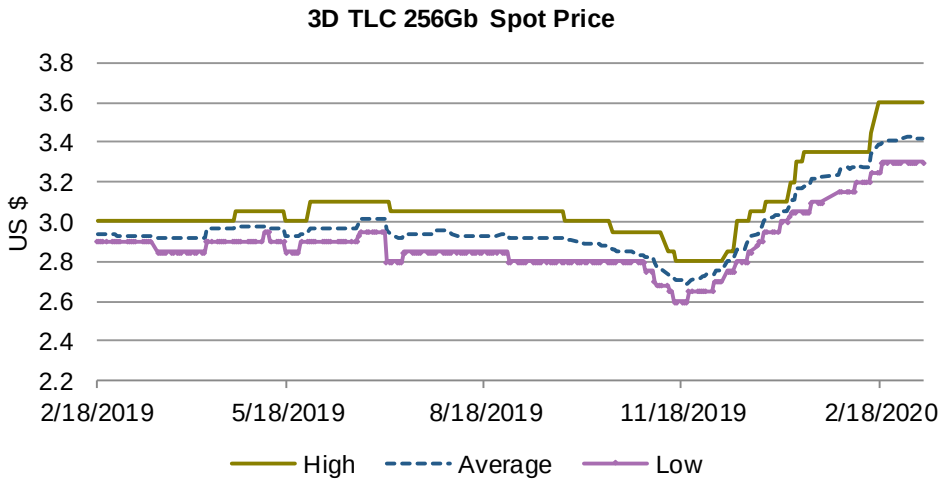
Source: DRAMeXchange, Credit Suisse

Figure 55: 256GB TLC SSD price



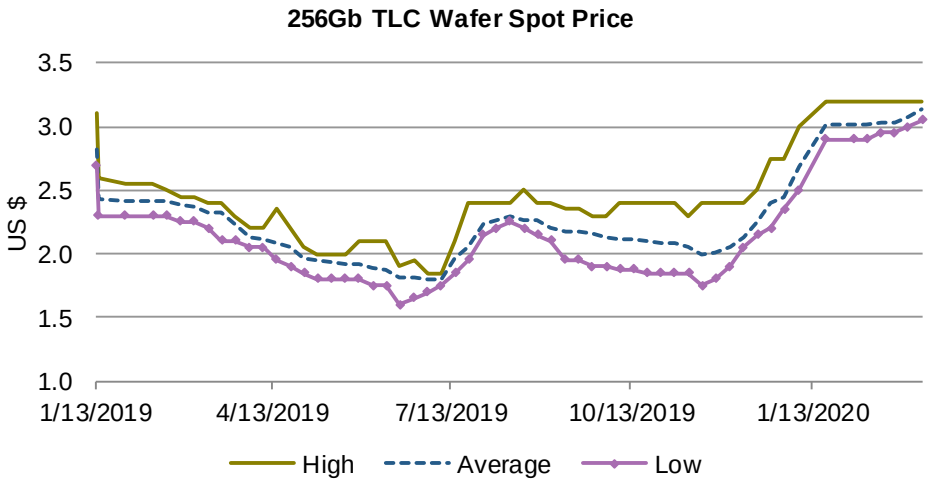
Source: Bloomberg, Credit Suisse

Figure 56: 3D NAND spot price (TLC 256Gb)



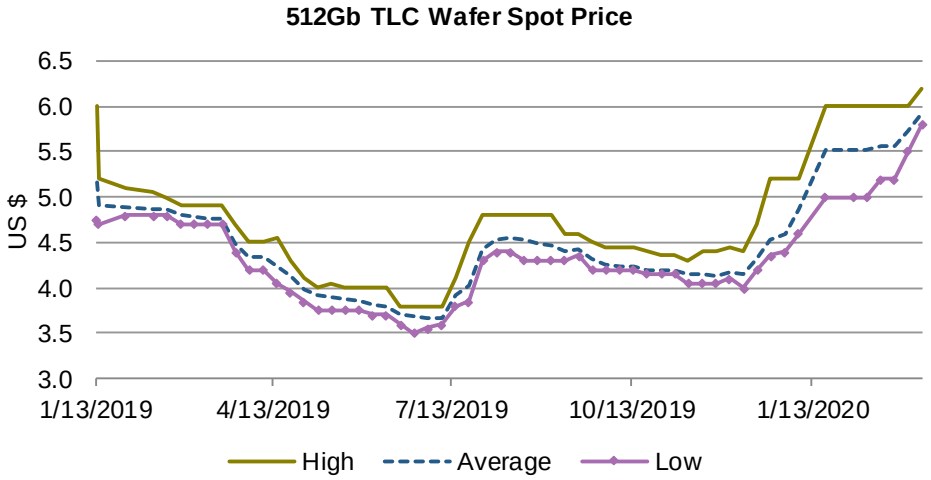
Source: DRAMeXchange, Credit Suisse

Figure 57: Wafer spot price (TLC 256Gb)



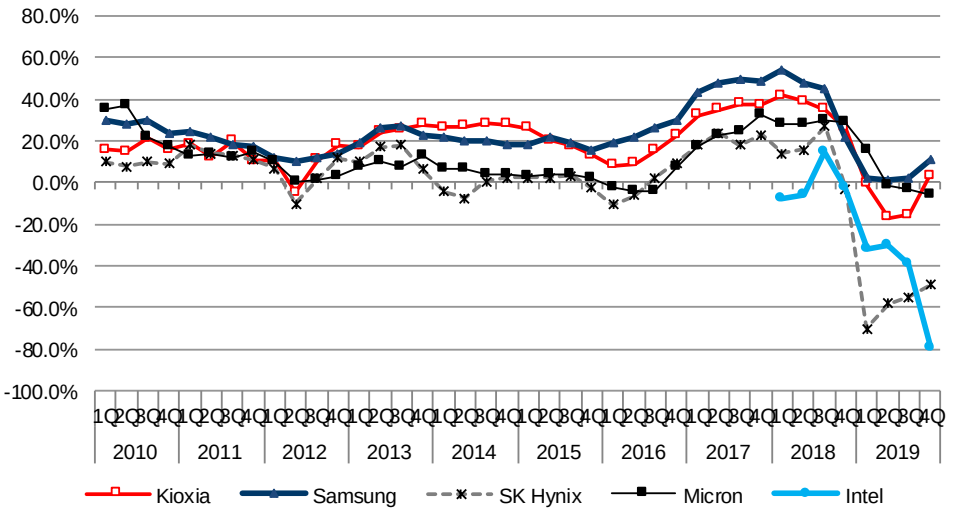
Source: DRAMeXchange, Credit Suisse

Figure 58: Wafer spot price (TLC 512Gb)



