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Global Semiconductors | North America

2019 Outlook: Stay Cautious; Bottom Not in Sight

It's going to get worse before it gets better, as weaker end demand and inventory reductions drive negative estimate revisions. We remain cautious, and detail risks around memory, inventory, China trade tensions, slowing M&A, and cloud digestion.

WHAT'S CHANGED

	From	To
Applied Materials Inc. (AMAT.O)		
Price Target	39.00	**40.00**
Ambarella Inc (AMBA.O)		
Price Target	50.00	**52.00**
Broadcom Inc. (AVGO.O)		
Price Target	250.00	**265.00**
Intel Corporation (INTC.O)		
Price Target	54.00	**55.00**
Inphi Corporation (IPHI.N)		
Price Target	34.00	**39.00**
Microchip Technology Inc. (MCHP.O)		
Price Target	72.00	**75.00**
Marvell Technology Group Ltd (MRVL.O)		
Price Target	19.00	**20.00**
Maxim Integrated Products Inc. (MXIM.O)		
Price Target	54.00	**53.00**
Qorvo Inc (QRVO.O)		
Price Target	70.00	**68.00**
Quantenna Communications Inc (QTNA.O)		
Price Target	17.00	**18.00**
Skyworks Solutions Inc (SWKS.O)		
Price Target	76.00	**74.00**
Western Digital (WDC.O)		
Price Target	53.00	**50.00**
Xilinx (XLNX.O)		
Price Target	87.00	**98.00**

We remain Cautious on semis given additional risks to estimates... In tandem with this report, we are downgrading ADI due to concerns that Street estimates my prove too high in the face of additional weakness in its core market of Industrial and potential slowing in Comm (see - Downgrade to Equal-weight: High Bar for 2019). Risks around the semi cycle dictate our Cautious view on the group (Why This Cycle Looks Worse than the 2015 Down Cycle) and since August nearly every key market with the exception of wireless infrastructure has taken a turn for the worse (see our note Downgrading to Cautious as Risks Grow). There has been a pronounced slowdown in Industrial (Cracks Forming in Semis Sold into the Industrial Market), meaningful production cuts in automotive (Estimates Are Still Too High in Autos – Reiterate Underweights on ON and ST), big misses in

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Semiconductors

North America
IndustryView **Cautious**

Greater China Technology Semiconductors

Asia Pacific
IndustryView **Cautious**

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smartphones, and a deceleration in the data center. Looking to 2019, the problem is the trajectory of growth in these markets likely deteriorates further, which we think results in additional inventory drawdown at customers and distributors. From a macro perspective, the slowdown seen in China and Europe is troublesome, with PMI readings decelerating throughout the year. We estimate a 4.7% decline in semi revenue in 2019, led down by NAND (down ~14%) and DRAM (down 21%).

...And a lack of valuation support in most stocks. One of the key debates for the group is how much of these negative trends is already priced in? While stocks are well off their highs, they are still up significantly over the past few years and more importantly we still see downside to estimates. Furthermore, even though sentiment has turned negative, there have been no signs of capitulation in semi stocks. In analog, stocks such as ADI, TXN, MXIM, and ON are trading 50-60% above the trough EV/S multiples seen in the 2015 correction, which is not comforting when considering the ongoing pressures we see on the business. Of note, higher multiples also reflect the expansion seen in the broader market, with the EV/S multiple of the S&P 500 15% above the trough level seen in 2015. Memory and semicaps discount a more negative scenario, and our rating on Semiconductor capital equipment remains in-line, but we do remain well below consensus on 2019 earnings prospects.

Lowering our forecasts: We now look for global semis revenues to decline by ~5% in CY19, vs. our prior estimate of down 1%, driven mostly by memory declines as pricing looks likely to decline meaningfully through the year. We expect growth in the more unit-driven sectors, but very modest 1-3% growth, trailing global GDP growth as we see inventory correction after 2 years of strong builds. In terms of semicaps, we look for high single digit declines in wafer fab equipment in our bottom up model of capital spending (which tries to capture companies published intent); but we see high likelihood of downward revision, as most memory and foundry participants are likely to revise down spending forecasts.

Below we highlight our key Overweight and Underweight stock calls. Inside, we also address Equal-weight stocks that could move in 2019, including **INTC**, **AVGO**, **TSM**, and **Samsung.**

Exhibit 1: Our key Semi calls

Overweight	
US	XLNX, NVDA, LRCX, AMBA, APH
Asia	Realtek, Goodix, ASE, Chipbond, Toshiba, Hitachi Hi-Tech
Underweight	
US	ON, CY, ST, AMD
Asia	Hynix, MediaTek, Win Semi, Novatek, Macronix, Winbond, GigaDevice, Micronics Japan

Source: Morgan Stanley Research

Important issues to focus on in 2019:

1. The semi cycle is rolling over: It looks like 2018 will mark the peak of the cycle and we anticipate a reversal next year as weaker demand leads customers to burn off excess inventory that built up over the past 18 months. While some have been quick to call a bottom, cycles take time to play out and we continue to

expect this cycle to be worse than the 2015 downturn.

2. Memory cycle and semi caps weaker for longer: Weaker near term conditions are now discounted, but we remain concerned that the recovery will take longer vs. consensus; the issue is less about how temporary the demand factors of the last 6 months will be, and more about the inventory that is building during a period of seasonal strength and will have to be depleted during a period of seasonal weakness. We see weak conditions persisting through 2019, especially for DRAM.

3. China's domestic semiconductor efforts: We see the situation as increasingly binary, with recent trade frictions incenting China to accelerate its "made in China 2025" program for semiconductors - but increasing regulatory risk that the US could prohibit sales of semiconductor equipment to China sovereign customers. If that regulatory risk fades, we would expect substantial upside in CY20 and beyond to the semiconductor capital equipment names from China spending.

4. Ongoing pressure on smartphone growth: Smartphones went from bad to worse this year, with units down 4% YTD as iPhone and China smartphones fell short of expectations. This is weighing heavily on the supply chain, which should continue to feel the ripple effect in 2019 before potentially rebounding in 2020 when 5G becomes meaningful.

5. Data center slowdown: While the long-term story is still bright, we see a digestion in capex after outsized growth adding to the list of concerns in semis next year. This is already evident in memory and HDDs, while we also see risk to Intel in 2019 following 22% growth in its data center business this year.

6. Intel vs. AMD: We are biased to the Intel side of this debate, at least in the short term. While AMD has delivered a strong product pipeline on the CPU side, barriers to entry remain significant especially in the server space, and AMD's market share 5 quarters after its initial server launch remains less than 2%; and commentary for 4q indicates that while they will hit their mid single digit unit share target, they will remain less than 2% revenue share vs. Intel's broader data center group. Epyc 2 looks impressive, but won't really start its ramp until late 2019, giving Intel time to respond.

7. Ongoing momentum in AI/machine learning and Autonomous driving: 2018 was a breakout year for AI, with NVIDIA's data center business reaching an annual run rate of $3 bn, though with some deceleration late in the year around cloud digestion. We continue to see this trend broadening out, and continue to argue for a core position in the AI supply chain, with NVIDIA, Xilinx, and Ambarella as our favorite beneficiaries.

8. M&A is no longer a positive driver of stock performance: This is not a great environment for M&A, as a combination of cyclical and regulatory concerns give strategic acquirers pause. Furthermore, a difficult start to recently completed deals (MCHP/MSCC, MRVL/CAVM) is weighing on investor sentiment toward M&A.

Investment Summary by Region

US Semis - Cautious

We are Cautious on US semi stocks, and In-Line on US semicaps; We became negative on NAND memory in late 2017, and on DRAM and Micron in May 2018, and ultimately downgraded our industry view to Cautious in August, as double ordering and inventory excesses that we had flagged throughout the year became a clearer negative catalyst in light of slowing end demand, an end to shortages of memory and passives, intensifying global trade pressures, and a slowing M&A environment as well.

We now see semiconductor revenue declining ~5% in 2019. We expect global semis revenues to decline by 5% in CY19 to ~$446bn mostly by memory declines (down 18%) with DRAM down ~20% and NAND down 14%. Excluding memory, we expect semi revenue to be up 2% to $315bn with Analog and MCUs up 1%, Discretes up 2%, MPUs flat and Logic up 4%.

China trade pressures have mostly indirect impact, and while those tensions may be hurting end demand, they are also likely driving an inventory build for US semis. While we saw negative earnings revisions post 3q, we think that the biggest issues are still ahead. China trade, which has been very much in focus, has had a mixed impact on shorter term demand; while there is certainly negative demand side impact from end demand in China, we see multiple indications that the trade pressures are actually driving an inventory build. Customers have been building ahead of tariff implementations, adding to shorter term inventory (which may trigger a correction now that the 25% has been deferred). We have also seen supply chain increases as multinational customers move their manufacturing footprint away from China, requiring some duplication. And concenrs that the ZTE denial order (which is now behind us) might be repeated at other large Chinese customers is likely leading to some buffer stock.

It's too early to call the bottom. Certainly there was some weakness signaled in the 4q outlooks, but the real impact to earnings is still ahead. The inventory effects as shortages of passives and memory comes to an end are just beginning. We would let that run its course before trying to move back to a market weight view on the group.

Our US investment strategy for a downturn would be to own a few names where growth may shine through, with a sprinkling of higher octane recovery plays...Names with growth potential would include Xilinx, Amphenol, NVIDIA, and Ambarella. We provide more details later in the report, but the idea isn't that they are completely immune from industry issues, simply that they have growth drivers that will be apparent even with that weaker backdrop. We also have remained OW Lam Research (LRCX), a company that has already been impacted by industry trends - but we think that the stock already reflects that impact, and we do want some "bull market" insurance in case stocks move higher on resolution of trade frictions, and we think Lam has the most potential upside in those more bullish scenario.

...And stay Underweight stocks where estimates are too high. Relative to peers who have begun to reset expectations to reflect the weakening environment, ON Semiconductor and Sensata guided Q4'18 above and in line with the Street, respectively, effectively pushing out the risks into 2019 in our view. Our 2019 EPS is 15% below the Street for ON and 5% lower for ST. We also see increasing risks for Cypress in the NOR memory market in addition to broader cyclical concerns and our EPS is 4% below the Street.

Greater China Semis - Cautious

Compared to US semi companies, Greater China's semi players depend more on smartphone demand. For example, TSMC generates 45% of its revenue from smartphone semis, while MediaTek has 40% revenue exposure to EM smartphone demand. Smartphone semi weakness led our industry view to turn Cautious, and that is further propelled by crypto shortfall.

Smartphone demand softening across the board: In our report Asia Pacific Technology: Smartphone Supply Chain: Sell Into G20 Rally, we mentioned that it was fundamental weakness that drove our bearish call (the end of a major product cycle) rather than tariff issues. Later, Largan (covered by Yunchen Tsai) posted its November sales, which declined 23% MoM (-29% YoY), worse than market expectations of 10-15%; management cited demand weakness **across the board**, driven by volume rather than pricing, and guided for another sequential decline into December. In the circumstance of overall weak smartphone demand, we wonder if there is any differentiation of exposure to different smartphone OEMs.

We are concerned that recent iPhone supply chain order cuts could be just the first wave. If next year's iPhone doesn't have attractive features, weak orders from Apple could be a new normal for TSMC. By reflecting the non-Apple smartphone demand downside in 2019, we cut our TSMC rating to EW with a target price of NT$214. We don't think secular growth drivers, such as AI semi and AMD CPU outsourcing, are strong enough to differentiate the stock in a logic semi downcycle. Given growing chipset inventories, we expect MediaTek's smartphone chipset shipment to drop 20% Q/Q in 1Q19, hence our downgrade to UW (report). We also have UW ratings on Novatek, UMC, and WIN Semi for key smartphone-exposed names.

The "hard landing" scenario for crypto mining semi is coming through: In "After the gold rush", we indicated that corrections in cryptocurrency price plus the excessive mining capacity could cause a correction in wafer and semi capex. Over the past week, Bitcoin's price is down 29%, to US$4522. Thus, we think miners' profit is squeezed and look for 16nm mining ASIC demand to go to zero in 4Q18. We also see impact on demand for new 7nm mining ASIC at key customers of TSMC (Bitmain) and GUC (GMO). Another key TSMC customer, NVIDIA (~6-7% of TSMC's 2018e revenue), cited crypto mining market weakness, and commented that this would take around 1-2 quarters to digest graphics inventory. That bodes ill for TSMC's 16nm/12nm wafer demand in 1H19.

Korean Semis - Cautious

The memory sector down cycle is likely to turn significantly worse in the first half of

next year and we stay Underweight on SK Hynix and Equal-weight on Samsung Electronics. Stabilization in 2H19 is still uncertain and tied to macro outlook, demand that is weakening and supply discipline. Weaker market conditions should continue to lead to supply growth exceeding demand into the middle part of 2019, driven by a sharp slowdown in server DRAM demand from data centers, deteriorating smartphone industry, and excess inventory build. We believe that it is too premature to call a bottom and start buying, and would look for YoY pricing (second derivative) to turn less negative as we move past 1Q19. Furthermore, our outlook is significantly worse than Samsung's and Hynix's managements, pointing to seasonal downturn followed by recovery in the back half of 2019. We would also look for market sentiment and valuation to reflect increased challenges to the industry in 2019.

The DRAM market has worsened since October and companies are struggling to move bits: Production has continued to outpace shipments since 3Q18 and the prospects for the rest of memory in 1Q19 are also worsening. Recent data points signal weaker-than-expected DRAM outlook in 2019, especially for server DRAM, which could see demand growth fall below 25% in 2019 vs. 48% in 2018. A shift in DRAM customer sentiment to continue to affect demand in 2019 as customers continue to purge inventory and reduce volumes across all categories: (i) server - clear volume drop from hyperscaler customers, channel inventory weeks have doubled with higher pricing headwinds, (ii) mobile - customer inventory (both US and China) are affecting prices and we think Samsung smartphone weakness drives further weakness in mobile DRAM in 1H19, (iii) PC - inventory destocking is under way and units held by CPU shortage, and (iv) graphics - down sharply in 4Q, with weakness in crypto mining and game VGA cards.

- Data center demand continue to weaken and reduced orders extending into 1Q19 from tier-1 hyperscalers, and customer sentiment reversing in view of greater supply availability. Some customers are able to buy at much lower spot prices, which is impacting server 32GB DIMM module contract prices. Server DRAM module prices are down -10% in October and we see further downside into end 4Q, much worse than our previous high-single digit decline expectation for the quarter. We believe server DRAM prices are likely to be down high-teens in 1Q19 given peak supply-demand imbalance >5% (excluding inventory).

- Mobile DRAM demand remains sub-seasonal, 4Q shipments stayed weak for China's top-tier smartphone makers and 1Q19 demand should be adversely impacted by Chinese New Year in Feb. Meanwhile, US mobile demand is likely to face some inventory correction from late 4Q. We estimate double digit decline in mobile DRAM prices in 1Q19 and higher fall for MCP.

- PC DRAM contract prices have dropped 13% in 4Q (vs. +1% in 3Q) as the PC supply chain continue to reduce inventory. Intel CPU shortage on PC DRAM impact is not evident as there seems to be plenty of available PCs to begin with and the net impact of CPU shortage may be on chip inventory reduction.

- Graphics DRAM contract prices are falling sharply in 4Q, and we cite weakness in VGA cards and a fall in the proportion of crypto mining. We estimate GDDR5 prices are likely to fall >10% in 4Q. 8Gb GDDR5 prices fell to ~US$8 from ~US$10 in 3Q contract prices, causing some reduction in graphics DRAM output and a shift to server output.

NAND pricing outlook remains difficult through 1Q: There is just too much supply, and

competition in enterprise SSD remains fierce. Samsung has lost most of its price premium in enterprise SSD and is now almost at parity with new entrants in 4Q price, with its much larger scale production allowing very thin premium. This aggressive competition stems in part from a transition period for US manufacturers: (i) having qualified with a growing number of enterprise customers; (ii) moving to 64 layers in large volumes, which brings higher cost benefit; and (iii) yield improvement. As we saw in the WDC outlook, this inventory build should lead to accelerated supply growth next year as 2018 producer inventory build lowers the denominator and adds to 2019 supply. We are more constructive in NAND, however, compared to DRAM as we expect demand elasticity to bring current excess into equilibrium possibly by 1H19.

Japan Semis

Our view on semi equipment names remains In-Line: As noted by our Korea team, the memory down cycle is likely to turn significantly worse in 1H19. Also, stabilization in 2H is still uncertain and tied to macro outlook and supply discipline. Against this backdrop, downside risk for the semi cap equipment market is rising, in our view, and while we maintain our In-Line industry view we take a moderately cautious investment stance on semi cap equipment stocks.

Wafer fab equipment: Global wafer fab equipment sales on a 3 months moving average basis amounted to $4.3bn in October 2018, and are trending down from peak levels in the first half of the year, but run rates continue to point an annual market exceeding $50bn and YoY expansion of 10%. While increasing number of memory capex projects are pushed out, we think it is too soon to assume that supply-side discipline is working.

Assembly and Testing equipment: Global assembly and testing equipment sales on a 3 months moving average basis totaled $778mn in October, with YoY growth of 7%, only in line with normal seasonal adjustment. Sales of testing equipment in particular were up 20% YoY in October, to $482mn on a 3 month moving average basis. However, with further deterioration in memory supply/demand likely, if the downside risk in smartphone markets noted by our Asia team manifests, we think there could be considerable downside risk to assembly/test equipment sales as well.

Logics, MCUs, and Discrete: With regard to logics, MCUs, and discrete semiconductors, Rohm expects F3/19 2H (October 2018 - March 2019) sales to remain flattish with 1H. Automotive and industrial equipment markets — the key verticals targeted by these chipmakers — are slowing (our global auto and shared mobility team forecasts worldwide passenger car sales down 0.4% YoY to 82.2mn units in 2019). We think prospects for weaker demand indicate heightened downside sales risk at all semi companies in F3/20 1H.

What would make us more constructive? Data points that could make us bullish on semi equipment stocks are (a) meaningful adjustment in semi equipment market (if the "meaningful adjustment" materializes in 1Q19, it could prompt some equipment makers to revise F3/19 forecast again, after already doing so in October following fiscal 1H results); or (b) stabilization of memory prices (at least for NAND, where prices fell earlier than DRAM and there is high price elasticity).

2019 Key Global Semi Stock Calls

Key Overweight Calls

Xilinx (XLNX, $98 PT)

We expect Xilinx to have the strongest growth profile in semis in what we expect to be a weak 2019 market. There are three meaningful idiosyncratic growth drivers: 1) Data center usage of FPGAs should start to inflect higher, with Xilinx garnering most of the relevant wins; we would expect this to contribute 4-5 points of growth in 2019; 2) Strong design win pipeline; while Altera's introduction of competing 14 nm products has helped, we think that 2019 growth will be driven by 2017-18 design wins; and 3) 5G wireless, where we expect Xilinx to win strong share and see several points of growth in 2019, driven in particular by massive MIMO antenna arrays. There are some cyclical challenges in areas comprising about 25% of sales (semis test and measurement, industrial, autos), but those areas were already soft in the most recent quarter. Valuation is high enough that further multiple expansion is unlikely in the short term, but we do expect strong revenue and earnings growth for multiple years.

NVIDIA (NVDA, $220 PT)

NVIDIA had a rocky close to 2018, as a cryptocurrency hangover, a somewhat lackluster reception for its new gaming products, and deceleration in cloud spending all took their toll on numbers. While we do expect those headwinds to linger through 1h19, we think the bar is likely low enough in the near term - we have gaming for CY19 declining by high single digits, with new midrange 2060 class products shipping at CES that should separate the revenue stream from over-inventoried last generation Pascal products; the company should gain substantial market share this year (with AMD lacking a competing high end product until late in the year) and 20%+ increases in average selling prices. The higher end features of the new products should become more compelling with driver support and ray tracing adoption over the course of 2019. More importantly, we expect a reacceleration of the HPC/cloud businesses, as the company's dominant position in deep learning "training" starts to lead to traction in newer markets (inference and graphics acceleration of traditional machine learning analytics).

Lam Research Corp (LRCX, $190 PT)

This may seem counter to our negative views on memory, and we are in fact well below consensus for 2019 earnings. But in our experience a long portfolio of semis stocks in a downturn needs a healthy sprinkling of down-and-out names with challenging exposures, given the hazards of trying to buy stocks perceived as bulletproof that may not be. Lam has already seen a 25% drawdown in revenues in 3q18 around weaker NAND spending, and while that isn't likely over (and DRAM seems certain to be another shoe to drop), the NAND exposure helps in several important ways - NAND spending already seems at or below trend, it will be the first place that China makes major investments if they are allowed to do so, it does not become negatively impacted by EUV, and it drives a larger and more repeatable service/spares component (which makes

up over 35% of our 2019 earnings forecast). We wouldn't argue strongly with those arguing for AMAT, but we do have mild preference for Lam. Headwinds are likely to be severe until NAND recovers and/or China spending kicks in, but we do see potential for substantial longer term upside.

Ambarella (AMBA, $52 PT)

Ambarella remains our favorite small cap idea**.** The company is in transition from a legacy "video processing" business that is struggling around a series of consumer setbacks in sports cameras (GoPro) and drones (DJI). But for the last four years, the company has spent significant development resources into computer vision, which we regard as one of the new frontiers in semis. The company claims design wins or serious evaluation for computer vision with all of the top ten surveillance camera manufacturers, and multiple wins in computer vision for automotive (both ADAS and autonomous), including a tier one. Revenue from ADAS and autonomous will take time, but design wins would substantially boost the strategic value of the company, and we are optimistic that the current base of surveillance and automotive revenue is set up to grow. The biggest risk would be trade pressures with Chinese surveillance manufacturers, which make up roughly 30% of sales.

Amphenol Corp (APH, $100 PT)

APH remains our top Overweight pick among broad-based suppliers, driven by the company's agile business model, strong operational track record, and highly successful M&A program. For more details, please see our report - Upgrade to OW: A steadier Hand into Supply Chain Turbulence. While we have concerns about the company's exposure to the iPhone (Apple is a high single digit customer), the planned $400mn acquisition of SSI Controls (expected to close early next year) will add $180mn in annual revenue and help to offset potential headwinds in mobile devices. Importantly, SSI is the company's 7th deal in the sensor market, which we estimate now represents 5% of Amphenol's sales. The total available market in sensors is around $125bn or 2X the size of the TAM in the company's core connector business, providing a long runway for organic and acquired growth.

TE Connectivity (TEL, $97 PT)

We are sticking with our Overweight on TEL, while acknowledging lingering risks in the automotive market (40% of company sales). On a EV/S basis, there is still around 15% downside to the trough level TEL reached in the 2015 correction if business gets worse from here. That said, this compares to many analog stocks that are trading 50-60% above trough levels on EV/S, which reflects a much higher degree of negative sentiment already in TEL. We believe management has done a good job at resetting near-term expectations for the next 2 quarters, although a rebound in auto production embedded in 2H'FY19 guidance may prove optimistic. Despite the near-term headwinds to automotive production, we still view the company's long-term dollar content story as compelling, led by the adoption of EVs (2x the average $ content) and its penetration of auto sensors (doubles the TAM). We also highlight a number of self-help initiatives (plans to reduce SG&A expense by 100 bps, reduction in its manufacturing footprint) that can help protect EPS in the current difficult environment. Finally, TEL is likely to remain active in repurchasing stock (~30% reduction in share count over the past decade), with the board authorizing a new $1.5bn buyback this week.

Realtek (2379.TW)

Realtek is one of our top picks in Greater China IC design. We expect several share price drivers for Realtek in 2019, including margin upside and TAM expansion (e.g. IoT and auto Ethernet). Firstly, we believe the market still underappreciates the margin expansion story. We think the stable industry competitive landscape, design optimization, and lower foundry/memory cost will drive the margin upside. On new product, Realtek is on track to ship its auto Ethernet ports, and Management remains confident and is expecting 400-500mn ports in five years. By assuming $1 per port, this will be a new total addressable market of US$500mn vs. the company's total revenue of ~US$1.5bn (2018e). Other than auto Ethernet, we also see Realtek's strong execution in the IoT market, including wireless headphones, home appliances, type-C, etc. The company should also gain share in the TV SoC market from 1Q19, so we think sales could stay flattish in 1Q19, making it a defensive play amid macro downturn.

Goodix (603160.SS)

We stay OW on Goodix given the new product cycle on optical underglass fingerprint, despite the smartphone weakness. We believe that Goodix is not only the technology leader in optical fingerprint sensors globally, it also has the most competitive cost structure. Therefore, we expect Goodix to win most of the optical fingerprint orders from Huawei, OPPO, Vivo, Xiaomi in 2019, with strong content increase (>5x ASP) and better margin profile (>50%). Our EPS forecasts are 11-13% higher than consensus for 2019e and 2020e. As well, the company could benefit from the China/US trade tensions. We thus believe the share price could continue to outperform the market.

ASE (3711.TW)

Once again, we do not think ASE is immune to the semi downcycle, as manifested in its 4Q18 decline in IC ATM. But we do see this decline manageable while EMS picks up strongly. With the recent volatility in the overall stock market, ASE has been holding up quite nicely and we do see our thesis of it being a rather defensive play. The stock is trading at 10.5x 2019e, which we find attractive while the downside is protected by the strong counter cyclical Apple Watch product cycle.

Chipbond (6147.TW)

Chipbond could start to see some order cuts, but its gross margin upside should offset somewhat. As the company is the sole supplier of Apple's LCD driver IC, we had expected some softness going into 2019. Chipbond has said it thinks gross margin can be sustained at a rather high level. TDDI appears on track to grow substantially in 2019. With foundry capacity no longer a constraint for TDDI, Chipbond will likely benefit from a continued testing supply shortage, as this should be the major driver for the company in 2019 based on company strategy and our analysis. While we think macro uncertainties could limit upside for the stock, we see it as a relative winner given its ASP increase and the supply shortage story.

Toshiba (6502. T)

Toshiba is our top pick in our Japan semiconductor coverage. Toshiba announced "Toshiba Next Plan", its 5-year earnings improvement target in November 2018. The

company splits the earnings improvement plan into phases: near (2019-20), medium (2021-23), and long term (beyond 2023). Near term through 2020, we expect the bulk of Toshiba's earnings growth to be driven by restructuring, cuts to procurement costs, and fewer loss-making projects; we believe these targets are quite attainable. We see significant room to cut purchasing costs in the Energy Systems & Solutions and Infrastructure Systems & Solutions segments in particular. We expect Toshiba to outperform other semi stocks as improvement expectations get priced in.

Hitachi High-Technologies (8036, T)

Hitachi High-Tech (HHT) has above average exposure to advanced logic and foundry capex, and in light of prospective downside to memory capex in 2019 HHT's earnings are likely to remain relatively stable. In its Science & Medical Systems business, the company will see continued growth in sales of biochemical/immunodiagnostic systems to Roche. Furthermore, as Hitachi Ltd adjusts its business portfolio, we see potential for a reassessment of Hitachi High-Tech's strategic value.

Key Underweight Calls

ON Semiconductor (ON, $14.50 PT)

We see heightened risk of an inventory correction at ON, as the company's lead times are still extended—in contrast to a normalization seen at other analog semi companies—into the face of weakening demand. Our CY19 EPS is 15% below the Street on lower revenue and GM. If the cycle turns negative like we suspect, we see risk of pricing returning to the normal decline of 6-8% annually compared to down slightly today. From an end market perspective, we expect production and inventory cuts in autos to weigh on growth over the next couple of quarters. We also see additional downside risk in industrial, while a major tailwind in computing from data center strength in 2018 is likely to moderate next year.

Cypress Semiconductor (CY, $12 PT)

In addition to our concerns over the broad-based semi cycle, we see pressure building on the company's NOR memory business (22% of sales, see - NOR Memory: We See a Reversal of Fortune and a Challenging 2019). And if memory deteriorates like we anticipate, it would have negative implications on the stock's multiple. Our target multiple is based on a sum-of-the-parts valuation and the 8X multiple we ascribe to memory could prove generous (MU trades at only 4X). A key test for Cypress in 2019 will be gross margin performance. We estimate GM will expand 450 bps y/y to 46.7% in CY18 and 50 bps y/y to 47.2% in CY19. While the sale of the company's NAND business expected in Q1'19 will help GM, nonetheless, the potential for weaker pricing in NOR and lower growth due to the semi cycle put a downward bias on GM.

Sensata Technologies (ST, $44 PT)

We expect ongoing deterioration in the auto end market (60% of company sales) to weigh on the company's 2019 guidance (given in January). Of note, our revenue and EPS estimates are 3.5% and 5% below the Street for 2019. While some other suppliers have already downticked on autos for Q4'18, Sensata guided in line which we think pushed the risk out into 2019. In addition to pressure from weaker than expected auto sales, we

highlight the company's levered balanced sheet as a risk (net debt to EBITDA is 2.7X). The company's aggressive stock buyback ($400mn completed in the past 2 quarters) helped support the stock this year, but we see less of an impact going forward ($250mn program over the next 18 months).

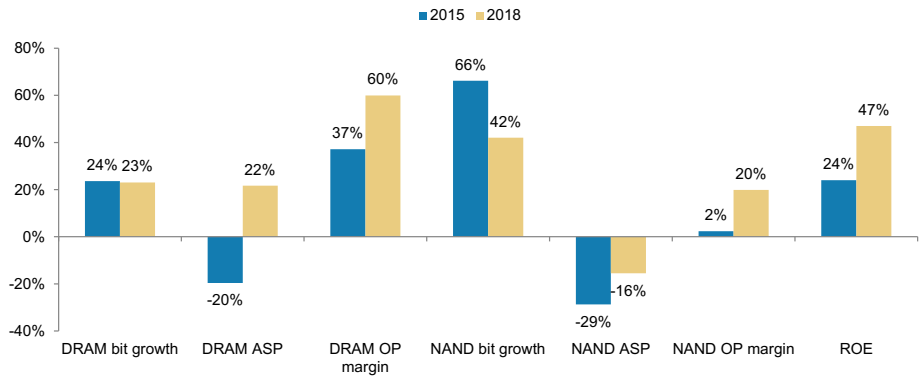
Advanced Micro Devices (AMD, $17 PT)

We have admired what AMD has accomplished on the microprocessor side, but revenues would have been disappointing over the last two years if not for a surge in cryptocurrency, and now that crypto has declined, we expect negative year on year revenue and earnings comparisons for the next several quarters; 60% of 2018 revenues from graphics and consoles will see double digit declines in 2019. While the company remains bullish on its unit market share targets in servers (mid single digits by end of 2018, double digits by 2q20), we expect it to have less than 3% revenue share by the end of 2019, with minimal revenue gain until Epyc 2 starts to be relevant in 4q19 - which gives Intel plenty of time to respond. While the company could gain share in desktop CPUs given the Intel shortage in the next couple off quarters, that isn't enough to drive year on year growth - and those share gains will likely reverse as soon as Intel supply catches up to demand. The stock remains expensive on earnings (over 33x 2019); it is inexpensive on ev/sales but we continue to see the company as subscale.

SK Hynix (000660.KS)

We believe market expectation and ownership for SK Hynix remains relatively positive at 47% foreign shareholding relative to KOSPI 35%. Our EBIT estimates for 2019-20 are 11% and 20% below consensus and valuation on trailing PB is 14% above historical trough multiples. We believe the wide variance between our forecasts and consensus arises from the market's (i) relatively more upbeat expectations for cloud and data center server DRAM demand recovery from 2H19, (ii) underestimated the dramatic impact of inventory build to supply growth in 2019, and (iii) management's expectations for the DRAM downturn to be seasonal and temporary, which is less likely, in our view.

Exhibit 2: SK Hynix's Now and Then (2015 vs. 2018)



Source: Company data, Morgan Stanley Research

MediaTek (2454.TW)

MediaTek could win projects at Oppo/Vivo with the new chips, but the key issue is that the smartphone end market is shrinking, which could translate into an inventory

correction in 1Q19. In addition, we think competition will remain intense in 2019 from both Qualcomm and Spreadrum, which means limited margin improvement. Street's expectations have increased to a high level after the recent news flow, while our 2019 EPS still suggests 16.3% downside to consensus. Around December 13, the P80 and P90 product launch event could be a good exit point from the stock.

WIN Semi (3105.TWO)

WIN Semi has ~70% revenue exposure to smartphones, making it one of the key sufferers from the weak smartphone semi demand. On top of that, weaker smartphone end demand should also result in longer than expected inventory correction for its customers, which could translate into lower utilization rate for WIN Semi's fabs in 1H19. Although potential 3D sensing adoption in smartphones might give WIN's operations a boost, before clear key killer apps emerge, we believe current street expectations are still too high. Our 2019 EPS suggests 9% downside to consensus.

Novatek (3034.TW)

We believe the company has passed its strongest year of earnings growth, and expect this to normalize in 2019. We don't think the market has priced this in yet, and note 2019 P/E (based on our estimate) is still at 12-13x 2019e EPS (mid to high end of historical average), with FINI holdings at a record high of ~70%. We also think the market is overestimating the revenue contribution from AMOLED DDI next year. With Y/Y earnings growth decelerating, GM likely around the peak and our macro concerns of a smartphone semi slowdown, we rate to Underweight.

Macronix (2337.TW)

We believe Macronix has also started to face pricing pressure from 4Q18. Since NOR Flash usually goes with MCU except for PC, our recent industry checks suggest that the MCU inventory is far above seasonal levels across the applications, including consumer, industrial and auto in Greater China. We thus believe that Macronix's NOR pricing will keep on facing pressure into 2019. SLC NAND is on the other hand is also in significant oversupply. We therefore remain UW Macronix.

Winbond (2344.TW)

Winbond's capacity ramp-up is proceeding faster than expected, which we don't think is helpful within a memory downturn. Factors behind the big decline in memory prices, including weaker consumer demand in China, and the increasing wafer supply from specialty memory players as well as the tier 1 players, still persists. Also, Winbond's NOR Flash quality is not as high as Macronix's, given Winbond's 40-50% exposure to low density. Thus, we think the company's NOR Flash pricing trend will be similar to the market trend. With both markets remain sluggish into 2019, we remain UW Winbond.

GigaDevice (603986.SS)

We appreciate the company's strong design optimization, but we think the margin trend could be difficult to sustain above the 35% level, given the continued NOR Flash pricing pressure into 2019. We think the competitive landscape is getting even tougher among its customers, GigaDevice and other tier 2 vendors. As supply continues to increase with

weaker than expected consumer/communications end demand, we think GigaDevice's GM on the NOR side could trend down Q/Q in the coming quarters. The new fab construction from XMC in China is still our biggest concern while MCU growth could also decelerate in 2019. We thus keep UW on GigaDevice into 2019.

Micronics Japan (6871.T)

We take a positive view of MJC's competitive strength in DRAM probe cards. However, looking forward over the next 6 to 12 months, we see major risk that the stagnating demand for smartphones in emerging markets will hurt demand for mobile DRAM probe cards. Our F9/19 OP forecast is 20% below consensus. We believe these risks are not fully priced in.

Key Equal-weight Calls

Intel Corp (INTC, $55 PT).

We expect that Intel will guide below consensus for 1h19 given headwinds in cloud spending and PCs that they have yet to see in their guidance; still, we continue to warm to the stock. We think that the CEO transition could be a substantial positive if it leads to better capital deployment (we wrote a detailed analysis of those prospects here Should the New CEO Focus on the Core Business or Continue to Diversify). We also think that the threat of a more competitive AMD is a manageable threat than is generally expected (A Deeper Dive into the Importance of Intel's Process Delays for Intel vs AMD) - we expect AMD to exit 2019 at less than 3% revenue share of Intel's data center group. The stock is very inexpensive on earnings, though roughly in line with peers on free cash flow, so the new CEO ability to close that gap will be key.

Broadcom (AVGO, $265 PT)

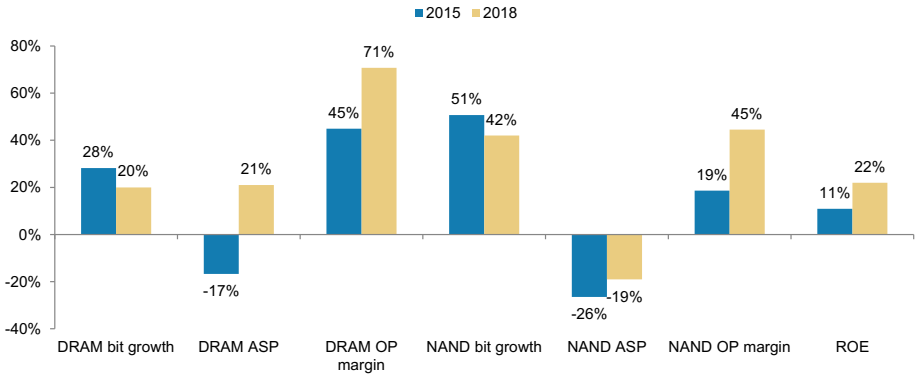
2019 could be a pivotal year for Broadcom, as the company integrates the software acquisition of CA and transitions to providing less disclosure (management is no longer providing quarterly guidance or breaking out its semiconductor business by end market). We do see the relative value angle in the stock, which trades at a FCF yield of ~10% and has a dividend yield of 4.2%. That said, a number of headwinds to its core business, including weakness in smartphones and HDDs and a deceleration in networking, keeps us Equal-weight. We could get more constructive if we felt the risks from these headwinds were fully factored in and/or the company's strategy in software begins to gel. Conversely, any miss to expectations amid less disclosure would be cause for concern.

Samsung Electronics (005930.KS)

Stocks and market sentiment already discount a fairly negative scenario as valuations have moved closer to cyclical trough levels. However, we see rising earings risk from Samsung smartphone business and underestimated DRAM pricing in the current down cycle. In contrast to management's relative optimism on the 2H19 outlook, we expect a further reset on both memory and smartphone expectations (Asia Pacific Technology: Smartphone Trilogy – iPhone, China and Now Samsung) into 2019. Samsung's NTM P/B valuation stands at 0.9x, which is even lower than 1 standard deviation from its historical avearge of 1.4x. Given 20% RoE and 26% operating profit margin, the valuation

seems very cheap and attractive, but we would stay at sidelines due to: (i) lack of near-term catalysts, (ii) lingering concerns on semi downcycle, and (iii) concerns over smartphone market in 2019.

Exhibit 3: Samsung's Now and Then (2015 vs. 2018)



Source: Company data, Morgan Stanley Research

TSMC (2330.TW)

With smartphone semi weakness, we expect order downward revisions from TSMC's key smartphone chipset customers such as Qualcomm, Hisilicon, and MediaTek. We think TSMC could offer a mild wafer price discount to encourage customers to pull-in orders, yet we see limited upside to our 1Q19 revenue forecast of down 12% Q/Q. Instead, we reiterate our Street-low GPM assumption of 46% in 1Q19 given the potential low utilization and pricing pressure. In previous semi downcycles, TSMC offered a price discount to boost fab utilization. TSMC's EBITDA margin dipped to 52% in 1Q09 and 67% in 3Q12, vs. 70% in 3Q18. We expect EBITDA margin to drop to <70% again in 1Q19. We maintain our 2019 topline growth as only 3% Y/Y, below the company's goal of 5%-10% CAGR, and our EPS still suggests 10% downside to consensus.

Price Target Changes for US Semiconductor Companies

With this report, we roll forward price targets for our coverage companies to 2020 estimates (Exhibit 4). Of note, we lowered out target multiple for many broad-based suppliers to reflect a lack of visibility in the space, downward risks to the semi cycle, and pressure seen on the overall market multiple.

Exhibit 4: Price target changes for our US coverage as we roll our PT methodology to CY20 #'s

Company	Ticker	Rating	Current Price	Old PT	New PT	PT Change	Upside/ Downside
Applied Materials	AMAT	EW	33	39	40	3%	22%
Ambarella	AMBA	OW	38	50	52	4%	36%
AVGO	AVGO	EW	255	250	265	6%	4%
Intel	INTC	EW	48	54	55	2%	15%
Inphi	IPHI	EW	33	34	39	14%	18%
Microchip	MCHP	EW	72	72	75	4%	4%
Marvell	MRVL	EW	15	19	20	3%	31%
Maxim	MXIM	EW	53	54	53	-2%	0%
Qorvo	QRVO	EW	61	70	68	-3%	11%
Quantenna	QTNA	OW	15	17	18	4%	18%
Skyworks	SWKS	EW	69	76	74	-2%	8%
Western Digital	WDC	EW	39	53	50	-5%	29%
Xilinx	XLNX	OW	89	87	98	13%	10%

Source: Company Data, Morgan Stanley Research

2018 Fundamentals and Stock Performance

Semiconductor growth in 2018 came in above of our expectations (+13.5% y/y vs. 10.4%), although growth began to disappoint as the year came to a close. Memory (mostly DRAM) drove ~50% of the upside. Memory revenue increased ~28% in 2018 with DRAM up 37% and NAND up ~17%. Excluding memory, semiconductor growth of 7.1% came in better than our expectation of 5.3% with upside mostly front half loaded. By category, apart from memory, MPUs showed the biggest delta coming in ~5% above our expectations, while Analog and Discretes came in 4% above our estimate in contrast to MCUs missing (Exhibit 5).