Source: DRAMeXchange, Credit Suisse

Figure 59: NAND makers OPM



Source: DRAMeXchange, Company data, Credit Suisse

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

Market feedback

- We note a gap among companies in 9X-layer development progress, but Samsung continues to lead the field. Kioxia has already been certified for cSSDs and continues to be assessed favorably for mobile applications other than eSSDs and iPhone. We understand SK Hynix has started securing certification.
- With the exception of Samsung Electronics, NAND makers are struggling with 96-layer cost reductions and certifications, so there are signs that they are concentrating development resources on the 1XX layer
- NAND makers that have been slow to mass produce 96-layer chips are planning to expand sales of 1XX-layer NAND rather than 96-layer NAND for enterprise applications, which take time to obtain certification
- We also expect gaps to emerge between companies in yields and costs for 1XX-layer chips. Development of 128-layer NAND (single stack) is behind schedule, and development at Kioxia, which has opted for 112-layer NAND (consisting of a 48-layer stack and a 64-layer stack), appears to be progressing smoothly compared with previous generations. Each company is still developing 1XX samples for the OEM market, and we understand that each company is behind schedule by more than six months.
- Some market participants think that Kioxia's fixed costs (the company has a low capex burden) could give it an edge over peers in 1XX-layer chips. However, declines in production capacity pose a challenge for the company.
- Demand for 512GB chips is low, and 256GB is expected to become the mainstream, even for 1XX-layer NAND. We understand that many customers continue to use 256GB due to chip size and firmware constraints. Given this, an increase in the chip surface area (in bit terms) for peripheral circuits makes it difficult to cut costs.
- In the 1YY model, which will follow the 1XX (112/128) layer NAND, the number of layers vary by company (160/176 layers), but we expect at least 2 stacks at all companies

- YMTC aims for mass production of 128-layer NAND using its Xtacking architecture in CY20. In addition to Xtacking 2 layers of 64-layer NAND stacks, the company also plans to build a three-layer structure that combines logic.

Opportunity for Kioxia to take a lead in cost and mass production in 1XX-layer development

In 1XX-layer NAND, makers saw development delays but Kioxia's initial production lots went well. Potential cost reductions due to reuse of equipment

In 9X-layer NAND, Samsung had already achieved yields of over 90% in 92-layer NAND as of 4Q last year, ahead of its competitors. However, rivals have started to concentrate their development resources on 1XX-layer rather than 96-layer NAND. Since 96-layer yields are poor at non-Samsung NAND makers, bit growth and cost improvement are unlikely even if production ratios rise. This means the cutting-edge process ratio is no longer an indicator of bit growth and cost improvement. Western Digital and Micron are able to supply different grades of chips due to their rework capability, so they can increase the ratio of 96-layer chips compared to Kioxia and SK Hynix. However, we are skeptical whether this equates to competitiveness. Samsung remains the leader in 9X-layer NAND.

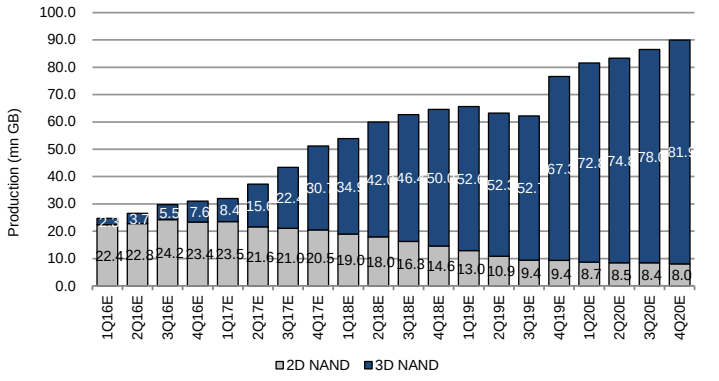
In the next-generation 1XX layer, we believe that Kioxia has the opportunity to lead the way in terms of development and cost. More specifically, we expect full-scale mass production to start in CY21 given the company has yet to ship samples. However, equipment makers have told us that initial lots are satisfactory compared with previous generations (48/64/96 layers), when Kioxia had struggled to ramp up. Moreover, because 112-layer chips use 48- and 64-layer stacks, depreciation costs are likely to be lower (except for some additional equipment) as existing equipment can be reused. In contrast, other companies have been behind schedule in their development plans, and we estimate that development has been delayed by more than six months across the board. The company is yet to ship samples for the retail and other markets, which are not that particular about quality, as well as for the OEM market, and we expect it to do so after mid-CY20.

In the next-generation 1YY-layer chips, we expect Samsung Electronics, which has continued to use the one-stack process up to 128 layers, to move to two stacks.

In terms of cost, customers tend to prefer 256GB chips, and although 512GB and 1TB chips will enjoy a significant cost advantage in 9X and 1XX layers, we expect 256GB to remain the mainstream in the 9X and 1XX generations. We understand that there are few benefits for customers in switching to 512GB chips from the standpoint of chip size limit, speed, and firmware development. In this case, the amount of space per chip for peripheral circuits other than NAND circuits would increase (NAND circuits would reduce chip size due to multi-layering), eliminating some of the cost-cutting benefits of multi-layering.

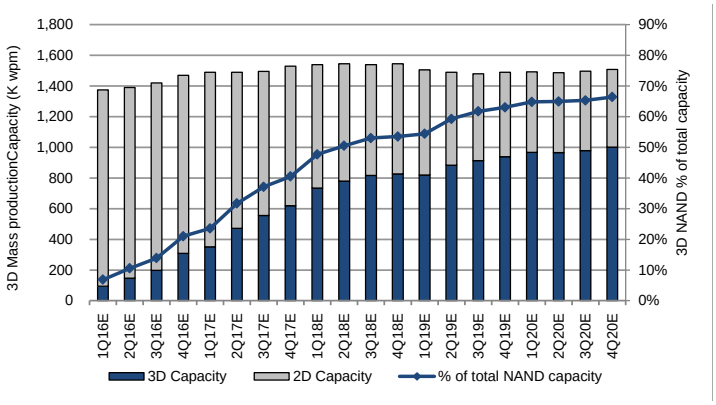
Thus, looking at cost reduction as a reason for investing in cutting-edge processes, annual cost reductions have generally been slower with 256GB chips due to a longer generational change cycle resulting from development delays and strong demand. Consequently, Kioxia's reuse of existing equipment could prove successful. However, there is still a need for additional investment to replenish production capacity as the above involves a trade-off in terms of reduced output capacity. Gaining cost advantage may not be that simple, but it may still be worth monitoring in terms of a potential gap versus the past.

Figure 60: 2D/3D NAND supply bit forecasts



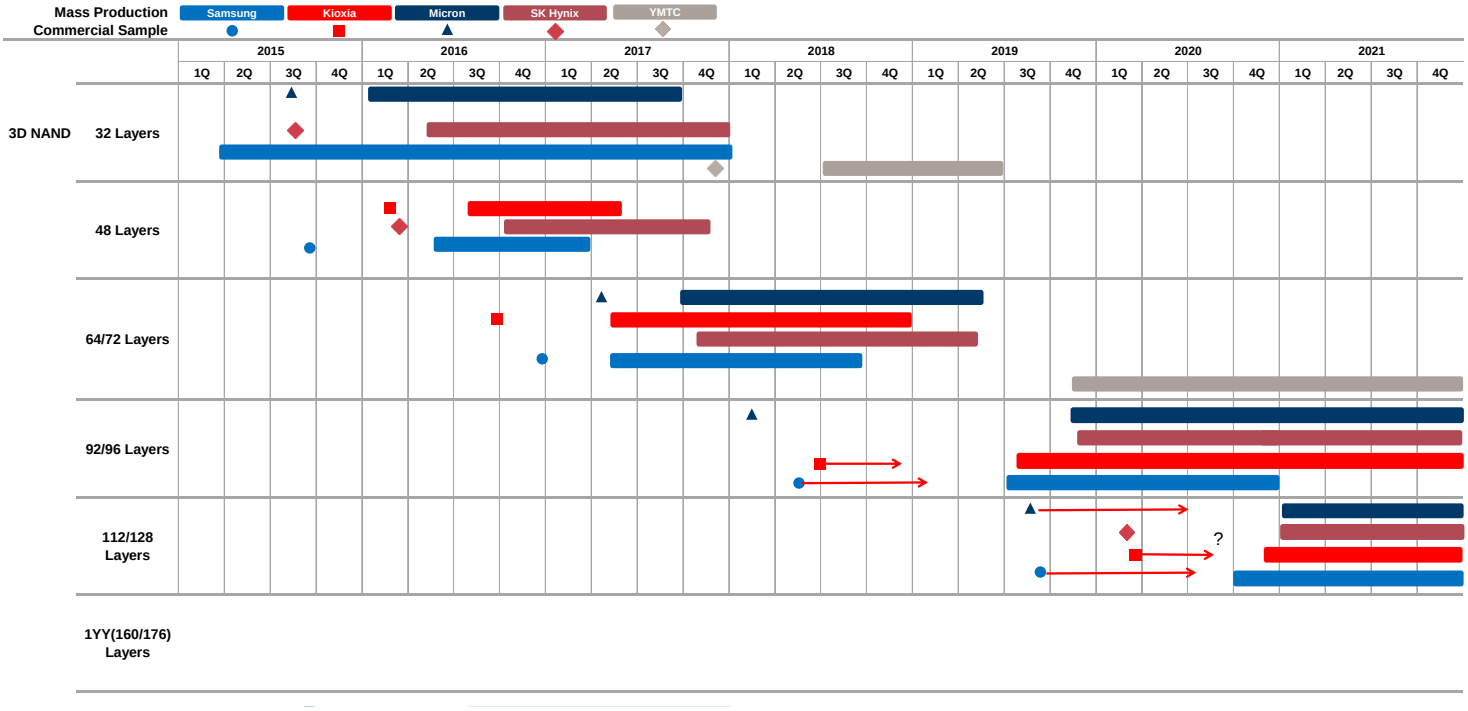
Source: Credit Suisse estimates

Figure 61: D/3D NAND production capacity forecasts



Source: Credit Suisse estimates

Figure 62: NAND makers' 3D NAND technology roadmap (sample/volume production is supply to OEMs, excluding retail/proprietary brands)



Source: Credit Suisse estimates

Front-end SPE market

Our view based on channel checks

Covid-19 outbreak impacting equipment starts. No specific plans for new memory-related investment

We believe the impact of COVID-19 will be that, as a result of global SPE companies repatriating their engineers, (1) the startup of equipment at investment projects in China (including the Samsung Electronics Xi'an Fab2 and ones by CXMT, SMIC, and HuaLi) will be delayed, and (2) capacity utilization will be at risk of declining owing to a shortage of maintenance personnel and an inability to cope with any upcoming equipment issues. We maintain our cautious investment stance on wafer fab equipment (WFE), as we see absolutely no sign of new investment plans, foundry investment is peaking out, and memory investment is unlikely to recover in 2H. Aside from Samsung Electronics and local Chinese makers, memory makers remain cautious on capex, and we see no signs of any changes to capex plans due to the impact of COVID-19.

We expect the WFE market to reach $39.5bn in CY20 (-4% YoY) and $42bn in CY21 (+6%). 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 consensus expectations for the stock market.

We do not expect a recovery in memory makers' capex for five main reasons. (1) Smartphone makers and the hyperscalers restocked both DRAM and NAND in 4Q CY19 and 1H CY20 owing to the risk of tight supply–demand conditions in 2H CY20, 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 some managements are withholding FID approval until then. (3) DRAM manufacturers are reluctant to invest because of delays to 1znm-process development and low ROI. (4) NAND manufacturers are seeing low yields on 96-layer chips and limited investment in the mass production of such chips (which are expected to increase in CY20). (5) In 3D NAND, 96-layer is viewed as a short node, and the timeframe for 1XX layer is CY21, so there is likely to be a pause in investment in CY20.