Exhibit 5: 2018 Semi growth forecast: Now vs. beginning of 2018

	2018 Forecast Beginning of the Year	*Y/Y Change*	Current 2018 Forecast	*Y/Y Change*	Delta	2019 Growth
Discretes / Optos / Sensors	72,446	4.9%	75,252	8.9%	4.1%	2.0%
Analog	55,339	4.3%	57,449	8.3%	4.0%	1.0%
MCU	17,302	5.3%	16,907	2.9%	-2.4%	1.0%
MPU	44,002	-0.8%	46,170	4.1%	4.9%	0.0%
Other	2,400	-27.0%	3,170	-3.5%	23.4%	-5.0%
Total Micro	63,704	-0.6%	66,248	3.4%	4.0%	0.0%
Logic (ex Micro)	112,108	9.7%	109,900	7.5%	-2.2%	4.0%
Total Logic	175,813	5.7%	176,148	5.9%	0.2%	2.5%
DRAM	94,637	30.0%	99,713	37.0%	7.0%	-21.1%
NAND	52,574	11.3%	54,969	16.4%	5.1%	-13.7%
Other	4,327	9.7%	4,433	12.3%	2.7%	2.0%
Total Memory	151,539	22.2%	159,114	28.3%	6.1%	-17.9%
Total ICs	382,690	11.5%	392,711	14.4%	2.9%	-6.0%
Total Semiconductor	455,137	**10.4%**	467,963	**13.5%**	3.1%	**-4.7%**

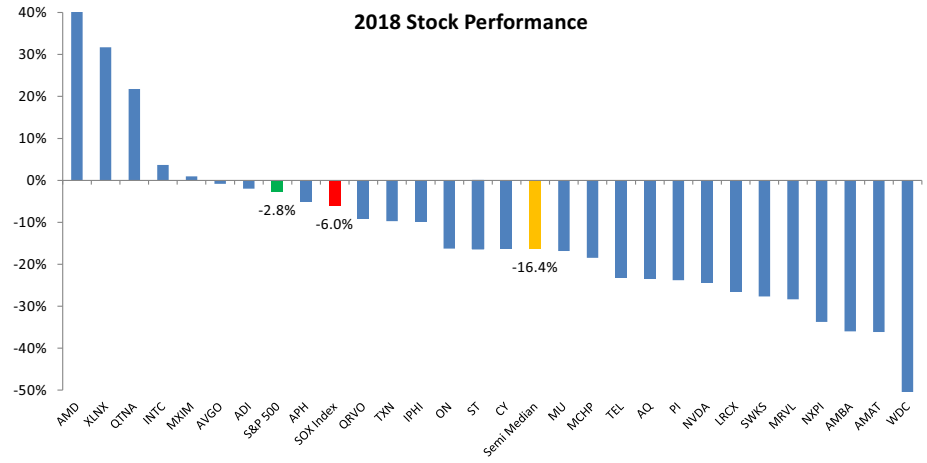
Source: SIA, Morgan Stanley Research

US Stock Performance

Overall, semiconductor stocks underperformed the broader market by ~330bps in 2018 (Semis down 6% vs S&P 500 down 2.8%), after 2 consecutive year of outperformance in 2016/17 (Exhibit 6 and Exhibit 7). In 2018, AMD (up ~94%), XLNX (~32%) and QTNA (~22%) were the key outperformers in the semi space, while INTC, MXIM, AVGO and ADI also outperformed. AMD at one point was up over 200% this year driven by enthusiasm for CPU share gain prospects vs. Intel but gave up some of those gains over the last few months as GPU business declined significantly in the 2nd half of the year and CPU share gains came in below elevated investor expectation. Xilinx's outperformance this year has been driven by strong growth in the company's Data Center and Autos (ADAS) businesses and recovery in its communications segment, augmented by multiple expansion on increasing investor confidence in the company's positioning in the data center. QTNA benefitted from an improvement in investor confidence as the adoption of its 10G 802.11ac Wave 3 product picked up this year. On the other hand, WDC - NAND weakness and cloud HDD digestion (down 51%), AMBA - weakness in its core consumer business offset traction for new CV products, AMAT - driven by NAND and display spending weakness (down 36%), MRVL - combination of lower Cavium revenue run rate

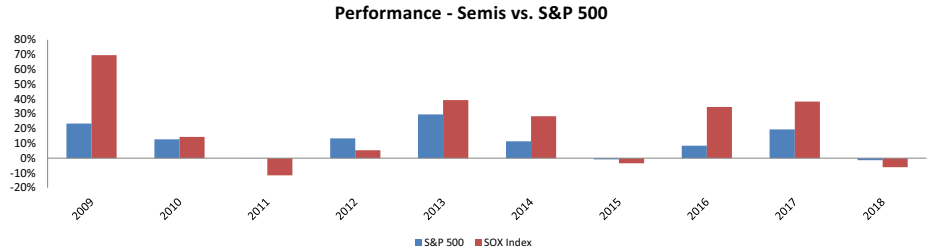
and recent weakness in HDD fundamentals (down ~28%) and SWKS - smartphone unit weakness and share loss in China (down ~28%) underperformed significantly this year.

Exhibit 6: AMD (up ~94%) and XLNX (up ~32%) led Semis this year, while the group underperformed the S&P by ~330 bps



Source: Morgan Stanley Research, Thomson Reuters
*Prices as of 12/14/2018; AMD up 94% YTD

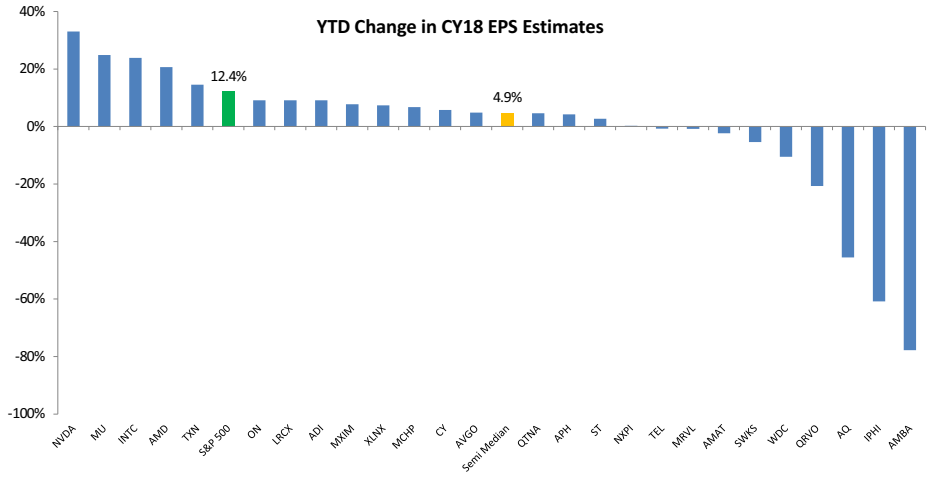
Exhibit 7: 2018 marks the 2nd year since 2012 that Semis underperformed the broader market



Source: Morgan Stanley Research, Thomson Reuters

Overall, EPS estimate revisions for the group were mixed this year. Our coverage experienced a median upward revision of ~5%. This compares to a 12.4% upward revision for the S&P, reflecting downward revisions for most semis during the last earnings season (Exhibit 8). On the higher end, AMD, MU, INTC, NVDA, and TXN saw double digit revisions upwards. However, these names were not immune from the recent sell-off and change in sentiment as all but INTC experienced negative revisions since August when we downgraded Semiconductors to Cautious and Semi-cap equipment to in-line (Stepping to the Sidelines and Semiconductors: Downgrading to Cautious as Risks Grow). LRCX, ADI and ON also saw moderate upward revisions with MCHP, AVGO, XLNX, QTNA, APH, NXPI, ST, CY, and MXIM rounding out the group that experienced positive revisions. On the other end, AMBA, WDC, IPHI, PI, AQ and QRVO saw the largest downward revisions with SWKS, MRVL, AMAT, and TEL rounding out the group.We anticipate further negative EPS revisions in CY19 as cyclical concerns continue to weigh on overall performance.

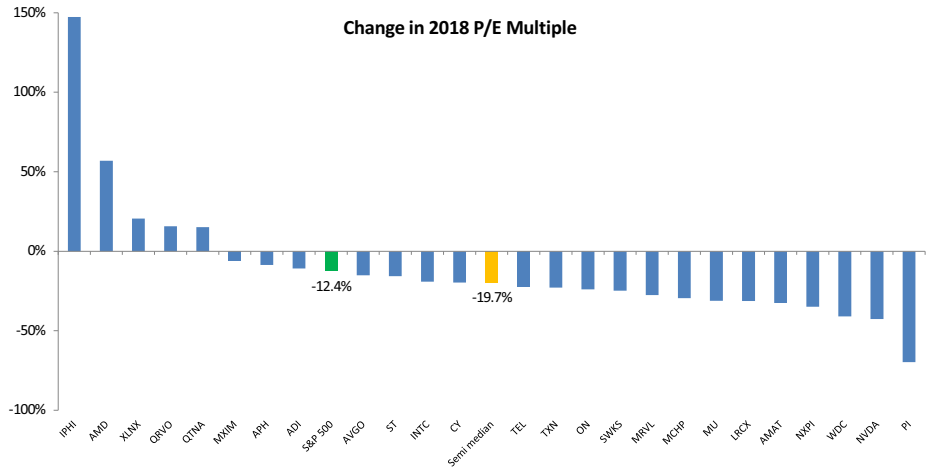
Exhibit 8: 2018 EPS expectations for the group came up slightly throughout the year



Source: Morgan Stanley Research, Thomson Reuters
*Current as of 12/14/2018

Generally, multiples contracted across the board, more than the broader market (Semis down ~20%% vs. S&P down 12.4%), Exhibit 9. We'd attribute this to the shift in sentiment as semis entered a cyclical downturn. While the long-term growth drivers such as ADAS, autonomous driving, and AI learning remain intriguing over a longer time horizon, trade tensions, softer end market demand in autos and industrial (Risks Beginning to Bubble Up in the Auto Supply Chain and Cracks Forming in Semis Sold into the Industrial Market), and cyclical concerns such as elevated inventory levels and weak memory pricing are weighing on stocks in the near term. In the absence of evidence that any of these issues have fully corrected, we expect further multiple contraction going into 2019 (Exhibit 9).

Exhibit 9: P/E multiple for the group contracted ~20% this year, more than ~12% for the S&P 500



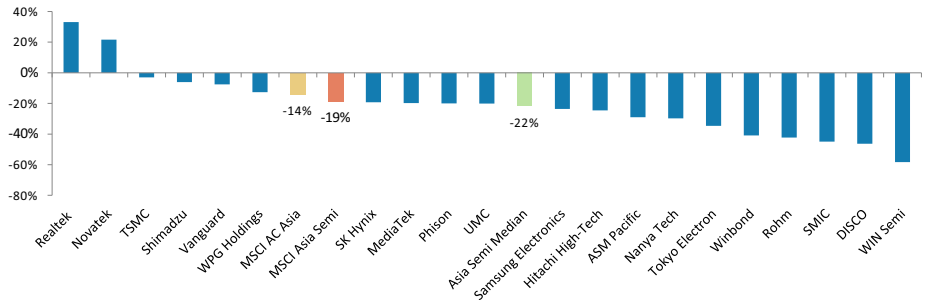
Source: Morgan Stanley Research, Thomson Reuters
*Current as of 12/14/2018

Asia Stock Performance

Overall, semiconductor stocks underperformed the broader market by ~455bps in 2018 (Semis down 19% vs MSCI AC Asia down 14%), after 2 consecutive year of outperformance in 2016/17 (Exhibit 10). In 2018, Realtek (up ~33%) and Novatek (~22%)

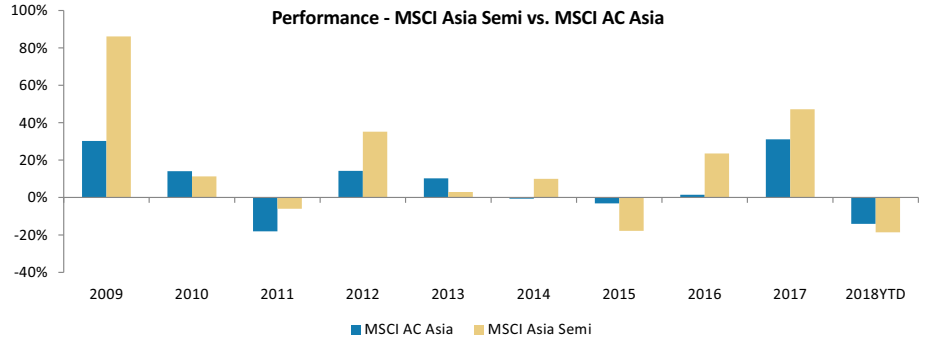
were the key outperformers in the semi space, while TSMC, Shimadzu, Vanguard and WPG also outperformed. Realtek share price rose on gross margin recovery, and in the longer term, Realtek benefits from multiple drivers, including IoT and auto Ethernet and no exposure to smartphones. Novatek's outperformance has been driven by TDDI market share gain; although risk are skewed to the downside due to smartphone semi slowdown. On the other hand, Win Semi share price fell -58%, given its ~70% revenue exposure to the smartphone end-market. DISCO stock fell 46% primarily due to the memory capex pushing out, which led to sales decline in its testing and assembly equipments. SMIC weakness was largely due to overcapacity issue for the trailing edge 12-inch nodes (40nm and 28nm), also its commitment to build 14nm capacity in the future place more burden in its cash flow (down 45%).

Exhibit 10: Realtek (up ~33%) and Novatek (up ~22%) led Asia Semis this year, while the group underperformed MSCI AC Asia by ~455 bps



Source: Thomson Reuters, Morgan Stanley Research. Price as of 12/14/2018

Exhibit 11: Asia Semi Underperformed the Broader Market in 2018 After Two Years of Outperformance in 2016/17

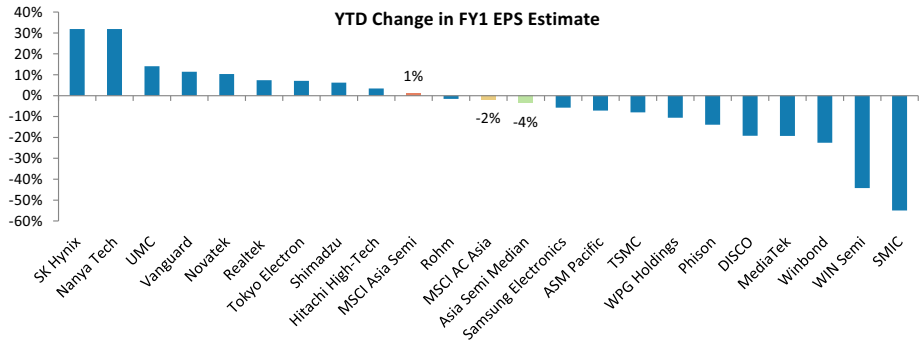


Source: Thomson Reuters, Morgan Stanley Research. YTD as of 12/14/2018

Overall, EPS estimate revisions for the group were mixed this year Exhibit 12. Asia semi coverage experienced a median downward revision of ~4%. This is worse than MSCI AC Asia with downward revision of 2%. On the higher end, SK Hynix and Nanya Tech saw the strongest upward revision due to benefit from DRAM price hikes in 1-3Q 18. However memory conditions have deteriorated, and we see significant downside risk to pricing and bit guidance of memory suppliers entering 2019 across Asia memory. On the other end, SMIC saw the largest downward revisions due to slower China semi demand and lower fab utilization. Besides, Win Semi, Winbond and Mediatek also saw significant EPS downgrades in 2018. Overall we anticipate further negative EPS revisions in CY19 as end demand is weak across the board (Smartphone, PC, Server and crypto), which should

weigh on the sector performance.

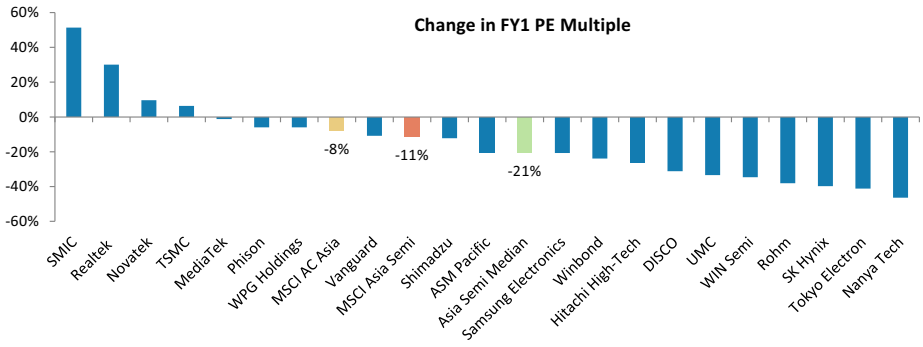
Exhibit 12: Mixed EPS Change with Median Stocks Saw ~2% EPS Downward Revision



Source: Thomson Reuters, Morgan Stanley Research. YTD as of 12/14/2018

Valuation multiplies contracted across the board, more than the broader market (Semis down ~11%% vs. MSCI AC Asia down 8%). The median stock derated by 21% in 2018, reflecting weak sentiment in this cyclical downturn. Though overall Asia Semi valuation is attractive, closer to 1 S.D. below the historical average, 2019 should be more about stock dispersion as investors look at individual stock opportunities. On the one hand, companies with countercyclical factors, such as semi content increases or market share gain, would be relative winners and their stocks should outperform. On the other hand, commodity cyclical stocks with cheap relative valuation are likely to stay cheap; therefore we suggest investor to look at a second derivative cyclical catalyst that would later drive earnings upgrades, especially for memory stocks.

Exhibit 13: P/E multiple for the group contracted ~11% this year, more than ~8% for the MSCI AC Asia



Source: Thomson Reuters, Morgan Stanley Research

2019 Semiconductor and Semicap Forecast

For 2019, we project Semiconductor sales to decline 4.7%, post the torrid ~22%/14% growth seen in 2017/18 (Exhibit 13). By segment, we expect memory revenue to decline 18% in 2019 after growing ~60%/30% in 2017/18 with DRAM down 21% and NAND down 14% - while NAND will decline by more than DRAM in the first half, we do look for some stabilization by 2h19, vs. our assumption that DRAM will remain soft all year. In addition, we expect to see only 2% growth in the broad-based categories of Analog, MCUs and Discretes this year, as the industry faces some headwinds around inventory reduction and broader deceleration in unit demand growth. Overall, as we look out to the next 5 years we believe semis remains an industry where growth is going to oscillate around GDP growth rates. Later in this report, we highlight two growth drivers adding to those already in place: artificial intelligence and automotive driver assistance. We are excited about them, but practically speaking none of them are big enough to provide much acceleration to a $450bn industry in 2019.

Meanwhile, our semicap equipment bottom-up model shows a 7% decline, though our anticipation is that this will continue to come down - we model tools shipments (ex services) down 12% for Lam, and the Applied semiconductor systems group down 13%, and we certainly are budgeting for potential downward revisions to those numbers as memory deterioration is worse than our expectations (Exhibit 15).

Exhibit 14: Annual Semiconductor Revenue Forecast

	2010 A	2011 A	2012 A	2013 A	2014 A	2015 A	2016 A	2017 A	2018 E	2019 E
Revenues ($ Millions)										
Discretes /	48,406	52,449	53,322	53,808	58,541	60,684	62,233	69,087	75,252	76,757
Analog	42,285	42,338	39,303	40,117	44,365	45,228	47,848	53,069	57,449	58,023
MCU	14,799	15,155	14,633	14,659	15,310	15,479	14,573	16,430	16,907	17,076
MPU	39,927	44,725	41,882	41,120	44,033	43,268	43,142	44,370	46,170	46,170
Other	5,908	5,324	3,723	2,909	2,728	2,551	2,869	3,286	3,170	3,012
Total Micr	**60,633**	**65,204**	**60,238**	**58,688**	**62,072**	**61,298**	**60,585**	**64,086**	**66,248**	**66,258**
Logic (ex M	77,377	78,782	81,703	85,927	91,633	90,753	91,498	102,196	109,900	114,296
Total Logi	**138,010**	**143,986**	**141,941**	**144,615**	**153,705**	**152,051**	**152,083**	**166,281**	**176,148**	**180,554**
DRAM	39,210	29,368	26,097	34,788	46,858	44,970	41,179	72,802	99,713	78,713
NAND	21,735	24,418	25,417	27,465	28,234	28,845	32,023	47,227	54,969	47,430
Other	8,669	6,963	5,481	4,790	4,140	3,390	3,565	3,946	4,433	4,521
Total Mem	**69,614**	**60,749**	**56,995**	**67,043**	**79,232**	**77,205**	**76,767**	**123,976**	**159,114**	**130,665**
Total ICs	**249,909**	**247,073**	**238,240**	**251,776**	**277,302**	**274,484**	**276,698**	**343,326**	**392,711**	**369,242**
Total Semi	**298,315**	**299,521**	**291,562**	**305,584**	**335,843**	**335,168**	**338,931**	**412,414**	**467,963**	**445,999**
Y/Y %	*31.8%*	*0.4%*	*-2.7%*	*4.8%*	*9.9%*	*-0.2%*	*1.1%*	*21.7%*	*13.5%*	*-4.7%*

Source: SIA, Morgan Stanley Research, Company Data

Exhibit 15: Semiconductor Capex Forecast

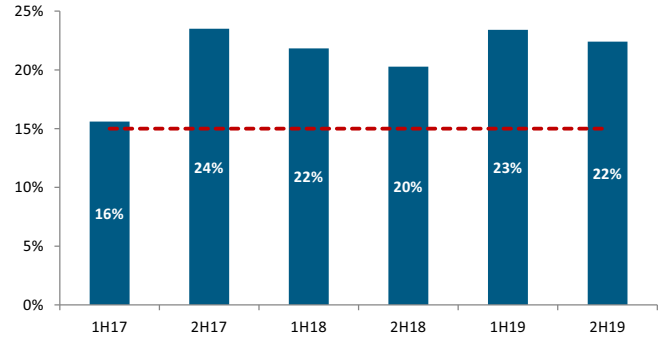
($mn)	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018E	2019e	2020e
Total Semi Capex	44,005	25,600	54,761	68,416	58,246	57,478	62,639	63,391	69,048	91,023	106,330	98,534	99,595
YoY % Change	*-30%*	*-42%*	*114%*	*25%*	*-15%*	*-1%*	*9%*	*1%*	*9%*	*32%*	*17%*	*-7%*	*1%*
Intel	5,197	4,515	5,277	10,764	11,027	10,711	10,105	7,195	9,625	11,778	15,541	14,000	14,000
TSMC	1,886	2,881	5,029	7,833	8,329	9,688	9,700	8,123	10,190	10,426	10,275	10,087	10,093
Samsung (Semiconductor)	6,526	3,604	10,381	11,733	12,425	11,506	13,579	12,997	11,369	23,761	22,000	17,250	17,690
Micron	1,911	254	1,019	2,782	1,436	1,336	2,801	4,342	5,817	5,426	9,495	8,500	9,600
SK Hynix	2,333	798	2,940	3,052	3,775	3,472	3,886	5,814	5,131	8,078	14,542	11,634	10,716
GF (former Chartered)	576	550	2,750	4,900	3,000	4,000	3,500	3,700	1,400	2,000	2,200	1,500	1,500
SanDisk	1,617	438	1,052	1,368	1,100	859	1,150	427	350	1,420	1,550	1,250	1,300
Toshiba	2,188	844	2,118	1,620	1,013	1,476	1,960	1,792	2,390	2,750	1,800	1,790	1,610
UMC	348	562	1,781	1,646	1,753	1,103	1,385	1,859	2,808	1,438	1,037	1,091	936
XMC									2,800	2,000	2,000	2,000	2,000
ASE	590	347	1,081	1,003	1,349	984	1,311	956	829	812	1,061	1,064	1,064
SMIC	664	215	486	950	417	650	653	1,231	2,757	2,342	2,319	2,102	2,084

Source: Morgan Stanley Research, Gartner, Company Data, DRAMexchange

When to Turn Cyclically Bullish on the Memory Cycle?