TSMC could resume production of 5nm-process chips in CY21, if customers utilizing them increase

Regarding foundry investment, we previously expected a change in the new iPhone product cycle to two cycles per year (spring and autumn) in CY21. However, Apple appears to have reverted to one cycle in autumn, although the reason is unclear. If this results in TSMC winning new customers and failing to normalize production for the iPhone, the company may need to invest in 5nm-process capacity expansion to meet demand. Our previous forecasts were premised on two new product cycles per year for the iPhone, so we had thought that iPhone-related production would level out and that existing production capacity would be sufficient to meet demand for some time even if TSMC obtained new 5nm-process customers. As a result, we have expected no investment in expanding 5nm production capacity for the time being. We intend to keep a close eye on trends at customers using 5nm processes.

Market feedback

- TSMC plans to install equipment at a 3nm-process R&D pilot line in mid-CY20.
- The company intends to introduce 7nm processes at its 300mm Nanjing Fab in late CY20.
- SMIC and HuaLi each plan to expand their 14nm lines in 2Q CY20 and enter volume production.
- Local Chinese DRAM maker CXMT intends to ramp up monthly production to 30-40k units by end-CY20 (vs. 5k units at end-CY19), as planned.
- However, due to the impact of COVID-19 on the Chinese market, major SPE makers have delayed plans to start up equipment due to staff shortages. Plans have been on hold for more than a month, going back to the Lunar New Year holidays.

- Kioxia plans to expand capacity to 20k/month (currently 7.5k). Its outlay is limited as it is both transferring equipment from the Yokkaichi plant and purchasing new equipment.
- Samsung Electronics plans to introduce 1znm DRAM process technology at Pyeongtaek Fab2 (P2) in 2H CY20. In NAND, the company plans to invest in line with the increase in the ratio of 128-layer NAND production in CY21.
- There is a shortage of maintenance personnel in the Chinese market. Although there are no problems at present, capacity utilization could be at risk of declining if there are equipment issues that local engineers are unable to deal with.
- The investment schedule for Intel's 7nm process remains fluid as the company has yet to decide whether or not to use EUV lithography.
- EUV process volume production yields remain low and have yet to improve. Korean makers at only 30–40%.
- Completion of EUV mask pellicle development is not expected until 2Q CY21 at the earliest.

Specific investment projects concentrated in China

China accounts for two-thirds of planned capacity expansion - reflecting Covid-19 impact

Specific memory-related capacity expansion projects that we are aware of (excluding process migration) include (1) Samsung Electronics' plan to expand its Xi'an Fab2 plant (from 20k per month at end-2019 to 60–65k by end-2020); (2) Samsung Electronics' Pyeongtaek Fab2 1znm process prototype line (10–20k by end-2020); (3) expansion of the Kioxia Kitakami Fab1 (K1) (from 7.5k at end-2019 to 20k by end-2020); (4) local Chinese DRAM manufacturer CXMT Fab1 project (from 5k to 30–40k); and (5) local Chinese NAND maker YMTC Fab1 project (from 20k to 40–50k).

We also expect logic and foundry projects including (1) TSMC's 3nm R&D pilot line (a 5–10k line; equipment installation in mid-2020); (2) TSMC's Nanjing Fab1 start of 7nm process (+5k by end-2020); (3) SMIC 14nm process (+5–10k in 2Q 2020); and (4) HuaLi 14nm process (+5–10k in 2–3Q 2020).

Of the nine expected projects, six are in China. There are specific projects that may not be affected by COVID-19, but signs of delay in delivery schedules are already appearing with the return home of engineers called in for the launch by US, European, and Japanese SPE makers. Equipment installation at Samsung's Xi'an Fab has been halting since early February, and we expect some impact on 2020 output (1–2% hit to bit supply growth for every one-month delay). For local Chinese investment, we expect the CXMT project to proceed in line with plan, albeit with some equipment installation delays. YMTC was able to attract staff from global rivals, but we doubt staff will return to Wuhan, the epicenter of the COVID-19 outbreak, so YMTC is likely to face delays.

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

Makers cautious on investment

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. 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 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. With recent demand from smartphone makers and data centers largely driven by restocking, we think that more and more memory makers concerned about a subsequent pullback in demand.

We still see a significant disconnect between SPE makers' expectations for a recovery in memory investment in 2H 2020 and memory makers' cautious investment stance.

Foundry investment could boost 5nm capacity in 2021

5nm-process investment could resume in CY21

In our report last December, we noted that Apple was expected to split its flagship iPhone releases into separate spring and fall cycles starting in 2021. Based on our current survey, however, we understand that Apple will stick with its fall-only releases. We had assumed that TSMC would require production capacity for cutting-edge processes for new iPhone models to peak at 40–50k/month assuming a fall-only release, or around 30k/month (due to the leveling-out of production) under a spring-fall release cycle. We had thought that the shift to a spring-fall release cycle could leave TSMC with some excess 5nm capacity in 2021. For this reason, if Apple sticks with the fall-only release schedule in 2021, the need to secure peak-period production capacity for the iPhone would likely require TSMC to invest in capacity expansion if it acquires new 5nm process customers. However, the second-generation 5nm process will likely be used for the new iPhone models, so we think investment would be limited to an increase in EUV layers.

Moreover, yields on EUV processes at TSMC and Samsung Electronics have not improved much, partly due to the lack of EUV-masks pellicles. We do not think EUV mask pellicles will be ready for volume production until 2Q 2021 at the earliest; until then, we expect demand for EUV process inspection systems to remain brisk.

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

Regarding 14nm process investment in China, we believe SMIC has the lead in 14/16nm process development thanks to its hiring of a former development executive 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. For this reason, TSMC likely needs to develop superior technology vs SMIC and HuaLi for its Nanjing Fab. We think it will shift its plans to non-EUV 7nm process by end-2020 (our survey three months ago assumed 16nm process expansion instead).