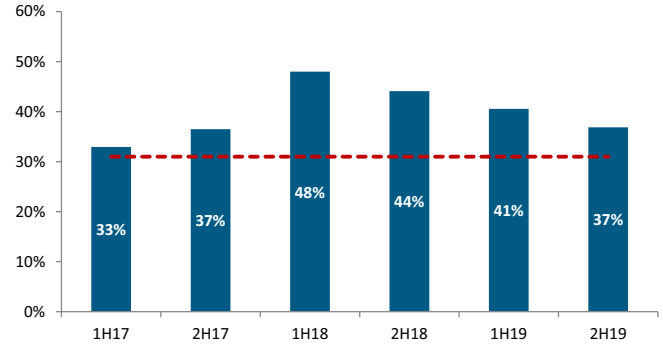
We believe this cycle will be worse than the 2015 cycle, given the imbalance between actual bit production (+22% YTD) and digested output in the market (+15% YTD), which is likely to drive excess inventory and supply into 2019. The softness in memory pricing in 2015 was not driven by supply, as DRAM bits shipped grew by only 14% in 2015, but rather by the dynamics of demand and inventory as highlighted in our recent report Asia Pacific Technology: Memory – 2018 vs. 2015 (13 Nov 2018). This in turn set up tougher comps for bit supply, which grew 23% in 2016. In contrast, 2019 could see supply bit grow almost 30% which puts heavy burden on demand growth and require significant price adjustments to get to supply and demand in equilibrium. For NAND, the much tougher price environment that we expect through early 2019 should set up strong elastic demand increases by late 2019, despite the daunting supply effects of inventory build that are causing pricing to undershoot into 4Q.

Exhibit 16: DRAM supply growth



Source: DRAMeXchange, Morgan Stanley Research

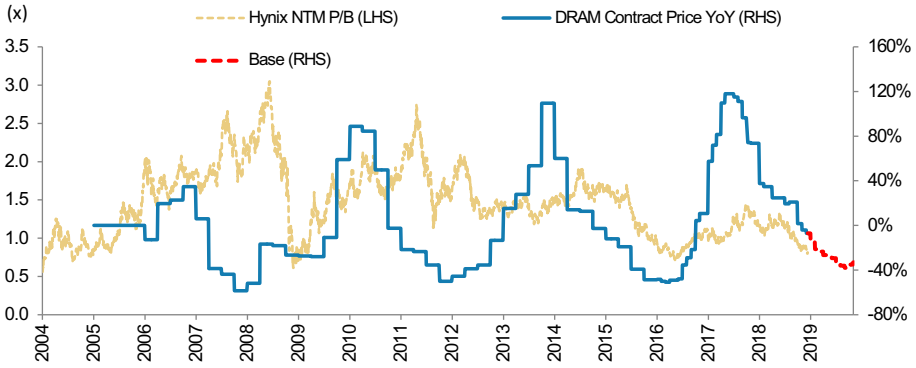
Exhibit 17: NAND supply growth



Source: DRAMeXchange, Morgan Stanley Research

When will we hit bottom? Exhibit 18 shows that previous downturns were 4-8 quarters in duration, which suggests that we are unlikely to see a recovery until mid-2019 at best. The biggest difference in memory fundamentals now vs. the last correction seen in 2015 is the degree of excess inventory built in the supply chain. We see a slower return to growth as exceptional growth factors that drove the industry in 2018 not being as robust in the next up cycle, and demand for new applications in the 'Data Era' are longer term in nature. But near term, more downside for now. Memory continues to under-ship supply, clearly highlighting the risk that producer inventories are growing, given consistent forecasts from suppliers in the low 20s vs. YTD shipment growth of only 15% (through Oct) in the case of DRAM. For NAND, the much tougher price environment that we expect through mid 2019 should set up strong elastic demand increases, despite the daunting supply effects of inventory build that are causing pricing to undershoot into 4Q18.

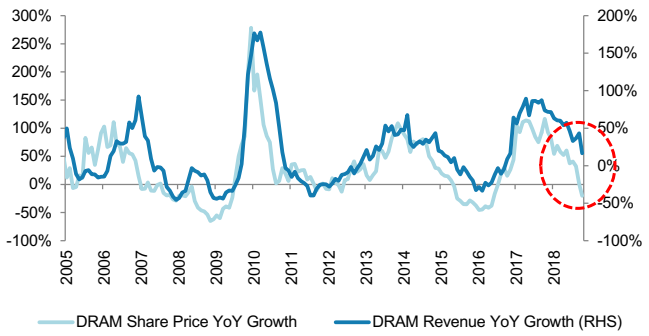
Exhibit 18: The DRAM Cycle – Monthly DRAM Contract Price YoY vs. SK Hynix's NTM PB



Source: Thomson Reuters, DRAMeXchange, Morgan Stanley Research Estimates

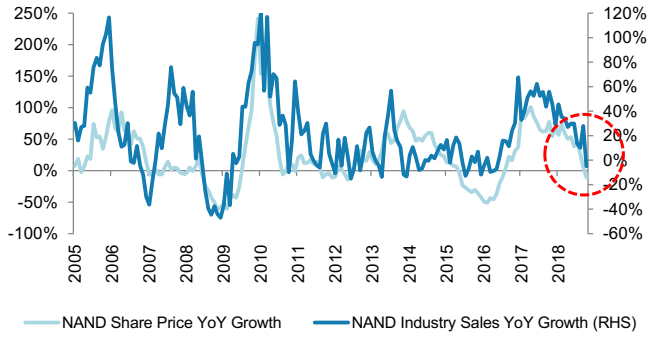
Stocks and market sentiment already discount a fairly negative scenario as valuations have moved closer to cyclical trough levels. However, valuation in itself is insufficient without a second derivative cyclical catalyst, earnings estimate revisions continue to lag and we are nowhere near a fundamental bottom. The rate of change in YoY revenues, or prices, has been useful to time inflections in memory, which we estimate is at least a couple of quarters away. For DRAM, we see growing risk that we may not see a recovery in all of 2019, so we think investors should be more patient and look for signs of cyclical bottom to emerge illustrated on Exhibit 19 rather than time the inflection. WFE spend in DRAM remains high due to excessive cash flow and supply will lag any controlled capital spend by at least 3 quarters. This signals supply inflation in 2019 as that inventory becomes incremental supply and the magnitude of the supply demand imbalance is cause for concern on pricing that may be worse than our already low levels.

Exhibit 19: Global DRAM cycle - Not at the bottom yet



Source: WSTS, Bloomberg, Morgan Stanley Research

Exhibit 20: Global NAND cycle - Still in a downturn

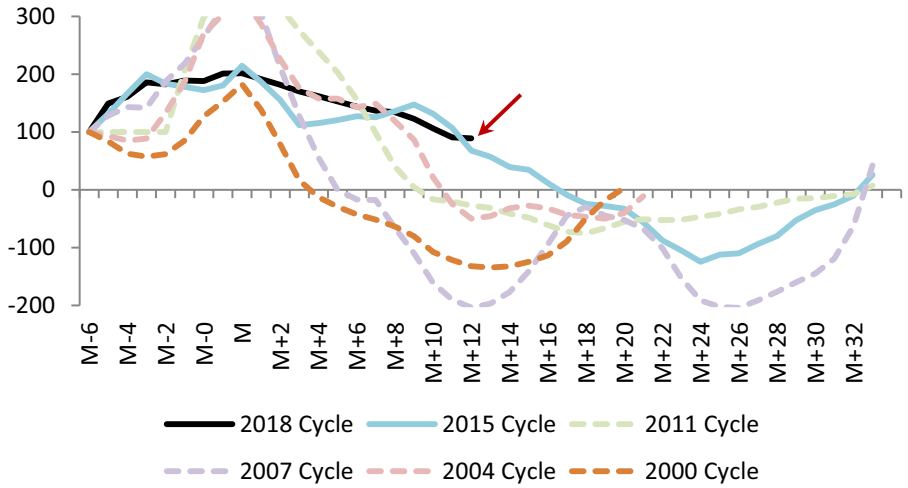


Source: WSTS, Bloomberg, Morgan Stanley Research

This time is not different. Global memory stocks are off -19-28% from YTD – SK Hynix is almost at W60,000, MU at US$34 and Samsung is below W40,000. This correction appears like another normal cyclical adjustment in share prices (i.e., a hard landing) with smaller cap names hit harder. Memory sector valuation are approaching historical troughs as recent guidance from companies for a mild downturn, becomes less of a representation of what is in the market. However, valuation in itself is insufficient without a second derivative cyclical catalyst that would later drive earnings upgrades. Buying stocks once meaningful second derivative strength has begun (at least a couple of quarters out) has rewarded investors in past cycles – and, in our view, clearly now is

still not the time.

Exhibit 21: DRAM in the Context of Past Cycles – Tracking the 2015 Cycle (Revenue YoY from previous Peaks)



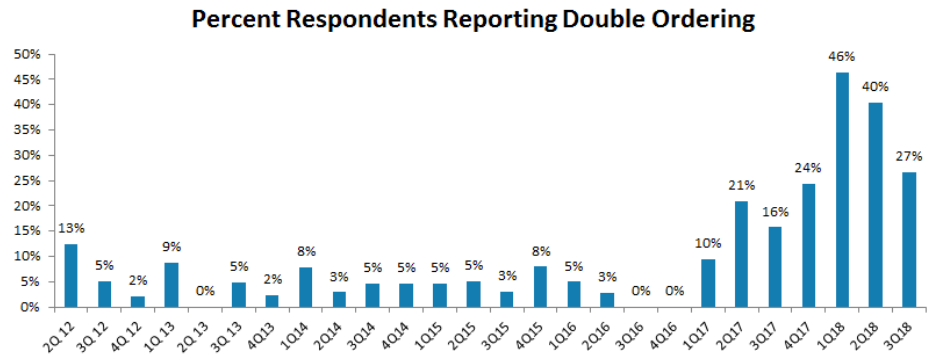
Source: Morgan Stanley Research

Issue 1 - Where are we in the Semi cycle?

We are currently in a cyclical downturn for semiconductors

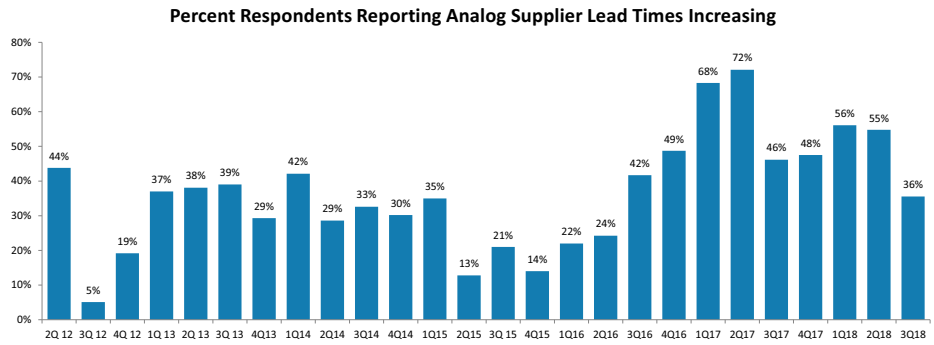
This is driven by a combination of demand slowdown in the verticals of autos and industrial and an inventory correction across the supply chain. In addition, incremental weakness on the smartphone front, especially at Apple and in China more broadly, is pressuring semiconductor demand even further. Our recent distribution survey (Disti Survey Q318: Slight Downshift in Cyclical Indicators) indicated that double ordering from customers that helped semi company results in 2017/1H18 has started to come down but still remains elevated (5X the historical median in Q3'18), Exhibit 22. In addition, fewer respondents cited further extension in lead times and supply constraints (Exhibit 23 and Exhibit 24).

Exhibit 22: Signs of double ordering have come down, from record highs in 1Q18



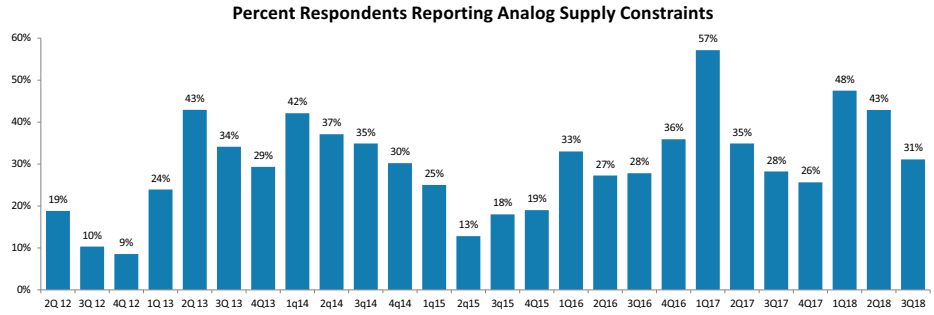
Source: AlphaWise, Morgan Stanley Research

Exhibit 23: 36% of respondents reported that analog lead times are extending, the lowest in 2 years



Source: *AlphaWise*, Morgan Stanley Research

Exhibit 24: Analog - fewer respondents are reporting supply constraints



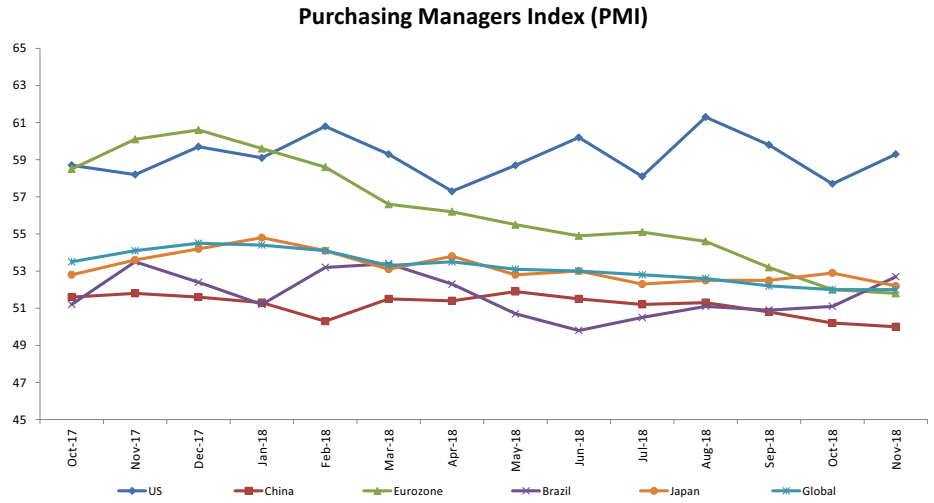
Source: *AlphaWise, Morgan Stanley Research*

Demand environment has weakened, especially in China

Global PMI has been trending down in 2018 from its peak reading of 54.5 in December 2017, with November 2018 coming in at 52. While manufacturing activity in the US remains strong (PMI at 59.3 last month), PMI in China is about to venture into contraction territory (down to 50 last month from 51.9 in May) and Europe has continued to decelerate with November coming in at 51.8 down from 59.6 in January (Exhibit 25). From an end marker perspective, demand weakness has been driven by autos in China and Europe and Industrial in Asia. The current tariff uncertainty is causing customers and distributors to pause orders and has an impact on consumer spending in China, while also likely leading to inventory build ahead of the tariff implementations.

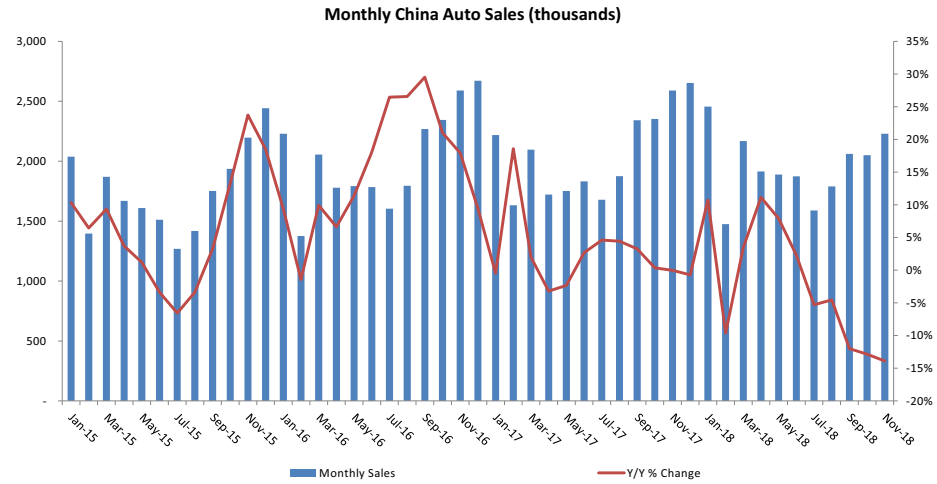
Automotive sales in China (largest auto market in the world) have been declining y/y for the last 5 months, with shipments down ~14% in November, worse than 13% decline seen in October (Exhibit 26). Slowing auto unit sales is dragging down auto production as well with auto production down ~1% in Q3'18. This should negatively impact orders for automotive semiconductors for the coming quarters, where sales for semi companies had been growing at 3X the rate of production over the last 2 years (Exhibit 27). Industrial OEMs are also seeing a deceleration with y/y growth slowing to 3.7% on average in Q3'18 vs ~7% in the 1st half of the year (Exhibit 28).

Exhibit 25: Global PMI has been steadily declining since the end of last year



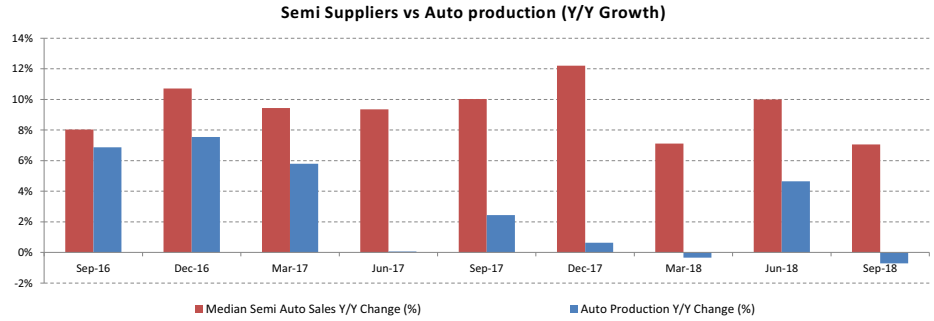
Source: Bloomberg, Morgan Stanley Research

Exhibit 26: Auto sales in China remain on a downward trend in 2018



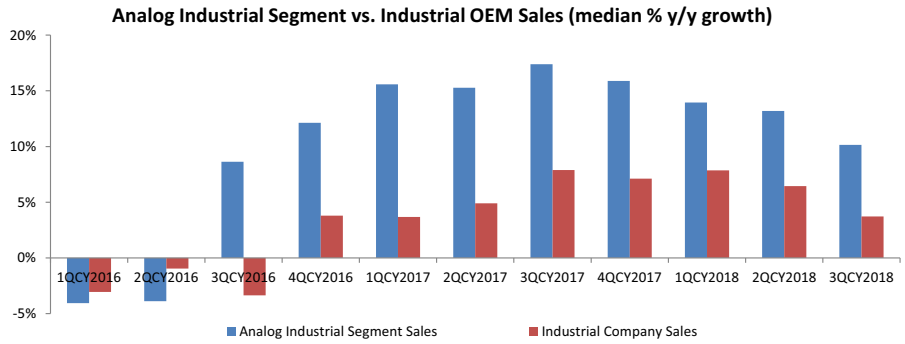
Source: CAAM, Morgan Stanley Research

Exhibit 27: Semi auto sales have grown at 3X the rate of production over the last 2 years



Source: Morgan Stanley Research, IHS, Company Data
Semi companies include ADI/LLTC, MXIM, ON, NXPI, TEL, APH and ST
Semi Auto sales represent organic growth (excluding the impact of acquisitions)

Exhibit 28: Semi industrial sales have grown 2-3x faster than industrial company sales this cycle



Source: Company Data, Thomson Reuters

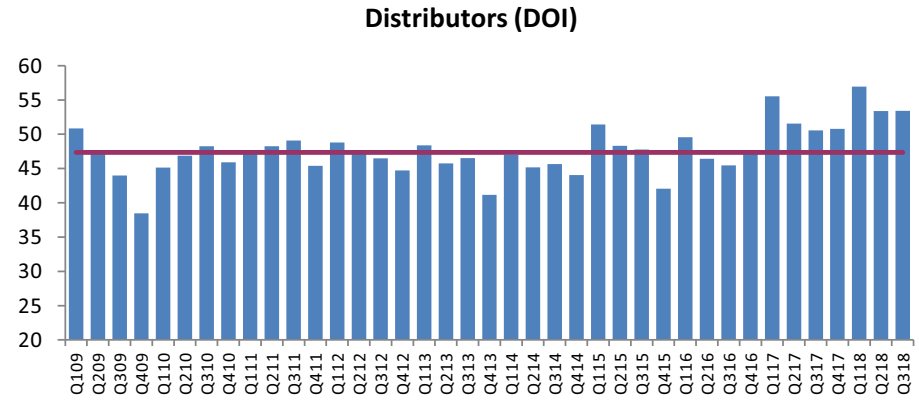
Supply chain inventory, which remains elevated, needs to be depleted before a recovery can begin

Inventory at all 3 main groups - distributors, semi customers and semi companies is above the historical median. Distribution inventory is currently 13% above its historical median and that at semi customer is ~10% above median levels (Exhibit 29 and Exhibit 30). While, Inventory at Semiconductor companies downticked slightly in Q3 but remains well above the historical median (Exhibit 31). Inventory in the Auto supply chain

has now increased to the highest level in over a decade, which could makes recent production cuts even more painful for suppliers (Exhibit 32 and Exhibit 33). OEMs saw a 3 day q/q increase in DOI in Q3 to 58 days (8 days or 15% above median) and suppliers saw 4 day q/q uptick to 42 days (7 days or 20% above median).