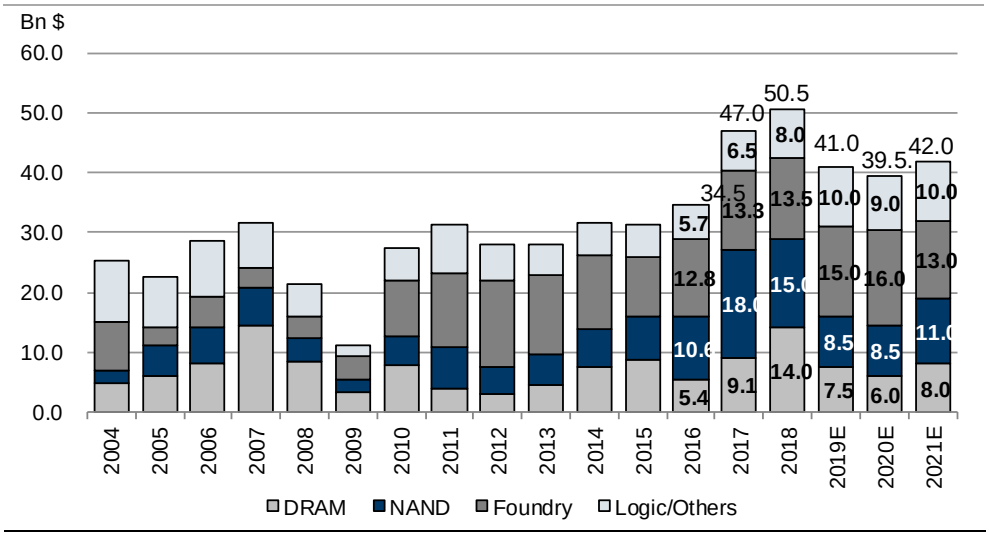
WFE market forecast

In light of the above, our Japan Technology team forecasts the wafer fabrication equipment (WFE) market to grow by $39.5bn in 2020 (-4% YoY, previously $39bn) and $42bn in 2021 (+6%).

For existing memory applications, memory makers have no choice but to be somewhat cautious on new capacity expansion: in data centers, DRAM makers have not established strong relationships with clients, while in NAND, where over 50% of demand is accounted for by smartphone applications, players face a cloud-driven structural slowdown in the pace of growth in installed memory capacity. Accordingly, even if memory makers' profitability improves in 2021 due to a recovery in memory prices, we think it will be difficult for them to invest in capex.

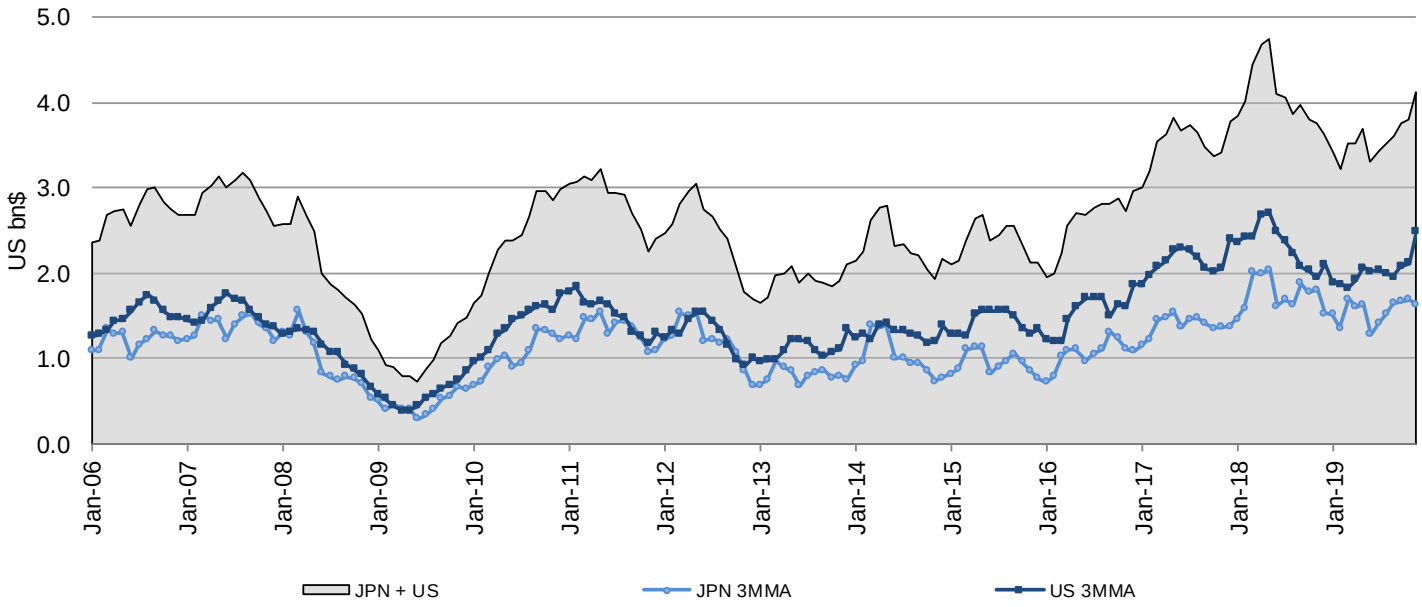
With the exception of Intel's 7nm process investment, we think logic and foundry investment is likely to slow in 2021.

Figure 63: WFE market forecast (Japan team estimates)



Source: Credit Suisse estimates

Figure 64: SPE sales



Source: SEMI, SEAJ

Back-end SPE market outlook

Our view based on our survey

In China, major OSATs still investing, SME inquiries slow slightly; uptrend in Taiwan OSAT investment over for now

There was no notable movement in the overall investment cycle; we get the impression that capex is steadily moving forward based on individual technology themes.

In 4Q 2019, Taiwan's OSAT capex was strong, bucking seasonal trends, but investment appears to have eased. In the Chinese market, COVID-19 is having an impact on factory utilization, although inquiries from major OSAT makers remain brisk. Inquiries from SMEs have weakened on the other hand, likely reflecting credit risk concerns stemming from COVID-19.

In addition, players are looking at moving production bases out of China or investing in factory automation as a means of addressing their high reliance on China or China-based operators—a weakness that has been highlighted by the COVID-19 outbreak. However, we do not expect this to be a particularly promising source of demand for now, as these discussions have yet to develop into concrete plans.

Individual themes of note for our most recent survey include DDR5, HBM2, FO-PLP (fan-out panel level packages), and plans by Chinese home appliance makers to build out their own semiconductor assembly operations. So far, however, we do not see signs of sufficient scale or specific plans that could be expected to boost back-end maker orders.

DDR5 investment has peaked out for now, and weaker-than-expected demand has led DRAM makers to shift a cautious tone for DDR5 adoption.

As we noted in the DRAM section, HBM2 is expected to double in 2020 following the demand dip in 2019. However, this likely doubling would only represent 20% growth vs 2018. While we are seeing some HBM2-related capex, the overall scale remains limited.

FO-PLPs are only used in PMICs so far, with minimal progress made in application processor (AP) applications. Capex for now is limited to R&D.

In assembly-related investment for China's appliance makers, the major air conditioner maker Gree is investing in its own power semiconductor back-end processing plant, while home electronics major Konka Group plans to build back-end processing facilities to meet internal demand. However, we do not think the scale of investment will be as large as that for the major OSATs.

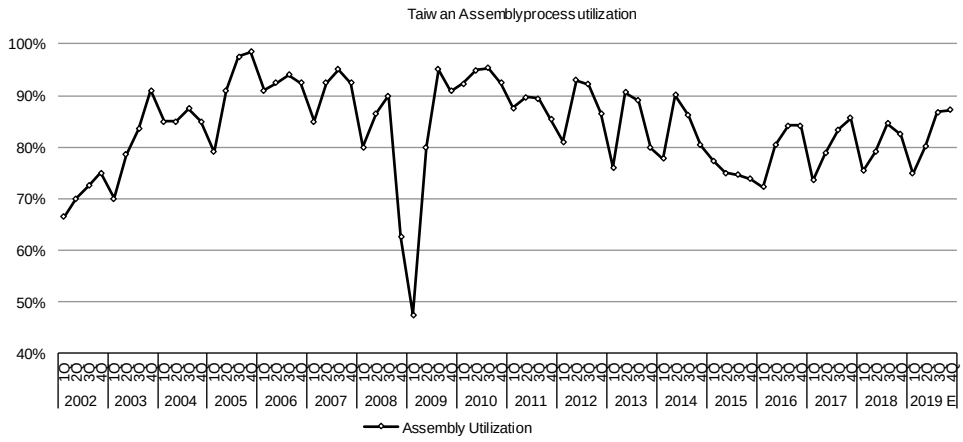
Market feedback

- Operating rates at major Chinese OSAT makers remained at 70–80% around the Chinese New Year. However, capacity utilization is low at plants where rates had fallen during the Chinese New Year, as operators have yet to return.
- For antenna-in-package (AiP), the former SPIL has started commercial-scale production for Qualcomm. Volume production for MTK is likely to start soon, and ASE plans to start volume production for Apple.
- Samsung Electronics has started placing orders for front-end testers for HBM and 1znm pilot line.
- The initial investment in DRAM DDR5 has run its course; the next cycle is expected in 2H 2020. Continued investment in DDR4 (process migration, HBM-related).
- 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.
- Major home appliance maker Konka Group plans to build its own memory assembly plant (automated lines). Following the lead of Gree's power semiconductor back-end processing

plant, major home appliance makers are also building out their own in-house semiconductor assembly facilities.

- In the Chinese market, resource shortages are causing delays in new plant construction and equipment installation. Some facility installation is still awaiting government approval.
- For back-end processes, the current order environment in the Chinese market remains largely unchanged compared to the situation before the full-fledged start of the COVID-19 outbreak; inquiries and orders over Feb–Mar so far remain largely as expected. However, inquiries from SMEs appear to be slowing.
- While many players are discussing the idea of moving production out of China, this has yet to proceed to concrete plans.
- We understand there has been no increase in inquiries for assembly process automation in China.

Figure 65: OSATs: Assembly capacity utilization forecasts



Source: Company data, Credit Suisse estimates

Other

Our view based on market survey

Supply-chain moves to bolster sourcing in response to Covid-19

COVID-19 impacts have temporarily reduced capacity utilization for factories in China to 40% or less, but many companies expect this figure to recover to 70–80% in March with a possible return to full capacity in April. However, the soaring cost of air freight (to roughly four times the normal rate) and difficulties in securing cargo space are leading companies to consider switches to sea freight. Such moves generally only mean a few days' delay if shipping within Asia, but the situation is likely to begin affecting the air cargo-reliant semiconductor-related trade if numbers of flights between China and the US and Europe continue to fall going forward. Many suppliers are likely to experience higher-than-average demand because supply chain disruption and related procurement risks have prompted customers to bring orders forward since the latter half of February.

There is also evidence that COVID-19 is causing delays in installing equipment as part of capex programs in China. Companies are deferring installation of 5G network base stations due to personnel shortages and other logistical constraints, and factories are struggling to install machinery due to a lack of engineers. This issue is especially acute in the precision equipment sector, where there is often few local back-up staff.

Weak demand for automotive, industrial, consumer-electronics, and other applications

Demand projections for semiconductors and other electronic components have already been lowered for major consumer electronics sectors such as air-conditioners, as well as the automotive and industrial sectors where the correction has now lasted at least a year. While expectations of a recovery have not been extinguished, uncertainty remains the critical prevailing factor. Within the air-conditioning sector, demand remains firm for semiconductors and electronic components for inverter A/C systems (including power semiconductors, transformers, and medium-to-high-voltage capacitors) because firms see these products continuing to enjoy subsidies in China. Aggregate air-conditioner unit output in 1H CY2020 is expected to decline in YoY terms.

COVID-19 impacts

- The general prevailing view for capacity utilization in China is that it will recover from 40% in February to 70% in March and 100% in April.
- Capacity utilization in China within the consumer electronics sector is 50%, but 80% of factory operators has returned now, expecting a return to production as normal by the end of March.
- All the vendors that we surveyed expect production in China to improve in March before a return to full capacity in April, but some firms also expressed concerns about extended supply chain disruption due to the risk of potential COVID-19 impacts on production by suppliers outside China.
- Supply chain vendors harbor a range of differing outlooks about what will occur once the COVID-19 outbreak in China has died down. Some expect a rush of orders, while others envisage inventory corrections due to ongoing issues such as lower incomes in China or intermediaries having operational financing woes.
- Air freight rates into China have risen to about four times normal, and there are difficulties in securing cargo space. Domestic road haulage within China is also fraught with difficulties due to driver shortages and issues obtaining permits.
- In some cases, goods cannot be received because the warehouses in China or Hong Kong are full. This is resulting in the return of shipments, or in suppliers reconsidering whether to proceed with ex-factory shipments.