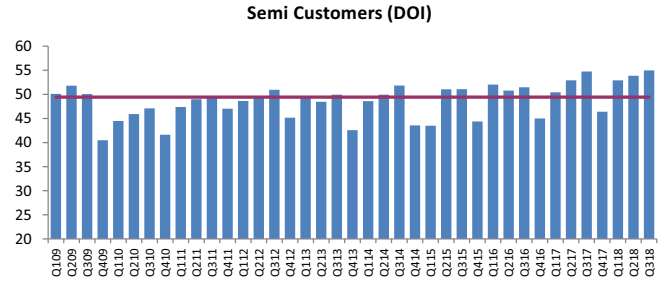
Similarly, inventory at Industrial and Machinery companies is slightly above historical levels (Exhibit 34 and Exhibit 35). In addition, distribution survey hasn't picked up any downtick in distributers/customer inventory plans, who have continued to build their inventory buffers in Q3 (Exhibit 36 and Exhibit 37). Finally, in looking at semiconductor companies, we highlight that inventory for Maxim, Cypress and Microchip in distribution is above their median levels, while TI and NXP is below (Exhibit 38 to Exhibit 42).

Exhibit 29: Distributor inventory was flat q/q in Q3 but remains 6 days above the historical median



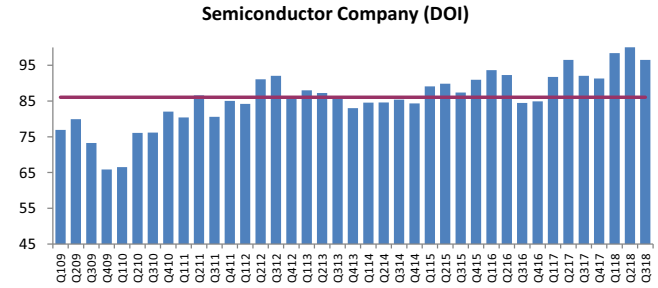
Source: Morgan Stanley Research, Thomson Reuters

Exhibit 30: Semi Customer DOI increased 1 day q/q to 55 days in Q3 and is now 6 days above the historical median



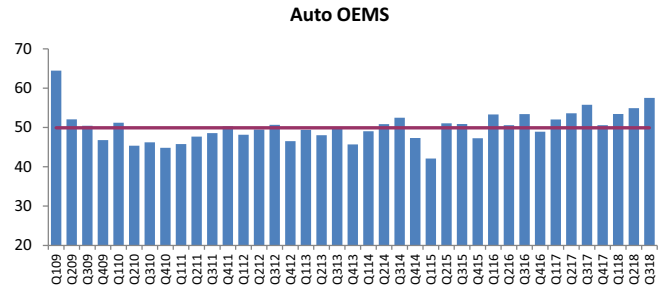
Source: Morgan Stanley Research, Thomson Reuters

Exhibit 31: DOI for Semi Companies was down 4 days q/q in Q3 and is now 10 days above the historical median



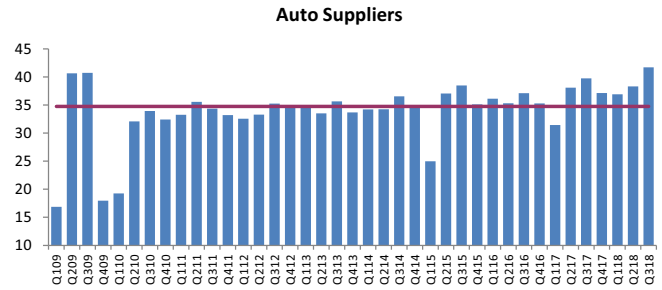
Source: Morgan Stanley Research, Thomson Reuters

Exhibit 32: Auto OEM DOI was up 3 days q/q in Q3



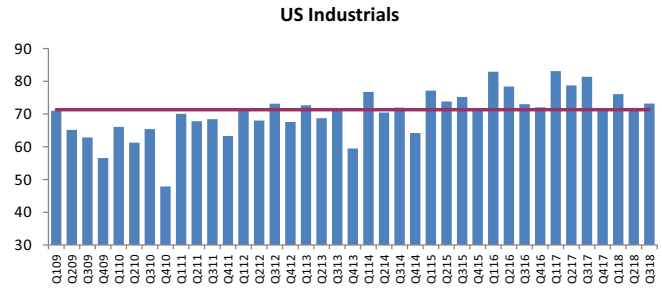
Source: Morgan Stanley Research, Thomson Reuters

Exhibit 33: Auto suppliers DOI was up 3 days q/q in Q3



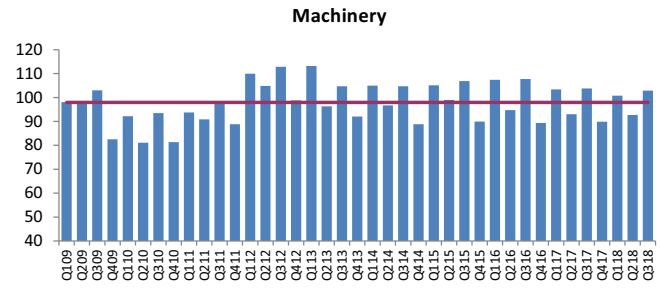
Source: Morgan Stanley Research, Thomson Reuters

Exhibit 34: Industrial DOI saw a 2 day q/q increase in Q3



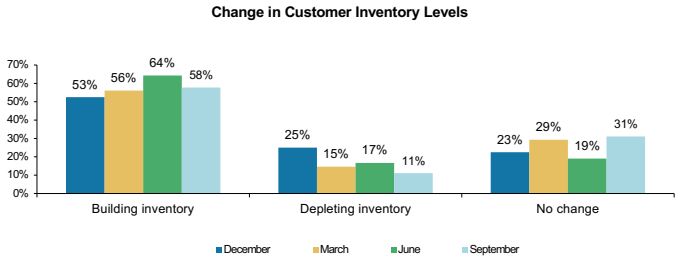
Source: Morgan Stanley Research, Thomson Reuters

Exhibit 35: Machinery DOI was up 10 days q/q in Q3



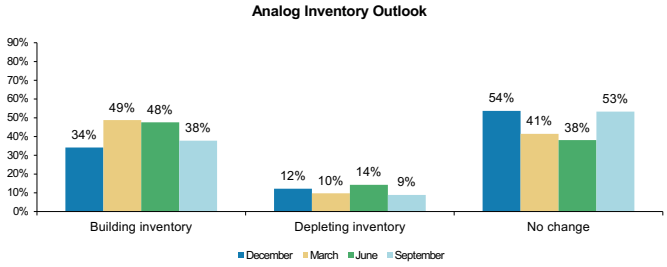
Source: Morgan Stanley Research, Thomson Reuters

Exhibit 36: Most respondents believe their customers built inventory in Q3



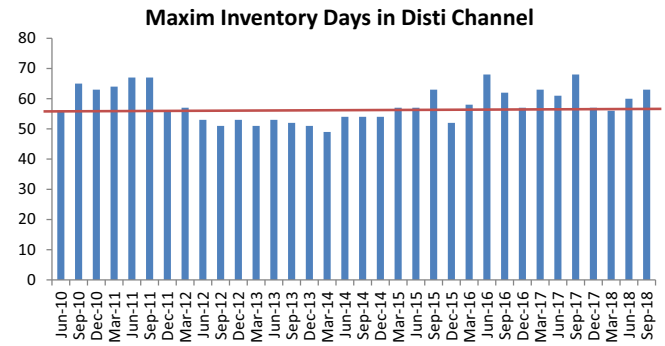
Source: AlphaWise, Morgan Stanley Research

Exhibit 37: Distributors are still looking to build analog inventory



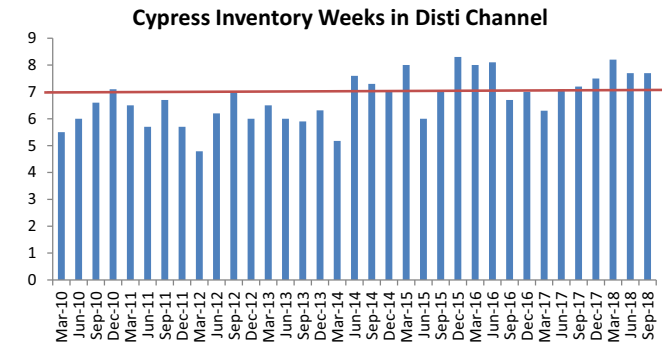
Source: AlphaWise, Morgan Stanley Research

Exhibit 38: MXIM channel days were 63 in Q3, 6 days above the median of 57



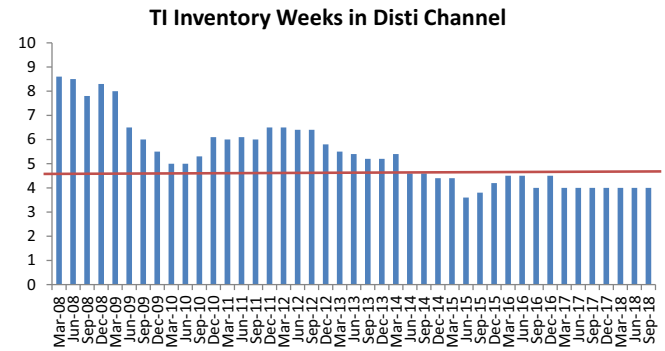
Source: Morgan Stanley Research, Thomson Reuters

Exhibit 39: Cypress channel weeks were 7.7 in Q3, .7 weeks above the historical median of 7



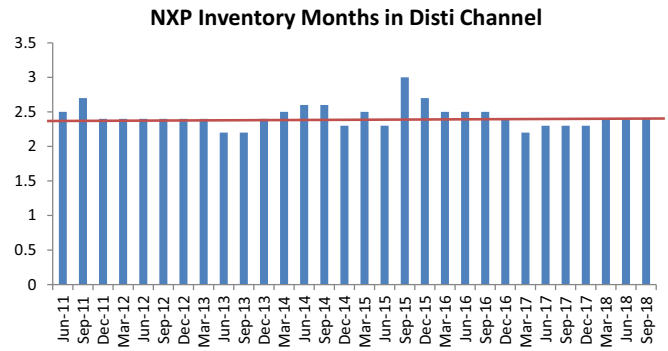
Source: Morgan Stanley Research, Thomson Reuters

Exhibit 40: TI channel weeks were 4 in Q3, .5 weeks below the median of 4.5



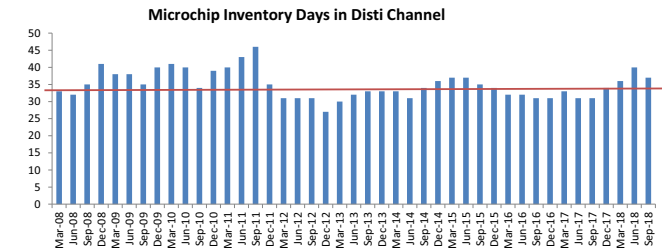
Source: Morgan Stanley Research, Thomson Reuters

Exhibit 41: NXP channel months were 2.4 in Q3, in line with the historical median



Source: Morgan Stanley Research, Thomson Reuters

Exhibit 42: MCHP channel days were 37 in Q3, 4 days above the historical median of 33



Source: Morgan Stanley Research, Thomson Reuters

Issue 2 - Outlook For Memory/Semi Caps

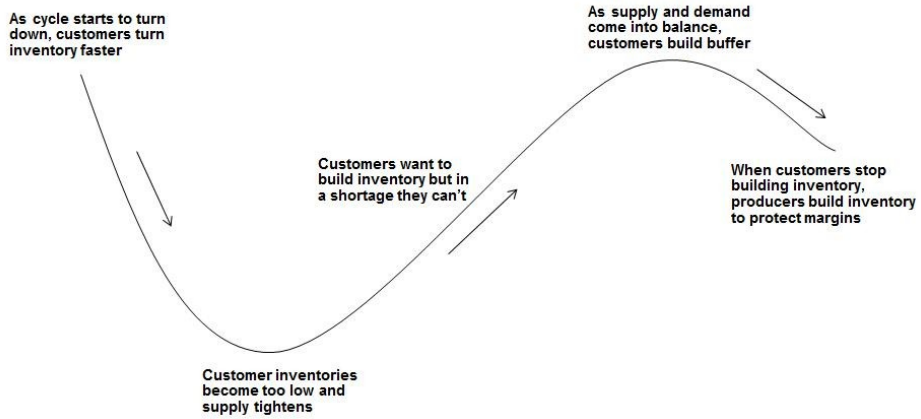
Memory - We see significant inventory-driven supply acceleration next year; we remain fundamentally cautious

In 24 years of covering memory stocks, we are hard pressed to find an example where there was a strong payoff to buying stocks that are inexpensive on peak earnings once meaningful second derivative weakness has begun. We have theories about the reason for this - described below.

Of course, we need to balance that comment by pointing out that this time has *already* been different in multiple important ways - margin upside is without precedent, the significant concerns from cloud buyers in 2017 reflected supply constraints more severe than anything since 1995 or 2000, the multiple on peak earnings is the lowest we have ever seen, the 2016 downturn was very shallow by historical standards, and the Micron buyback is 10x higher than anything they have done historically. So it's a debate, and with the sell-off in US memory stocks we see near term-risk reward as relatively balanced - especially into an earnings report in a couple of weeks. But we would be very hesitant to shrug off small price declines in 4Q as "the market coming into balance". In fact, we have maintained that both NAND and DRAM have a long way to go before they hit the bottom (with NAND in a better position than DRAM) given the inventory build that will need to be cleared out in 2019, effectively accelerating supply.

The reason that second derivative weakness at cycle peaks is such a consistent leading indicator is because there are positive feedback loops with customer inventory behavior that are far more durable than week-to-week demand variances. When prices fall, customer focus turns to maximizing inventory turns to avoid negative P&L impact of depreciating inventory. When component availability starts to tighten, customers would like to hold more inventory and inventories remain lean, as the shortage makes it impossible to build inventory. As the cycle plateaus and comes into balance, inventories build - initially from customers trying to build buffer stock after being negatively impacted by shortage, and then by producers, who are trying to protect high profit margins as customers stop building (Exhibit 43).

Exhibit 43: Memory Cycle

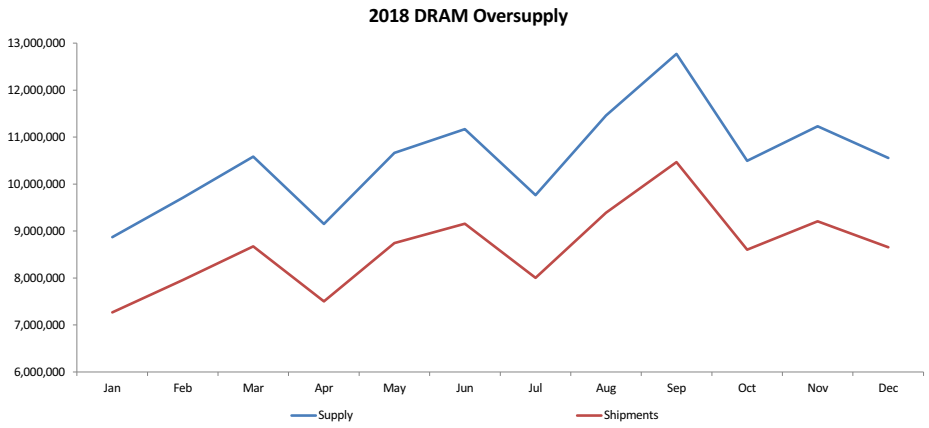


Source: Morgan Stanley Research

This cycle behavior seems very consistent with this pattern, though with significant amplification. But we think that 1h18 was the "plateau" phase for NAND, and that 2h is the same phase for DRAM. The plateau tends to see strong earnings, as inventory behaviors boost economics - but just as building NAND inventory in 1h18 masked oversupply, which became more evident in July, we would argue that DRAM conditions are somewhat worse than they appear in 3q18.

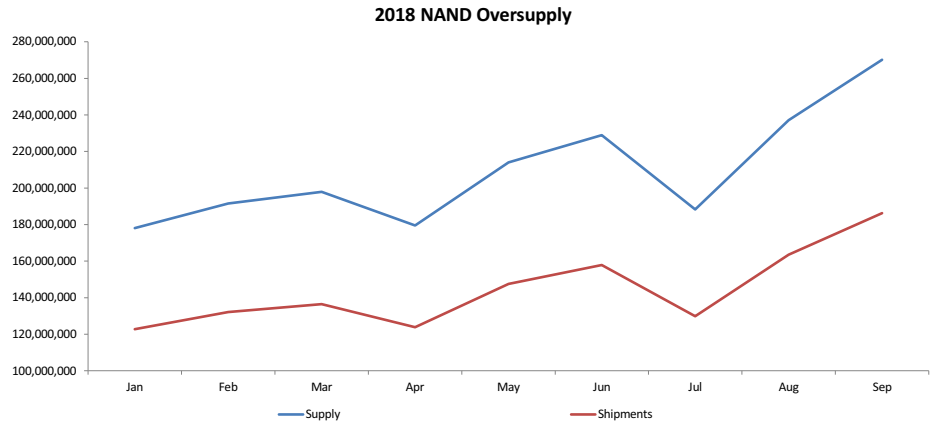
Semiconductor Industry Association data through October supports this view, showing bit shipments YTD that substantially trail our estimates of supply growth. Specifically, DRAM bits shipped YTD have been up 15.0% year over year. vs. producer estimates of supply growth of 22%. NAND bits YTD are up 33% year over year, vs. estimates of supply growth of about 45% Exhibit 44Exhibit 45) While we would not pretend to have artificial precision, it seems highly likely that the differential between supply and shipments is at least partly inventory build.

Exhibit 44: 2018 DRAM supply-demand situation



Source: Morgan Stanley Research, SIA, DRAMeXchange

Exhibit 45: 2018 NAND supply-demand situation

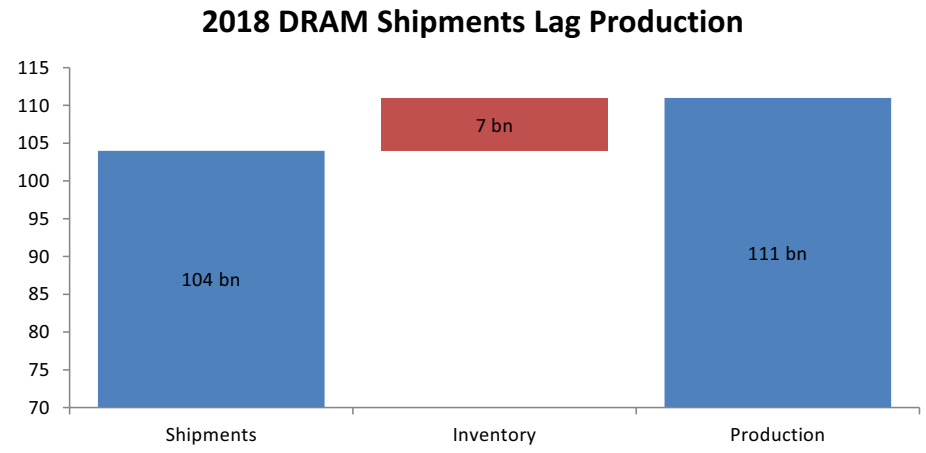


Source: Morgan Stanley Research, SIA, DRAMeXchange

Anecdotal evidence supports that this disparity grew over the course of 3q, as we think it has become harder to move bits without price concessions in 4q. As customers see prices starting to fall, they become reluctant to build inventory only to see it depreciate.

Why this matters - producer inventory builds effectively substantially accelerate 2019 supply growth - including inventory effects - to almost 30% in DRAM and over 50% in NAND - even with capex deceleration. If we believe that production growth in DRAM will be 22% this year, the industry would produce 111 billion gigabits of DRAM; but shipment growth is likely to be 14% or so, to only ~104 billion, with 7 billion building in producer inventory (Exhibit 46).

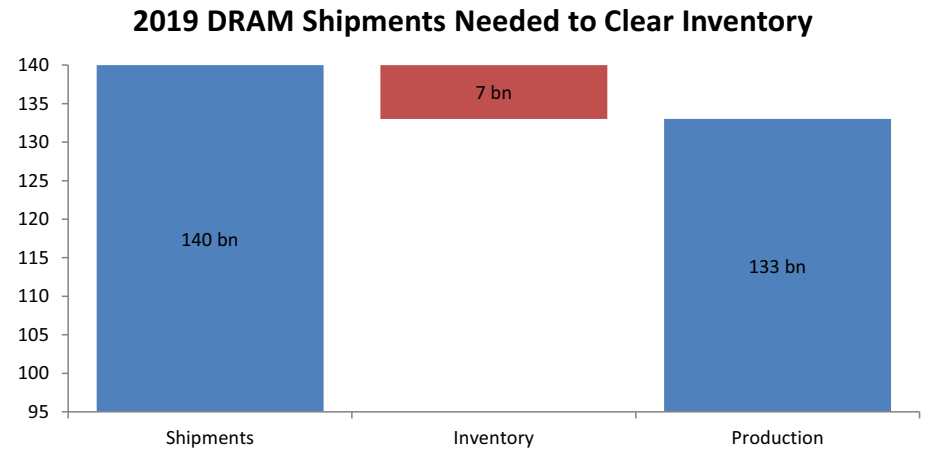
Exhibit 46: DRAM inventory build in 2018



Source: Morgan Stanley Research, SIA, DRAMeXchange

Twenty percent production growth in 2019 would bring production to 133 bn; but to clear the inventory and create a better pricing environment would require shipments of 140 bn. Production grows 20% (111 to 133), but effective supply, including inventory effects, will be 35% above 2018 shipment levels (104 to 140). That puts a very heavy burden on demand growth, in our view (Exhibit 47).