- COVID-19 impacts are resulting in the deferral of 5G base station investment programs due to a lack of delivery trucks and critical installation resources.
- Capex programs in China requiring the installation of equipment from overseas are experiencing delays because the global manufacturers cannot dispatch the required personnel to the site and remote set-up via smartphone or video link is not a viable option.
- The bankruptcy risk for Chinese intermediary firms is now lower than in the first half of February.
- The experience of COVID-19 is leading many manufacturers to take a further look at ways to reduce their degree of Chinese supply-chain dependence.
- Companies are hopeful of economic stimulus measures in China going forward in the form of infrastructure investment (including public works and railways).

Automotive, industrial, consumer (air-conditioners)

- Demand for automotive semiconductors is sluggish globally, except for Toyota. Even the Toyota Group has seen production in China affected, with production shifted in part to Japan.
- The EV market in China is likely to expand marginally in 2020 to approximately 1.2–1.3mn vehicles, against an official forecast of 2.0mn. Many observers think volume growth will require additional government subsidies.
- Demand in India for two-wheel vehicle-related semiconductors is sluggish.
- Demand for industrial semiconductors has been recovering since December. However, compared with the earlier projections of a 30% rebound in March, it appears that COVID-19 has knocked the sector back. Uncertainty prevails.
- In air-conditioners, initial 2020 projections will probably be revised downward by 10–20%. The latest forecasts point to a YoY fall in production in 1H CY2020, followed by positive YoY growth in 2H.
- A/C system production and related semiconductor demand remain firm, though there are still no signs of recovery in capacity utilization at Gree or Midea.
- With both Gree and Midea planning to shift completely to inverter-type models, demand is increasing for power semiconductors, transformers, and medium-to-high-voltage capacitors.
- Procurement of semiconductors and components is rising on the assumption the risk of supply chain disruption will persist for all applications sectors across the entire Chinese market (including smartphones, automotive and consumer electronics). Order volumes have reportedly been increasing significantly since the final week of February.

Gaming consoles

- Demand is still firm for gaming console-related components for Nintendo and Sony, with no apparent drop-off in orders following the seasonal pre-Christmas rush. However, production bottlenecks are reportedly emerging, with Foxconn and other vendors unable to increase capacity utilization within China.
- The CY2020 production forecast for Sony PS5 consoles is around 6mn units. Related memory requirements are 16GB of DRAM and 768GB of SSD storage. We expect memory to cost more than $150 on its own.

Displays

- Companies do not harbor realistic expectations of the micro-LED market taking off over the next two or three years.

- The supply of development boards, PCBs and other LCD-related components has reportedly begun to dry up because of the concentration of suppliers in the Wuhan area.

Companies Mentioned *(Price as of 11-Mar-2020)*

ASE Industrial Holdings (3711.TW, NT$67.3)
ASML Holding N.V. (ASML.AS, €238.0)
Advantest (6857.T, ¥4,520)
Alibaba Group Holding Limited (BABA.N, $198.91)
Alibaba Group Holding Limited (9988.HK, HK$197.0)
Alphabet (GOOGL.OQ, $1210.9)
Amazon com Inc. (AMZN.OQ, $1820.86)
Anritsu (6754.T, ¥1,693)
Apple Inc (AAPL.OQ, $275.43)
ByteDance (Unlisted)
CXMT (Unlisted)
China Mobile Limited (0941.HK, HK$57.55)
DISCO (6146.T, ¥20,580)
FOXCONN TECHNOLOGY (Unlisted)
Ferrotec (6890.T, ¥549)
Gree Electric (000651.SZ, Rmb59.63)
HiSilicon (Unlisted)
HuaLi (Unlisted)
Huawei (Unlisted)
Intel Corp. (INTC.OQ, $51.66)
JEOL (6951.T, ¥2,337)
JSR (4185.T, ¥1,742)
KONKA GROUP (000016.SZ, Rmb12.58)
Kioxia (Unlisted)
Lasertec (6920.T, ¥4,630)
MediaTek Inc. (2454.TW, NT$363.0)
Meiko Elctrncs (6787.T, ¥1,525)
Micron Technology Inc. (MU.OQ, $43.72)
Micronics Japan (6871.T, ¥762)
Microsoft (MSFT.OQ, $153.63)
Midea Group (000333.SZ, Rmb54.47)
NVIDIA Corporation (NVDA.OQ, $246.47)
Nintendo (7974.T, ¥35,470)
OmniVision (Unlisted)
QUALCOMM Inc. (QCOM.OQ, $74.62)
SCREEN (7735.T, ¥4,815)
SK Hynix Inc. (000660.KS, W85,500)
SMIC (SMI.P^F19)
SUMCO (3436.T, ¥1,477)
Samsung Electronics (005930.KS, W52,100)
Shin-Etsu Chemical (4063.T, ¥10,850)
Sony (6758.T, ¥6,145)
TOWA (6315.T, ¥742)
Taiwan Semiconductor Manufacturing (2330.TW, NT$302.0)
Tencent Holdings (0700.HK, HK$378.4)
Tokyo Electron (8035.T, ¥20,835)
Tokyo Ohka Kogyo (4186.T, ¥3,655)
Tokyo Seimitsu (7729.T, ¥2,946)
Toyota Motor (7203.T, ¥6,535)
Tripod Technology (3044.TW, NT$108.5)
United Microelectronics (2303.TW, NT$14.8)
Western Digital (WDC.OQ, $45.14)
Yangtze Memory Technology Corporation (Unlisted)

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.

As of December 10, 2012 Analysts' stock rating are defined as follows:

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.*

Restricted (R) : In certain circumstances, Credit Suisse policy and/or applicable law and regulations preclude certain types of communications, including an investment recommendation, during the course of Credit Suisse's engagement in an investment banking transaction and in certain other circumstances.
Not Rated (NR) : Credit Suisse Equity Research does not have an investment rating or view on the stock or any other securities related to the company at this time.
Not Covered (NC) : Credit Suisse Equity Research does not provide ongoing coverage of the company or offer an investment rating or investment view on the equity security of the company or related products.