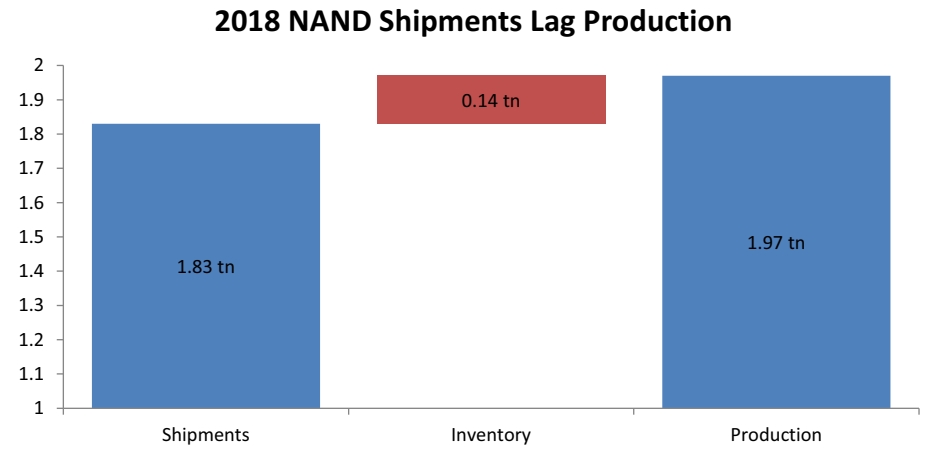
Exhibit 47: 2019 DRAM Shipments needed to clear inventory



Source: Morgan Stanley Research, SIA, DRAMeXchange

In NAND, the disparity between shipments and production seems even wider - though demand is more elastic, and current price declines should help to solve the problem by 2h19. 43% supply growth in NAND in 2018 would take us to 1.97 trillion gigabits from 1.38 trillion last year, but 33% shipment growth - which requirers substantial 2h acceleration - would only take us to 1.83 trillion (Exhibit 48).

Exhibit 48: NAND inventory build in 2018



Source: Morgan Stanley Research, SIA, DRAMeXchange

Assuming 38% production growth next year, we would produce 2.72 trillion gigabits, but clearing the inventory would require shipments of 2.86 trillion - up 56% from 2018 shipment levels. This also puts a heavy burden on demand growth although it is not quite as severe as DRAM (Exhibit 49).

Exhibit 49: 2019 NAND shipments needed to clear inventory



Source: Morgan Stanley Research, SIA, DRAMeXchange

We would not pretend we have true precision, or that the SIA data is completely accurate, but we do think this captures the current issue.

Conclusions - a material acceleration in 2019 supply growth creates a more challenging fundamental picture, which will require a negative supply shock or a positive demand surprise to get back to a tighter environment.

So where does this leave us on fundamentals?

We expect DRAM to remain difficult throughout 2019 and even beyond, as production levels grow at 20%+ but 2019 supply is even higher given the 2018 inventory carryover.

We expect NAND to remain difficult for the next 2-3 quarters, but expect profits to at least stabilize and possibly improve by 2h19; while NAND also has some inventory carryover into 2019, the elasticity of end demand should drive very high rates of demand growth by 2h19.

Semi Caps - We see equipment stocks as more range-bound for the next ~6 months, reflecting our more cautious view of memory and memory capital spending

We still see wafer fab equipment growing this year, but 1q18 was the peak, and we see declines of about 6% next year. We estimate that memory shipments in 2h will be down 20% or so from 1h, with delays in Samsung's DRAM wafer start increases and some other modest pushouts in the NAND space. We highlighted some pushouts in our Micron downgrade (Moving to the Sidelines as Stock Approaches PT; MU to EW), and became aware of additional weakness several months ago around company commentary and a competitor's call; our checks corroborate substantial pushouts, and corroborate the view that at least for now, the deceleration is being characterized as a two-quarter pushout.

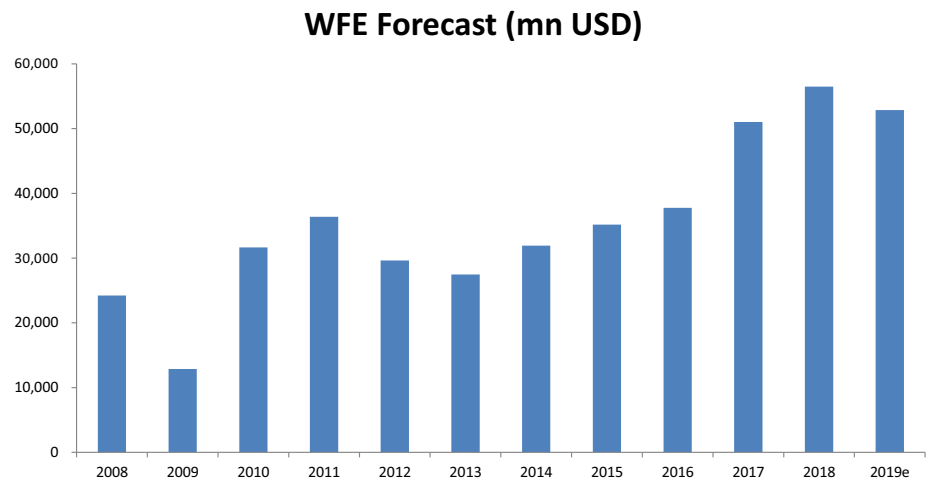
WFE tracking slightly up for 2018; still see 2018 as 10%+ above cycle norms

In 2016, both Applied Materials and Lam Research projected a 3-5 year wafer fab equipment market of ~$35 bn. Applied, in fact, made a virtue of the low year to year standard deviation/variance of this number, suggesting that the lack of year to year change was a significant positive.

Since then, our view is that volatility has reemerged with a vengeance, as memory profits have soared, and capital intensity concerns have become front and center, and as we are likely to cross the $50 bn level this year by a healthy margin, growing double digits y/y, we have seen longer term expectations steadily ratchet higher as well.

The question is obvious: were those management forecasts wrong then (and too conservative), or are they too optimistic now?

Exhibit 50: Our global WFE forecast points to a ~$53bn WFE number in 2019



Source: Gartner, Morgan Stanley Research., Company Data

We have argued - this is not new - that structural WFE has improved since 2016, as NAND spending costs have been above expectations, but that through-cycle WFE should oscillate around $43-45 bn, and that this year represents a cyclical overshoot. This assumes minimal contribution from new sovereign memory vendors, which remains a key variable.

Capital intensity for logic, foundry, and DRAM continues to increase, but there isn't much evidence that the outlook has changed since Lam and Applied gave their 2016 projections.

- **Foundry** capex rose 16% y/y in 2017 but moderated significantly this year and is now at the same level as in 2016. TSMC's spending this year will trend towards the low end of their multiyear range, and they have said that they can maintain that multiyear range while continuing to grow at historic rates.

- Intel has kept **logic** spending roughly stable over the last few years (with increases coming from NAND spending). It could be argued that stability is a sign of surprisingly high capital intensity, given the multi-year delay in 10 nm, but we haven't heard Intel articulate this, and we think the unplanned delays in 10 in a robust demand environment did drive additional spending on 14 nm.

- **DRAM** spending has been healthy, but the surprises in supply/demand balance have had more to do with cloud demand upside than capital intensity surprises. There is a continued ramp in capital intensity, but nothing that should have been surprising relative to forecasts made in 2016. We have seen this borne out in the presentations given by the equipment companies, who have chosen to emphasize the demand side ramifications of AI and cloud and have stayed with very similar descriptors of capital intensity.

NAND capital intensity has surprised to the upside

At the same time, capital intensity of NAND transitions - in particular, 3D conversions, adding layer count - has proven legitimately more expensive than anyone had perceived just a couple of years ago.

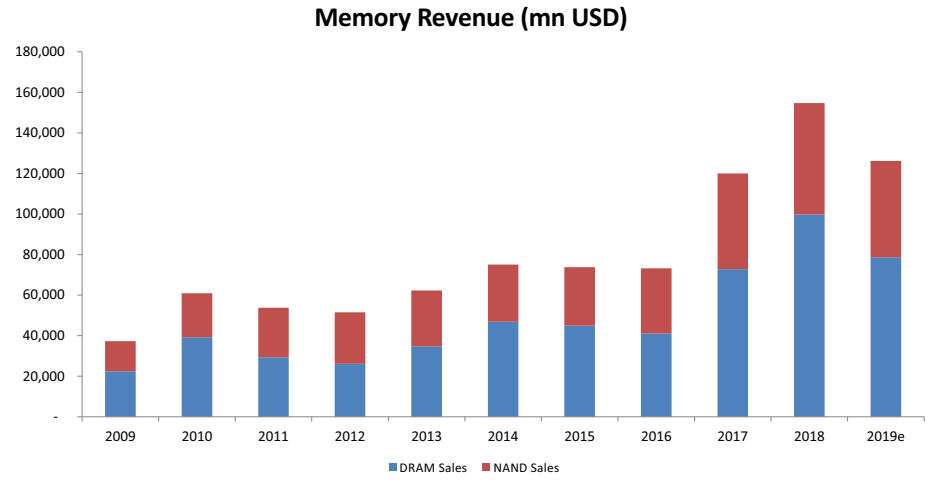
We note that significant upwards revisions in NAND capex in 2016, 2017, and 2018 have not resulted in a higher supply growth trajectory for NAND. At the flash memory summit 12 months ago, Lam Research presented a view that the 5 year wafer fab equipment forecast for NAND was $70 bn, vs. their previous assumption of $50 bn - and that despite this higher level of spending, supply is likely to remain in a 40% long term supply trajectory.

This was not a rationalization of a 40% increase in spending - the notion that 3D vertical scaling of NAND is more expensive than originally thought is something that we have heard from nearly every participant.

As a result, we would think that it's reasonable to add $4 bn or so to longer term through-cycle expectations for WFE, assuming that we remain on a 40% demand growth trajectory. A side note is that this should lead to secularly higher margin levels, as the cash generation required for steady state maintenance capex will be materially higher.

We have raised our estimates for through-cycle WFE from $35 bn to $43 bn in just two years - but the current $50+ bn is still well above cycle levels

Exhibit 51: DRAM sales grew 37% y/y and NAND sales grew 16% y/y in 2018



Source: SIA, Company Data, Morgan Stanley Research

We expect mid single digit declines in 2019, with potential for

further downside

Our bottom-up WFE model shows only small declines in 2019. But to some degree, this forecast is always a lagging indicator, since we use it to do our best to capture the consensus of the memory spenders.

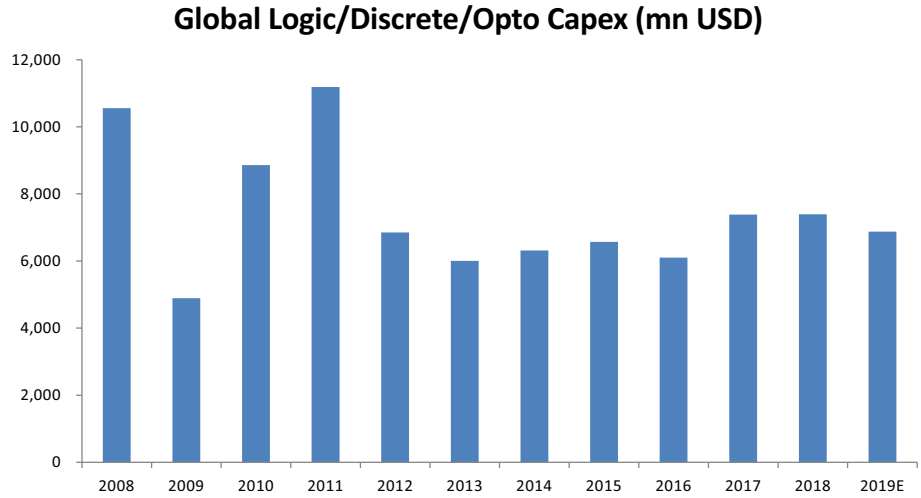
An important caveat is that Samsung is not providing even qualitative assessments of 2019.

Given our view that both NAND and DRAM move into modest oversupply next year, we do see continued deceleration in spending.

Most of our bottom-up views would point to declines:

For Logic (Exhibit 52), which at this point is mostly Intel, we see spending being roughly stable in 2019. Intel has argued that its delays in 10 nm have afforded it very little capex relief, since the delay was not planned - in fact, we think that spending in 2018 is tracking slightly higher than planned, due to the need to backfill with 14 nm capacity.

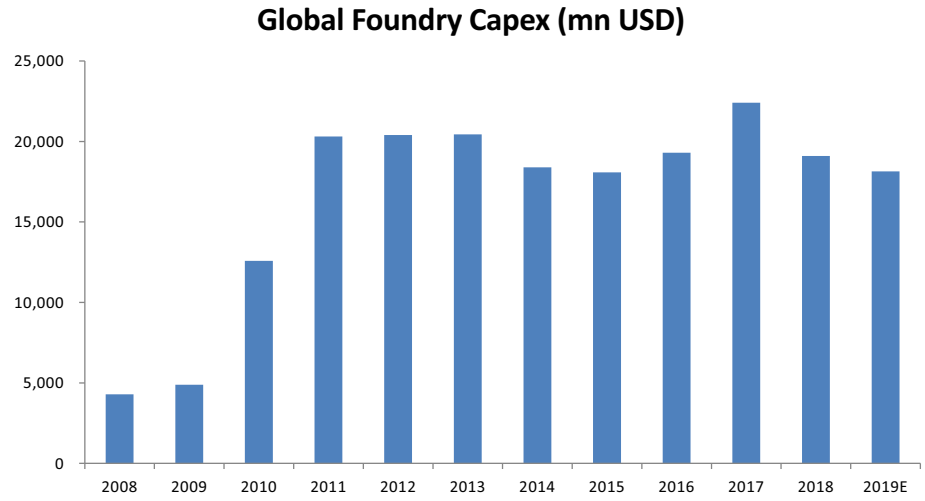
Exhibit 52: Logic spending should be roughly stable in 2019



Source: Gartner, Company Data, Morgan Stanley Research

We expect small declines in foundry (Exhibit 53). TSMC has argued that capital spending can remain in the $10-12 bn range even while driving strong growth, which compares to an estimated $11.8 bn in FY18. We expect other foundry participants to decelerate as well. While there has been much focus on AI/HPC, we note that the majority of the increases that foundry associates with that category have actually come from cryptocurrency mining.

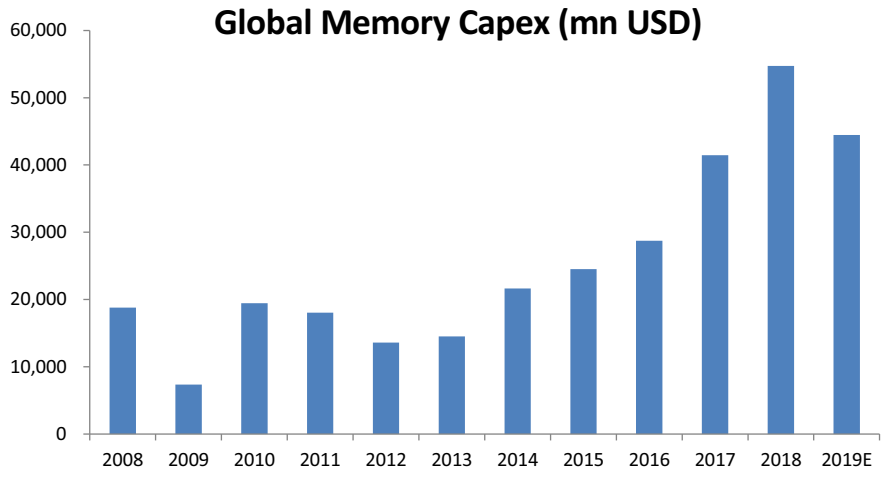
Exhibit 53: Foundry spending moderated in 2018 and should come down slightly in 2019



Source: Gartner, Company Data, Morgan Stanley Research

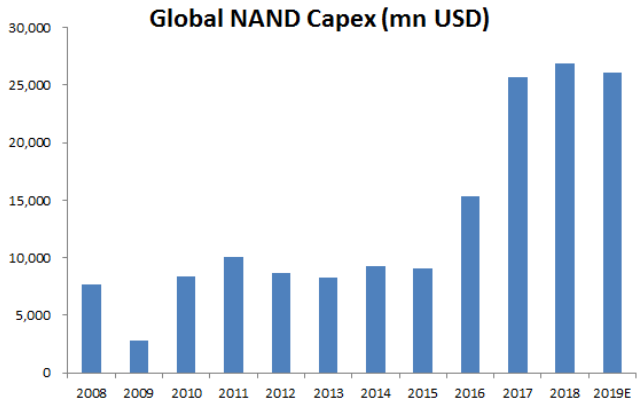
We expect small declines in memory, though there remains some uncertainty as Samsung is largely unknown (Exhibit 54). We have maintained that a decline in memory spending is necessary to bring supply and demand into balance. With that being said, we still anticipate high levels of memory spending even if they are down from the peak this year.

Exhibit 54: Memory spending should remain elevated but come down from 2018 peak levels



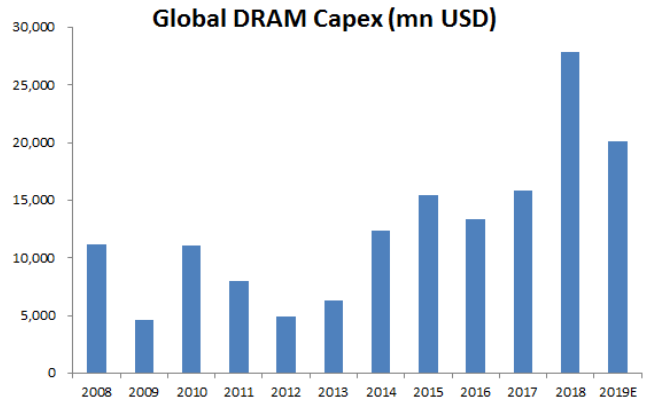
Source: Gartner, Company Data, Morgan Stanley Research

Exhibit 55: NAND capex should remain elevated in 2019 as supply and demand come into balance sooner than DRAM



Source: Gartner, Company Data, Morgan Stanley Research

Exhibit 56: We expect DRAM capex to moderate significantly after record highs in 2018

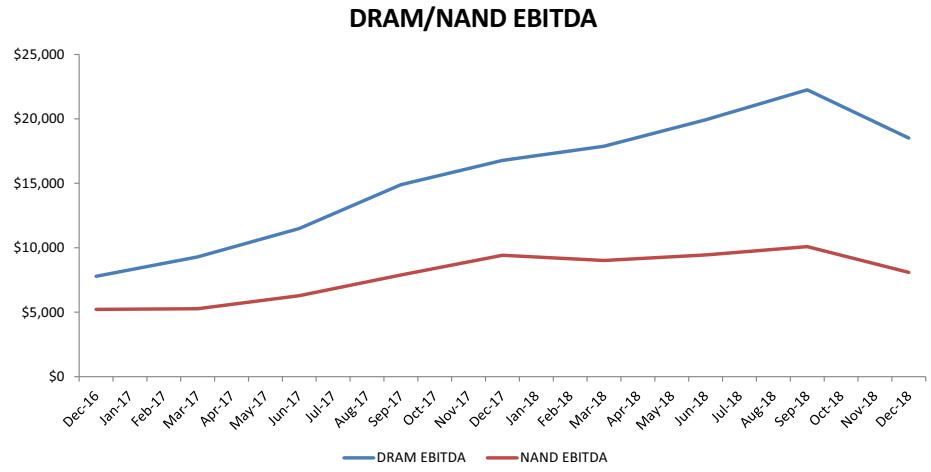


Source: Gartner, Company Data, Morgan Stanley Research

Why does spending remain relatively high when conditions are deteriorating?

Although we forecast MSD declines in spending for 2019, the absolute level will still be very high. Why is this the case given the poor fundamentals? We think that the answer lies in the magnitude of operating cash flow, which we consider one of the best predictive inputs to capital spending.

Exhibit 57: DRAM and NAND Quarterly Cash Flow



Source: Company Data, Morgan Stanley Research

When we look at the absolute level of revenues, as per the reported SIA data, we see that even though NAND prices have been eroding since late last year, that this deterioration was mild through 1h. Through Q3 sequential bit growth outpaced price declines to drive record levels of absolute revenues. Although we anticipate a sequential decline in total revenue for Q4, revenues for all of 2018 are on track to be up ~16% and achieve record levels. With assumptions of relatively stable labor, overhead, and raw materials, and steady mild increases in depreciation, we would assume that record revenues drives operating cash flow to very near record levels. Our rudimentary

model indicates quarterly EBITDA of close to $9 bn - a $36 bn run rate that more than surpasses capital spending of ~$27 bn.

Even in the case of Western Digital, which will reduce wafer starts in the coming quarters to alleviate its own oversupply issues, there should still be fairly healthy capital spending, as the company idles aging planar capacity while investing heavily to migrate its 3D to 96 layer and meet its overall cost objectives.

For DRAM, of course, prices were still increasing through 3q. DRAM revenues of $27 bn in 3q - a remarkable $108 bn revenue run rate - were over $2 bn higher than in the previous quarter, and over 2.5x the previous cyclical peak. We estimate that quarterly cash flows are close to ~$20 bn, an ~$80 bn run rate that of course dwarfs capital spending of about ~$28 bn.

While each company in isolation is dealing with mild oversupply (that we are increasingly convinced will intensify), there is still a heavy incentive to spend on increased competitiveness, as the laggards want to close the cost gap, while the leaders want to maintain it - and the only way to reduce costs in a stable fixed cost environment is to drive more production upside.

Conclusions - for equipment things are not getting worse now, but beware of false bottoms

It seems likely to us that as memory revenues erode in the next couple of quarters that equipment results will be "better than feared". We would consider this a false bottom to some degree, as we do think that it is highly likely that profit pools will be drained by enough to create risks to spending - but that may not happen until 2h19.