Volatility Indicator [V] : A stock is defined as volatile if the stock price has moved up or down by 20% or more in a month in at least 8 of the past 24 months or the analyst expects significant volatility going forward.

Analysts' sector weightings are distinct from analysts' stock ratings and are based on the analyst's expectations for the fundamentals and/or valuation of the sector* relative to the group's historic fundamentals and/or valuation:
Overweight : The analyst's expectation for the sector's fundamentals and/or valuation is favorable over the next 12 months.
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.
**An analyst's coverage sector consists of all companies covered by the analyst within the relevant sector. An analyst may cover multiple sectors.*

Credit Suisse's distribution of stock ratings (and banking clients) is:

Global Ratings Distribution

Rating	Versus universe (%)	Of which banking clients (%)
Outperform/Buy*	47%	(33% banking clients)
Neutral/Hold*	39%	(27% banking clients)
Underperform/Sell*	13%	(22% banking clients)
Restricted	2%	

**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.*

Important Global Disclosures
Credit Suisse's research reports are made available to clients through our proprietary research portal on CS PLUS. Credit Suisse research products may also be made available through third-party vendors or alternate electronic means as a convenience. Certain research products are only made available through CS PLUS. The services provided by Credit Suisse's analysts to clients may depend on a specific client's preferences regarding the frequency and manner of receiving communications, the client's risk profile and investment, the size and scope of the overall client relationship with the Firm, as well as legal and regulatory constraints. To access all of Credit Suisse's research that you are entitled to receive in the most timely manner, please contact your sales representative or go to https://plus.credit-suisse.com .
Credit Suisse's policy is to update research reports as it deems appropriate, based on developments with the subject company, the sector or the market that may have a material impact on the research views or opinions stated herein.
Credit Suisse's policy is only to publish investment research that is impartial, independent, clear, fair and not misleading. For more detail please refer to Credit Suisse's Policies for Managing Conflicts of Interest in connection with Investment Research: https://www.credit-suisse.com/sites/disclaimers-ib/en/managing-conflicts.html .
Any information relating to the tax status of financial instruments discussed herein is not intended to provide tax advice or to be used by anyone to provide tax advice. Investors are urged to seek tax advice based on their particular circumstances from an independent tax professional.
Credit Suisse has decided not to enter into business relationships with companies that Credit Suisse has determined to be involved in the development, manufacture, or acquisition of anti-personnel mines and cluster munitions. For Credit Suisse's position on the issue, please see
The analyst(s) responsible for preparing this research report received compensation that is based upon various factors including Credit Suisse's total revenues, a portion of which are generated by Credit Suisse's investment banking activities
See the Companies Mentioned section for full company names
Within the last 12 months, Credit Suisse has received compensation for non-investment banking services or products from the following issuer(s): 6758.T
Credit Suisse expects to receive or intends to seek investment banking related compensation from the subject company (6758.T) within the next 3 months.
Credit Suisse currently has, or had within the past 12 months, the following issuer(s) as client(s), and the services provided were non-investment-banking, securities-related: 6758.T
Credit Suisse or a member of the Credit Suisse Group is a market maker or liquidity provider in the securities of the following subject issuer(s): 6857.T, 6754.T, 6146.T, 6890.T, 6951.T, 4185.T, 6920.T, 6871.T, 7735.T, 4063.T, 6758.T, 6315.T, 8035.T, 4186.T, 7729.T
As of the date of this report, Credit Suisse beneficially own 1% or more of a class of common equity securities of (6315.T).

For date and time of production, dissemination and history of recommendation for the subject company(ies) featured in this report, disseminated within the past 12 months, please refer to the link: https://rave.credit-suisse.com/disclosures/view/report?i=499131&v=7002hlvayif2elf0yiip3hm4a .

Important Regional Disclosures
Singapore recipients should contact Credit Suisse AG, Singapore Branch for any matters arising from this research report.

The analyst(s) involved in the preparation of this report may participate in events hosted by the subject company, including site visits. Credit Suisse does not accept or permit analysts to accept payment or reimbursement for travel expenses associated with these events.
For Credit Suisse Securities (Canada), Inc.'s policies and procedures regarding the dissemination of equity research, please visit https://www.credit-suisse.com/sites/disclaimers-ib/en/canada-research-policy.html.
Investors should note that income from such securities and other financial instruments, if any, may fluctuate and that price or value of such securities and instruments may rise or fall and, in some cases, investors may lose their entire principal investment.
This research report is authored by:
Credit Suisse Securities (Japan) Limited Hideyuki Maekawa ; Akinori Kanemoto ; Mika Nishimura ; Yoshiyasu Takemura ; Sayaka Shimonishi ; Daisuke Tanimoto ; Tailai Qiu
To the extent this is a report authored in whole or in part by a non-U.S. analyst and is made available in the U.S., the following are important disclosures regarding any non-U.S. analyst contributors: The non-U.S. research analysts listed below (if any) are not registered/qualified as research analysts with FINRA. The non-U.S. research analysts listed below may not be associated persons of CSSU and therefore may not be subject to the FINRA 2241 and NYSE Rule 472 restrictions on communications with a subject company, public appearances and trading securities held by a research analyst account.
Credit Suisse Securities (Japan) Limited Hideyuki Maekawa ; Akinori Kanemoto ; Mika Nishimura ; Yoshiyasu Takemura ; Sayaka Shimonishi ; Daisuke Tanimoto ; Tailai Qiu

Important disclosures regarding companies that are the subject of this report are available by calling +1 (877) 291-2683. The same important disclosures, with the exception of valuation methodology and risk discussions, are also available on Credit Suisse's disclosure website at https://rave.credit-suisse.com/disclosures . For valuation methodology and risks associated with any recommendation, price target, or rating referenced in this report, please refer to the disclosures section of the most recent report regarding the subject company.

尖峰报告社群

分享8万+行业报告/案例、7000+工具/模版；
精选各行业前沿数据、经典案例、职场干货等。

截屏本页，微信扫一扫或搜索公众号“**尖峰报告**”
回复<**进群**> 即刻加入