Issue 3 - China's Domestic Semiconductor Efforts and impact to Semi/Semicap Suppliers

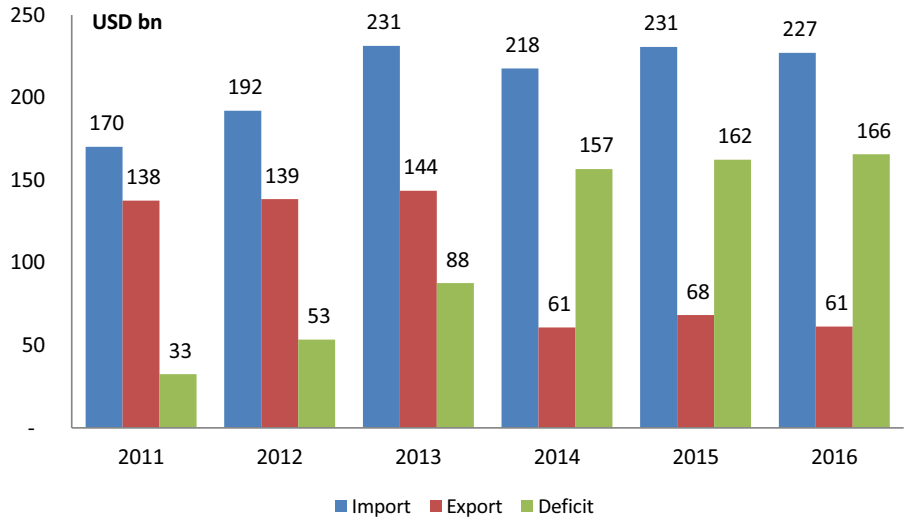
In the report, Asia Pacific Technology: How to Play the Data Era Investment in Manufacturing for Asia Tech (12 Jul 2018), we indicated that China's share of manufacturing in nominal GDP (and in real terms) has decreased since the 2007-08 financial crisis, from 32% to a 2016 floor of 29%. To improve its productivity, China has a target that by 2020 manufacturers in China must make notable progress to a higher level of digitalization. "Made in China 2025" lists New Generation Information Technology as one of the 10 strategic focus industries, in particular internet, AI, and semiconductors. China is therefore likely to continue to support local semiconductor producers.

Exhibit 58: China semi market share

Application	End product	Semi	China market share
Computing	Server	MPU(CPU)	0%
	PC	MPU(CPU)	0%
	Industrial	MCU	2%
Communication	Mobile	Application processor	18%
		Communication processor	22%
		Embedded MPU	0%
		Embedded DSP	0%
	Networking	NPU**	15%
Storage	Semi Storage	DRAM	0%
		NAND Flash	0%
		NOR Flash	5%
Display	HDTV/Smart TV	Image processor	5%
		Display driver	0%
General	PLC*	FPGA/EPLD	0%
	DSP system	DSP	0%

Source: Tech Investment Forum- China 2017

Exhibit 59: China semi trading

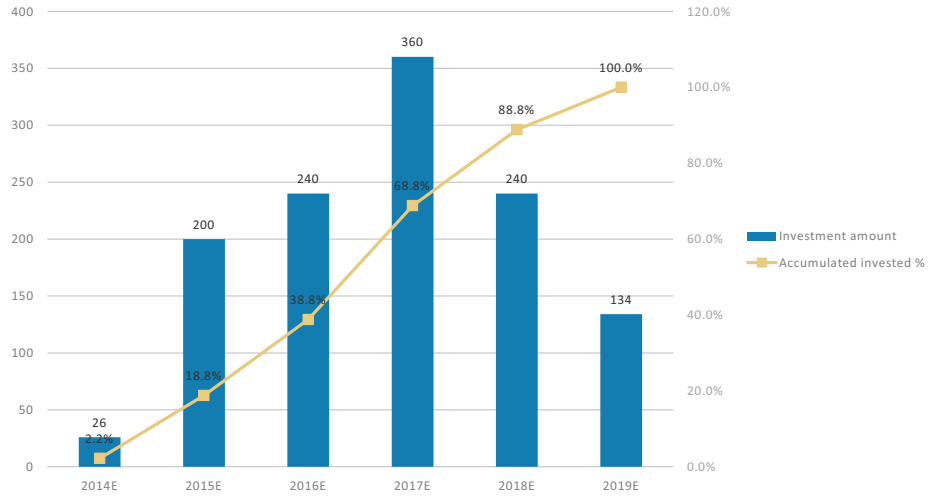


Source: Tech Investment Forum- China 2017

"The Big Fund"

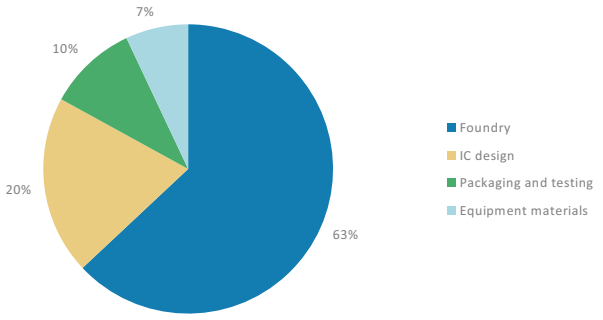
The China Integrated Circuit Industry Investment Fund, or "The Big Fund," was founded in September of 2014. It was the first fund of its kind to utilize the philosophy of a capital market as an unorthodox approach to replace the traditional subsidies and tax exemption to nurture an industry. Up until the end of 2017, it has invested in 62 projects with investment outflow of Rmb79.4bn. The invested projects spread across many segments of the semiconductor industry including foundry, IC design, packaging and testing, and equipment materials. It is an important to monitor the fund's activities to know which areas in semiconductors China is focusing on.

Exhibit 60: Big Fund original investment plan



Source: SEMI China, Morgan Stanley Research

Exhibit 61: Big Fund original investment breakdown by segment



Source: Morgan Stanley Research

Exhibit 62: Progress on each invested segment under semiconductor

Segment	Progress	Invested %
Foundry	SMIC 28nm yield to be 80% while YMTC has succeeded to produce sample wafers of 32L 3D NAND with 64L under development	63%
IC design	Spreadtrum has started developing key 5G communcation chip using 16/14nm process	20%
Packaging and testing	Supported JCET and TFME on international acquisitions to obtain leading technology and capacity. Now JCET is already the third largest OSAT company in the world	10%
Equipment materials	China has begun to set up core technology like etching equipment and 12" Silicon wafers	7%

Source: Morgan Stanley Research

China local semi company revenue size by sub-sector

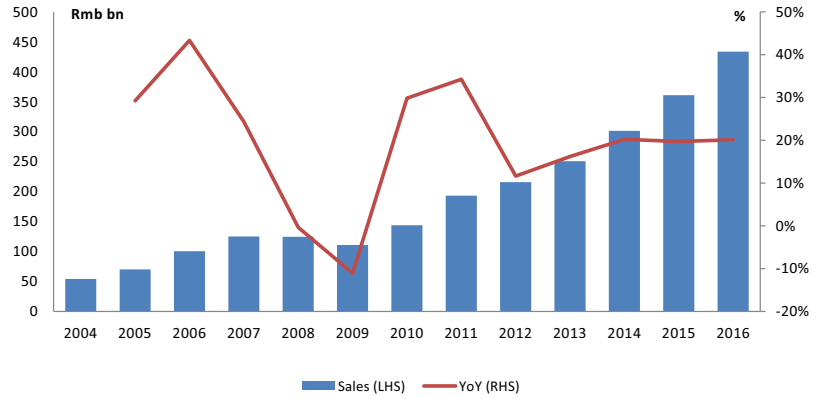
China has also built up local OSAT supply, led by company JCET. However, given the high financial leverage or poor profitibility, we are UW JCET. China also developed several strong IC design companies, such as HiSilicon for smartphone processor and SoC, Bitmain is the industry leader of mining ASIC, while Goodixs is monetizing from the finger print sensors (for which we are OW).

According to the China Semiconductor Industry Association (CSIA), China's local semiconductor industry size has exceeded Rmb$400bn for the first 9 months of 2018. We believe the key drivers behind the fast expansion could be 1) faster substitution to local providers of semi components that have lower barriers to entry, and 2) stronger local support from government in view of the increasing trade tensions in 1H18.

- Wafer foundry - 9M18 revenue at Rmb$115bn, +27.6% Y/Y
- Backend foundry - 9M18 revenue at Rmb$152bn, +19.1% Y/Y
- IC design - 9M18 revenue at Rmb$179bn, +22.1% Y/Y

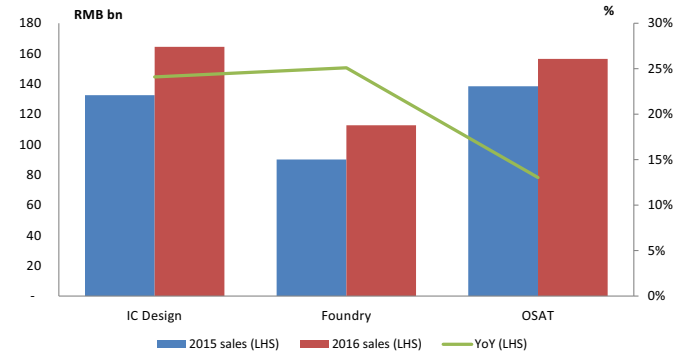
However, if we look at 3Q18 alone, total semiconductor revenue of Rmb$173nn declined 6.1% Y/Y, suggesting that the trade tensions has resulted in actual impact in demand, which we believe should persist into 4Q18 and 2019. We believe that without support from foreign companies, development of China local semiconductors would decelerate, as it would face more challenges ahead.

Exhibit 63: China-based semi company sales



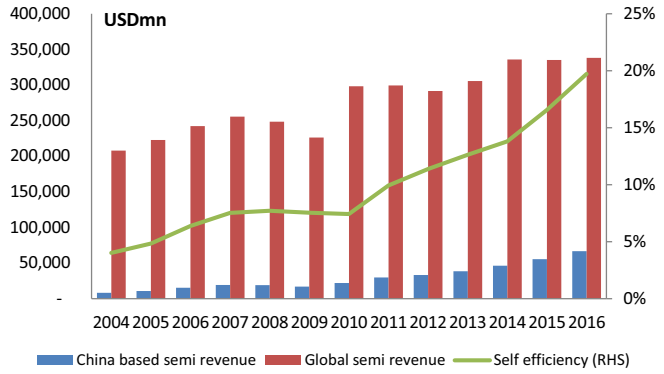
Source: Tech Investment Forum- China 2017

Exhibit 64: China-based semi company sales (in RMB bn)



Source: Tech Investment Forum- China 2017

Exhibit 65: Self-sufficiency ratio



Source: Tech Investment Forum- China 2017

China memory fab progress appears to be slow

YMTC is the Chinese memory company that owns IP for 3D NAND by licensing from Cypress Semiconductor. The company is constructing new fab to produce 3D NAND, but we think more effective capacity should be in 2020 when the company mass produces its 96L 3D NAND. In 2018, we think the total capacity for 3D NAND would be only 5k wafer per month for 64L 3D NAND, and it could expand to 20k in 2019.

On DRAM, Innotron (which is funded by Gigadevice) is developing 19nm DRAM technology. But without a big R&D team for support, we think the capacity could be only 1-2 k wafers per month. We also think UMC/Jinghua's 25nm DRAM technology development is quite behind. Overall, we don't think China memory fabs would move the needle of memory industry supply in 2018.

Alternatively, China can run a foundry business model for memory, just like the Inotera JV of Formosa Group and Micron. Outside of DRAM, we see China's opportunity in NAND, because China had acquired the IP license from Cypress four years ago, before the trade tensions started. If China were to build up a competitive NAND fab, it could potentially disrupt the current NAND supply chain.

China has also built up local OSAT supply, led by company JCET. However, given high financial leverage or poor profitability, we are UW JCET. China also developed several

strong IC design companies, such as HiSilicon for smartphone processor and SoC. Bitmain is the industry leader of mining ASIC, while Goodix is monetizing finger print sensors (for which we are OW).

Exhibit 66: Memory projects in China summary table

Company	Products	Invested Capital (US$bn)	Capacity progress and plans	Key investors
YMTC	NAND, DRAM	>24bn	- Mass production in 2020	China Big IC Fund, TsingHua Unigroup, Hubei IC Fund, Hubei Science Technology Investment Group
Fujian Jinhua	Specialty DRAM	5.7bn	- Risk production in late 2018; monthly capacity 60k - Monthly capacity to reach 240k in 2025	Fujian Electronics and Information Group, Jinjiang Energy Investment Co.
Innotron Memory	8GB DDR4/LPDDR4	7.2bn	- Mass production by end of 2018 - Monthly capacity to reach 20k in 2019	Hefei Industry Investment Group

Source: Digitimes, Morgan Stanley Research

Exhibit 67: Summary of 12" fab construction in China

Location	Company	Codes	Capacity (kwpm)	Status	Business
Beijing	SMIC	B2A	35	Exist	Foundry
Beijing	SMIC	B1(FAB4)	45	Exist	Foundry
Beijing	SMIC	B1(FAB6)		Exist	Foundry
Wuhan	XMC	F1	20	Exist	Memory
Wuxi	Sk Hynix	HC1	100	Exist	Memory
Wuxi	Sk Hynix	HC1	70	Exist	Memory
Dalian	Intel	FAB 68	60	Exist	Memory
Xian	Samsung	F1x1	100	Exist	Memory
Shanghai	HLMC	F1	35	Exist	Foundry
Shanghai	SMIC	S2(FAB 8)	14	Exist	Foundry
Hefei	Jinghe	HF	40	Buiding	Memory
Beijing	SMIC	B3	35	Buiding	Foundry
Quanzhou	Jinhua	F2	60	Buiding	Memory
Xiamen	United Chip	FAB 12X	50	Buiding	Foundry
Shenzhen	SMIC	SZ	40	Buiding	Foundry
Shenzhen	United Chip	SZ	40	Buiding	?
Wuhan	YRST	F2	200	Buiding	Memory
Huaian	Decoma	F2	20	Buiding	CIS
Nanjing	TSMC	NJ	20	Buiding	Foundry
Shanghai	SMIC	SN1	70	Buiding	Foundry
Shanghai	HLMC	F2	40	Buiding	Foundry
Chendu	GlobalChip	-	20	Buiding	Foundry

Source: Morgan Stanley Research

Our assessment of US/China trade tension impact on Greater China Semis

We think the trade tension is slowing down the commodization of the global semiconductor industry. In recent news reports, China actually plans to re-prioritize its strategy away from "Made In China 2025" to give foreign companies greater access to its economy, as a sign of good faith amid US / China trade tensions.

Originally with the "Made In China 2025" plan, China aims to increase its self-sufficiency ratio on key components and materials from 40% in 2020 to 70% in 2025, increasingly reducing its reliance on foreign technology. It was a policy or slogan that faces heavy criticism from the international market given its heavy government subsidies to gain market share. In the recent years, China has commoditized solar, LED, TFT-LCD products. This dynamic would also encourage Chinese semiconductor companies to invest in more R&D to build up their own patents. So we think it should be a short-term pain to the China local semi companies, but a gain to global semis in the long term.

Tariffs are the most obvious feature of the US and China trade tensions, and we did see that they caused some short-term semiconductor demand volatility, such as in consumer confidence, inventory build, and diversification of the production base to prevent further tariff hikes. The tariff impact to the semiconductor supply chain is more on an operational level, and so far we haven't seen a big impact from tariff issues on semi companies, because most of them already have production sites outside of China.

But what could change the semiconductor industry long-term is changes in the US's policies on technology, because on the one side they could delay China's goal for self-sufficiency. In early 2017, a US semiconductor association published a whitepaper urging US government to protect semi technology, and expressing concerns about Chinese competition or even disruption. Then in 2018, we started to see action from the US government, including the restriction of the sale of semi equipment to Jinhua in China. Jinhua is one of China's major memory projects for DRAM local supply.

The UMC/Jinhua event is an instance of US's changing policies on technology

On November 1, a federal grand jury indicted a PRC state-owned company (Jinhua), a Taiwan Company (UMC), and three individuals, and charged them with crimes related to a conspiracy to steal, convey, and possess trade secrets of an American semiconductor company. A press release indicated that if convicted, each company faces forfeiture and a maximum fine of more than US$20 billion.

UMC issued a press release and commented that the lawsuit is in the initial stages and will take some time to finalize. For more historical context of the lawsuit around the UMC/Jinhua case, please see the "Greater China Technology Semiconductors: Implications from UMC/Micron" court decision of July 5, 2018.

Will 'Made in China 2025' Become Relevant to Semicap Investors in 2019?

Our View	Market View
The opportunity is bigger than consensus, but 2019 is still small, and it is more binary than generally perceived — regulatory risk is growing faster than we had expected. China's push to offset its dependence on US semiconductors should begin in earnings in 2019, which is a substantial issue for US semicaps. We see 4 debates within the debate: 1) how big is the opportunity - we think it is larger than consensus, $7-10 bn of wafer fabrication equipment (WFE) by 2025; 2) How does it ramp near term? We are a bit cautious on 2019, as there isn't enough cleanroom space; 3) What are the regulatory risks? There is risk related to potential future trade policy actions; and 4) Which stocks are the biggest beneficiary of this potential binary event? We would pick Lam Research.	**Most investors see this situation as less binary.** While there is some enthusiasm for China as a modest kicker to growth, even the companies downplay the magnitude. In terms of our four debates, we think that 1) the market sees China as more of a $3-5 bn opportunity, 2) but with slightly higher near-term expectations. Regulatory risk is a widespread concern but generally the thought is that Chinese companies will persevere. In terms of stockpicking, there is some investor preference for Applied Materials given its greater business breadth.

The history of the semiconductor industry over the last 30 years has been driven by heavy sovereign investment adding to a boom/bust cycle, and the next 5-10 years seems likely to repeat that history with China. Sovereign investment driven by national

priorities in Japan, then Korea, then Taiwan characterized many of the boom/bust cycles within semis, each time driving a major investment cycle followed by multiple years of substantial oversupply. China's actions to date look similar, though there are some differences - the barriers to entry in memory were higher during Taiwan's push, and seem higher still now, and trade tensions may serve to increase motivation, but also could cause the effort to stall.

Why is China focusing on building a domestic semiconductor supply chain by 2025? Our sense is that the Chinese government may be concerned about continued access to US semiconductors. While the headlines are dominated by shorter-term tariff negotiations that might have only indirect impact to semis, some semiconductor industry-specific issues in recent years temporarily limited shipments of certain products. Most of these predate 2017, and have since been resolved, but China's dependence on the US semiconductor supply chain remains a potential risk for many large companies, and reducing this dependence is likely a goal, in our view.

What is "Made in China 2025"? *Made in China 2025* is a national program issued by the Chinese government in May 2015 to increase Chinese content of core materials to 40% by 2020 and 70% by 2025. The plan focuses on high-tech fields such as pharmaceuticals, robotics, and semiconductors. While one could conjecture that a portion of the rationale may be defensive, there is a clear goal to increase higher-end technology manufacturing.

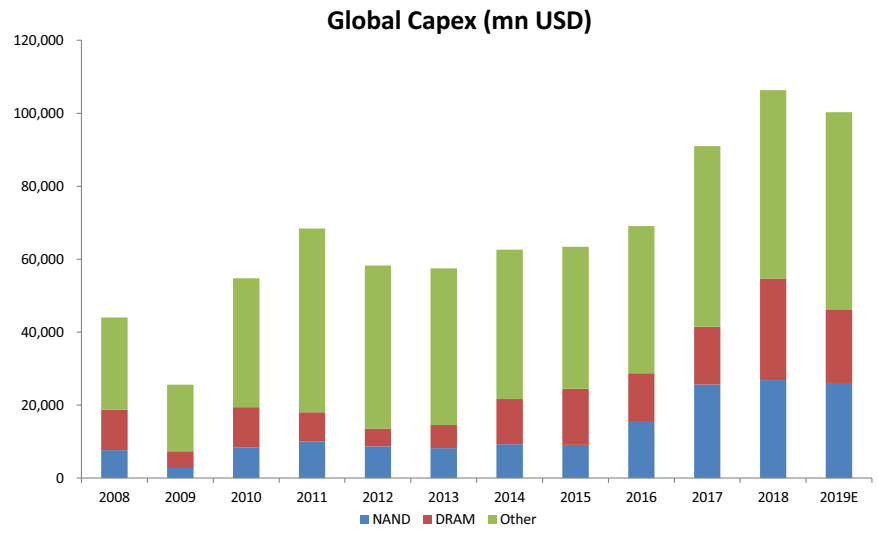
How does "Made in China 2025" affect semiconductors? There are many efforts underway to secure key technologies, including microprocessors, subsidies to logic and foundry developers, and securing of IP through smaller-cap M&A. But it appears that a major focus is going to be on memory, as we saw historically for other nations, as the scale — and lower barriers to scale —allows companies to climb the learning curve quickly (albeit likely painfully from profit perspective). While access to commodity memory seems unlikely to become problematic for Chinese hardware companies, focusing on memory may be the quickest path up the learning curve.

What is the current status of Chinese investment? Several Chinese memory players have emerged, with overlapping ownership and incentive structures. Investment thus far has been small from the memory makers, as generally the companies are trying to establish viable pilot production before ramping.

The key debates: We think that the investment in 2019 is relatively small on a global scale, but we think this will be one of the biggest issues for the semicap stocks for the next decade. We see 3 elements of the debate that should get sorted out in the coming year?

Debate 1) How big will the investment be over the next 5 years? We are more positive than consensus. While many of the fab announcements have dollar amounts associated with them that appear inconsistent with relatively small cleanroom size, it is clear that to be relevant on a global scale is an enormous expense, and it is one of the most relevant drivers of semicap profits.

Exhibit 68: Global Capex



Source: Company Data, Morgan Stanley Research

As shown in the exhibit above, global memory capital spending in the last 5 years has been $171 bn; over that time wafer fab level spending comprised ~60% of total capital spending, or about $102bn. There was only one new entrant over that time, Intel, which was about 5% of the total investment; the other 95% was primarily technology transition. We believe that these businesses only work economically with large scale, given that the large R&D burden is not volume-dependent. With multiple entrants in both types of memory, we estimate that Chinese memory investment could reach $15-20 billion in spending by 2025, even if profits don't follow immediately.

Debate 2) How quickly can the investment scale? We are more cautious than consensus on 2019 spending. We argue that there simply isn't that much cleanroom space for 2019 installations. Companies have substantial amounts of land, and the money to spend much more - but we think that 2019 spending will be fairly prudent. We also expect initial spending to have minimal impact on 2019-20 economics - the spending is small and the learning curve is steep

Debate 3) Could there be a US policy action? We note that any action could conceivably be negative. But in our view, it would be extremely challenging to build a cutting edge memory facility in the next 5 years without buying tools from Applied Materials, Lam Research, and KLA Tencor. And if trade tensions persist, it's conceivable that there could be action. We spent some time recently discussing the issue with the Morgan Stanley US Public Policy Research team. It's complicated, because US and other multinationals have fabs in China, but the US appears to have several means to potentially limit US tools vendors shipping into China.

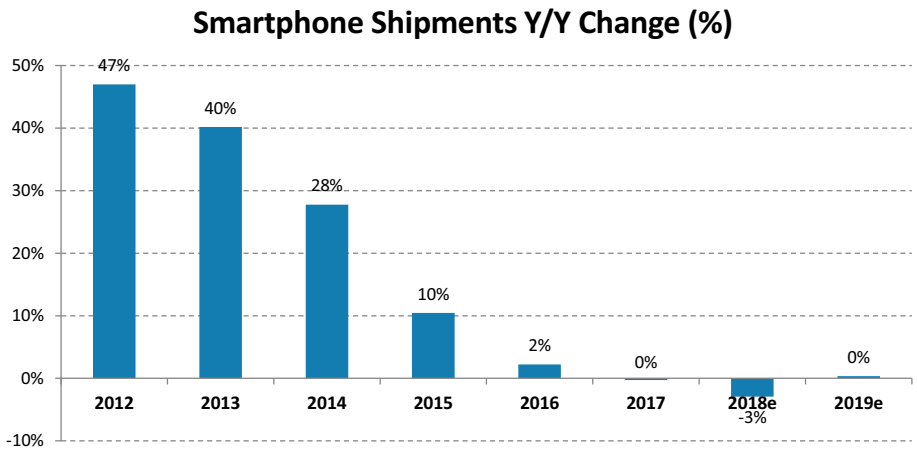
Debate 4) How does it affect semicap equipment stocks? We estimate an enormous opportunity, but limiting access to tools from Applied Materials, Lam Research, and KLA would be highly material, in our view. Though there are 2 key suppliers from outside the US (ASM Lithography and Tokyo Electron), we believe there are simply too many process steps where American suppliers are critical. That has been one reason for us keeping an In-Line industry view on Semicaps while we are Cautious on Semis - but we recognize the risk of potential disruption.

Our long term preference is for NAND exposure, for several reasons: 1) NAND spending has already come down meaningfully for 1h19 and investor expectations are even lower; 2) NAND will be the largest push from China initially; 3) NAND is relatively immune from "EUV deflation", where EUV technology will reduce patterning TAM for all markets but NAND; and 4) it drives a more consistent service business. All of that leads to our preference for Lam over Applied Materials and Tokyo Electron (covered by Kazuo Yoshikawa) globally. Still, we acknowledge that Lam also faces the issues outlined above

Issue 4 - We expect smartphones to remain a headwind to Semiconductor growth in 2019

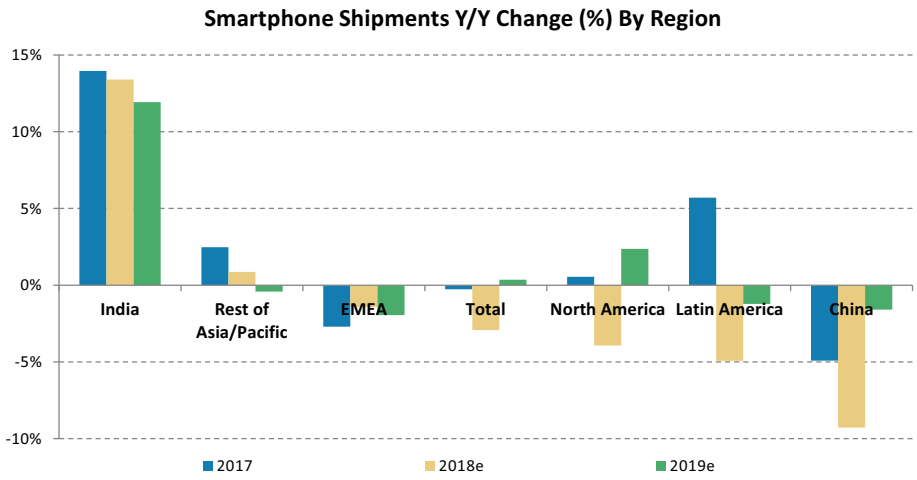
Smartphone demand continues to downtick: Smartphone shipments declined 6% y/y in Q3, below Morgan Stanley's estimate of 1% decline. Q3 marked the 4th consecutive quarterly y/y decline for the smartphone market (Q4'17 – down 8%, Q1'18 – down 3.5%, Q2'18 – down 1%). In China, which accounts for ~30% of the smartphone market, units have been declining since Q2'17 and were down 10% y/y in Q3'18. Overall, Smartphone shipments are on track to decline 3% in 2018 after coming in flat last year. (Exhibit 69 to Exhibit 70). Within US Semiconductors, the companies with the high exposure to the mobile market include **CRUS** (95%), **SWKS** (75%), **QRVO** (75%), **Dialog** (70%), **SYNA** (65%) and **KN** (33%).

Exhibit 69: We expect smartphone units to decline 3% in 2018



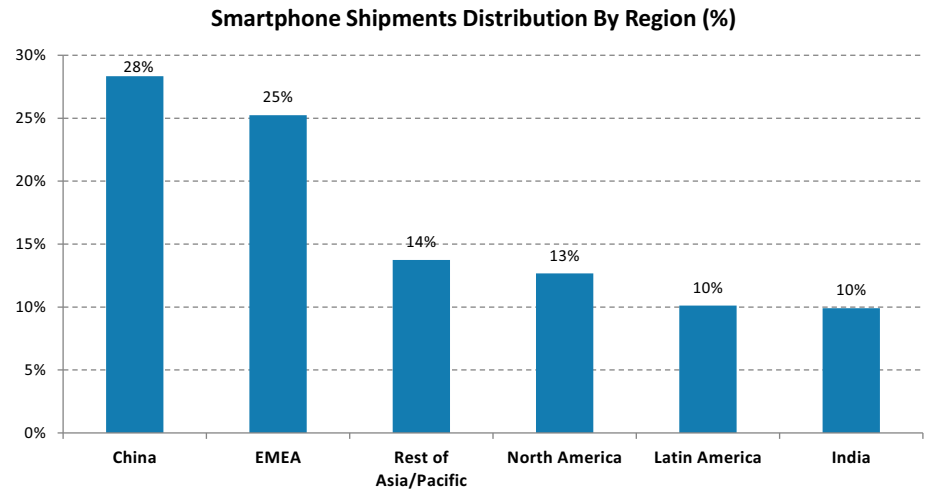
Source: IDC, Morgan Stanley Research

Exhibit 70: Growth in smartphone units in India is being more than offset by declines in China, North America and EMEA



Source: IDC, Morgan Stanley Research

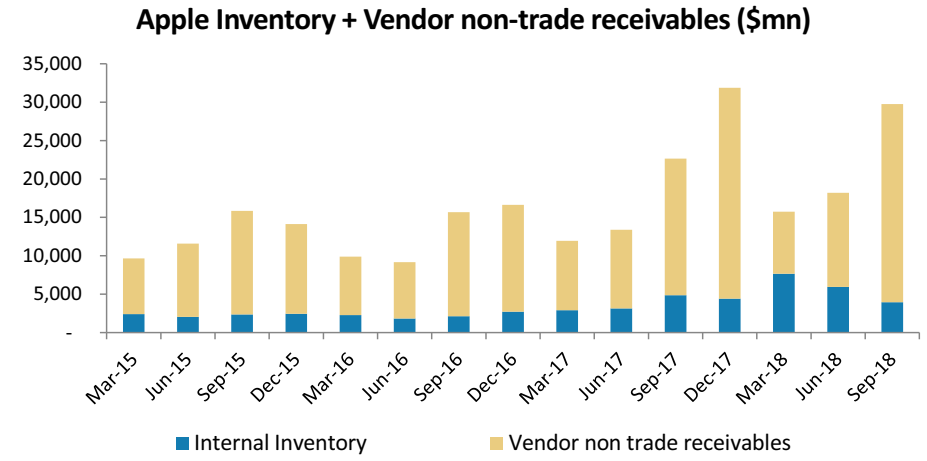
Exhibit 71: China accounts for 28% of smartphone shipments, followed by EMEA at 25%, rest of APAC at 14% and NA at 13%; While, India where smartphones are still growing is only 10% of sales



Source: IDC, Morgan Stanley Research

Elevated Inventory + Vendor non-trade receivables at Apple, though we think the memory drawdown is largely behind them, represents another risk for mobile suppliers in the near term. The combination of Apple's internal inventory and Vendor non-trade receivables increased 64% q/q and 31% y/y in Q3 (Exhibit 72). While, Apple's inventory was down 33% q/q and 19% y/y as they likely worked down some of its memory buffers, its non-trade receivables grew 110% q/q and 45% y/y in part as Apple added more suppliers to its supply chain. This sequential pick up in Apple's non-trade receivables represents a risk to Smartphone exposed Semi suppliers over the coming quarters. For memory, Apple's commentary indicated to us that the inventory builds of last year have been fully drawn down, which should lead to somewhat better purchases in 4q; still, with the buildup of producer inventories and weaker cloud demand we remain cautious on memory.

Exhibit 72: Apple's Inventory + Vendor non-trade receivables increased 31% y/y in Q3



Source: Morgan Stanley Research, Company Data

Our Asia Semis team led by Charlie Chan had cut its Apple iPhone supply chain

forecasts recently (see report), but EM smartphone demand could be the next shoe to drop. China's smartphone shipments showed a double-digit decline YoY in 3Q18, and softness should continue in 4Q18. Most Chinese smartphone OEMs remain bearish on the 2019 outlook, with a lengthening replacement cycle and 5G yet to be rolled out. Indian smartphone shipments have also gone from 20% Y/Y in 1H18, to only 9% in 3Q18, according to the latest IDC data. In addition, our Qualcomm analyst, James Faucette, forecasts its chipset shipments to be down 10% Y/Y in 2019 (see report), suggesting shrinking smartphone chipset TAM.

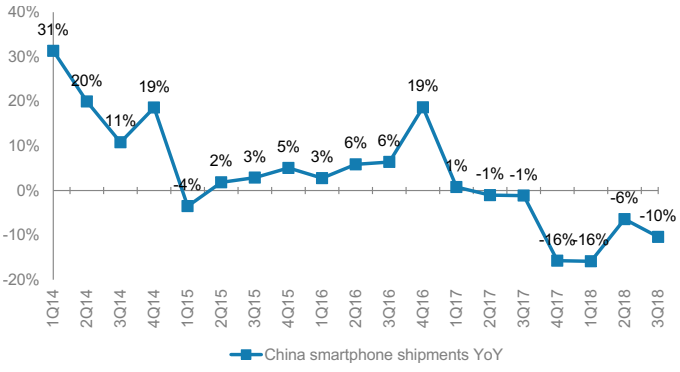
Compared to most US semi companies, Greater China's semi manufacturers depend more on smartphone demand. For example, TSMC generates 45% of revenue from smartphone semis, while MediaTek has 40% revenue exposure to EM smartphone demand. The recent smartphone vertical data points have started to turn negative in the past month. We therefore expect another cycle of earnings estimate cuts in the coming two quarters. In this report, we are reflecting the EM smartphone semi demand downside (mainly China's and India's Android smartphone markets).

Exhibit 73: Greater China Semiconductors in general have big revenue exposure to smartphones

	Rating	Total smartphone exposure (2018e)			Counter cycical factors	
		Apple iPhone	Android	Total smartphone mix	Semi content increase	Market share gain
Wafer Foundry						
TSMC	EW	20%	25%	45%	Larger chip size	QCOM/Hisilicon
UMC	UW	0%	35%	35%		
SMIC	UW	0%	30%	30%		
Win Semi	UW	40%	30%	70%		
Backend Foundry						
ASE	OW	20%	25%	45%	SiP	
Chipbond	OW	15%	20%	35%	TDDI/CoF	
JCET	UW	3%	47%	50%		
IC Design						
Phison	OW	0%	20%	20%		
SIMO	OW	0%	25%	25%		
Goodix	OW	0%	90%	90%	Optical Fingerprint	From Egis
Novatek	UW	0%	27%	27%	TDDI	
MediaTek	UW	0%	40%	40%		
Egis	UW	0%	100%	100%		

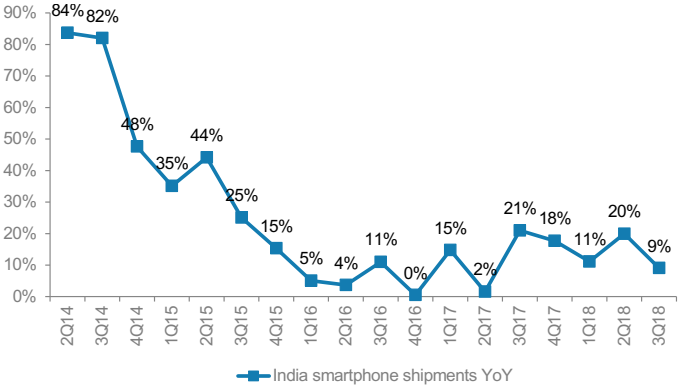
Source: Morgan Stanley Research estimates

Exhibit 74: Chinese smartphone shipments YoY fell again in 3Q18...



Source: IDC, Morgan Stanley Research

Exhibit 75: ...while Indian smartphone shipments growth has also dipped below 10%



Source: IDC, Morgan Stanley Research

What's the future for smartphones?

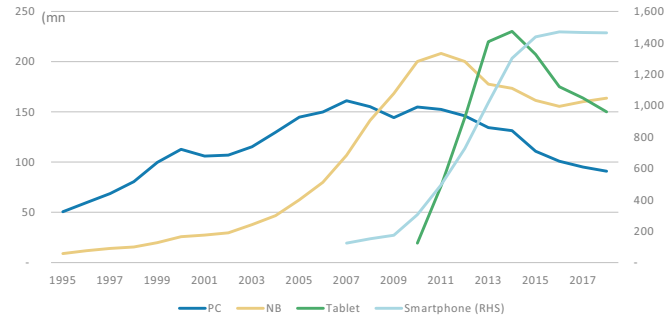
We are not arguing that smartphone demand will drop as significantly as it did for

tablets or notebooks after their peaks. Tablets and NBs were more susceptible to falling shipments after the introduction of smartphones, as they offered many of the same features in a smaller, more portable device. We expect smartphones to experience healthy replacement cycles in future given a current lack of a viable replacement for them.

We think smartphones have some similarities to the demand curves for desktop PCs and cars. If we look at the desktop PC market and the auto markets, the rises and falls in demand are much milder and lengthier, as well as displaying a healthier decline to replacement cycle after their peaks. Due to the high penetration of smartphones now, we expect a peak soon, but believe this will be followed by years of ex-growth before shipments stabilize at a lower level. Desktop PC never got back to their peak, while cars went through three cycles.

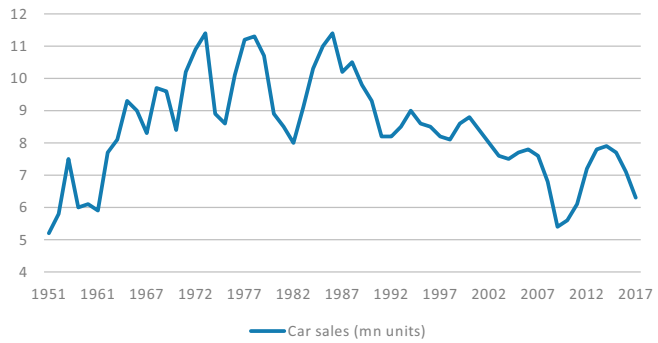
In 2019, the smartphone industry is facing a challenging year without any game changing features. Adoption of 3D sensing in world facing cameras is still low, and Apple has previously indicated it is unlikely to adopt the technology. 5G won't be widespread next year, but market/consumer anticipation of it in 2020 will likely hurt replacement demand. Triple cameras are also only seeing limited adoption. Therefore, we do not expect smartphones to see any strength in 2019. While these trends should emerge in 2020, we remain cautious on smartphone-heavy semiconductor companies, unless they have specific supporting factors, such as Apple Watch and cheap valuation for ASE, Chipbond's content increase in smartphone based on TDDI adoption (which has a longer test time) and supply shortage of testing capacity, and Goodix's margin accretion and share gain - hence our Overweight ratings on these three stocks.

Exhibit 76: Smartphone shipments vs. desktop PC, NB, and tablets



Source: Morgan Stanley Research

Exhibit 77: US car sales from 1951 to 2017 (mn units)



Source: Statista, Morgan Stanley Research

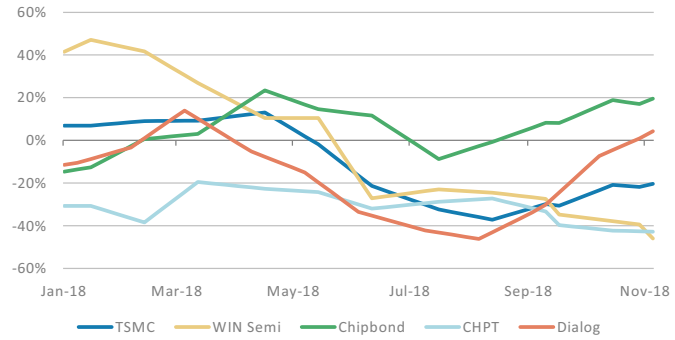
Any potential for further Apple order cuts?

We looked at the order patterns during the previous iPhone X cycle and note the earliest signs of order cuts in semi components were in January/February; key processor TSMC didn't guide down until late April (Exhibit 15). However, in this cycle Apple is making adjustments, with a number of suppliers already lowering their 4Q18 revenue forecasts. In light of this, we think 7nm Apple processor orders at TSMC could start to drop in 1Q19, and we look for company guidance on this in early January.

Given the potential order cuts and its 20% revenue exposure to Apple iPhone, we are forecasting TSMC's 1H19 revenue to be 2-3% below Street Consensus. Of the four semi

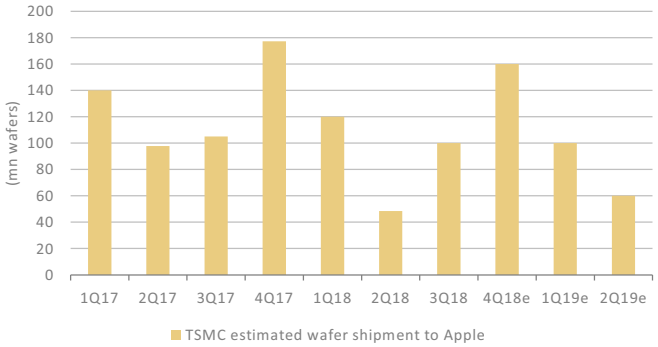
stocks in our coverage with high exposure to Apple, our key Underweight is WIN Semi, which has 40% revenue exposure to iPhone, while its key customers (Broadcom and Lumentum) are losing market share. WIN Semi trades at 15x 2019e EPS with a muted revenue growth forecast in 2019. We therefore recommend Chipbond among our iPhone plays, as we believe the structural trend of TDDI and testing capacity tightness should make it counter cyclical.

Exhibit 78: Earnings revisions for semiconductor companies during the last iPhone cycle



Source: Bloomberg, Morgan Stanley Research estimates

Exhibit 79: TSMC estimated wafer shipments to Apple



Source: Company Data, e= Morgan Stanley Research estimates

China smartphone brand exposure analysis

Further development of US/China relations may also impact the China smartphone supply chain that has higher exposure to the China local brand.

Exhibit 80: Smartphone Supply Chain: Revenue Exposure to Smartphone Brands

Ticker	Company	Last close (In LC)	Rating	Product supply to Huawei	2017 Revenue Exposure to			
					Apple	Samsung	Huawei	Other OEMs
Downstream Hardware								
2382.HK	Sunny Optical	69.95	EW	Camera module / lens	0%	5%	25%	50%
002456.SZ	O-film	10.7	UW	Camera module/touch/fingerprint module	15%	<5%	20-25%	50%
2018.HK	AAC	51.55	EW	Acoustic components	40%	5%	15-20%	30%
3008.TW	Largan	3035	UW	Lens	40%	<5%	10-15%	30%
0285.HK	BYD Electronics	10.7	UW	Metal casing	0%	15-20%	10-15%	40%
002475.SZ	Luxshare	15.04	OW	Connector	35%	<5%	10%	20%
2317.TW	Hon Hai	69	EW	Smartphone assembly	45-50%	0%	~5%	5-10%
2308.TW	Delta	127.5	OW	Power choke	8-10%	0%	0%	0%
2455.TW	VPEC	55.8	EW	PA epi wafer	30-40%	0-5%	5-10%	15-20%
6269.TW	Flexium	78.2	EW	F-PCB	65-70%	0%	<5%	<5%
4958.TW	Zhen Ding	80.6	EW	F-PCB	75-80%	0%	<5%	<5%
3189.TW	Kinsus	47	OW	IC substrate/SLP	30-35%	0%	5-10%	5-10%
Semiconductors								
2454.TW	MediaTek	229.5	UW	Smartphone chipsets	0%	0%	5-10%	30-35%
3105.TWO	WIN Semi	114	UW	PA/VCSEL foundry	40%	5%	5-10%	15-20%
3034.TW	Novatek	135	UW	LCD Driver IC	0%	5%	5-10%	15-20%
2330.TW	TSMC	220	EW	Wafer foundry	20%	0%	5%	20%
6510.TWO	CHPT	468	EW	Probe cards	50%	5%	5%	15-20%
3711.TW	ASE	59.7	OW	Testing and packaging services	20%	0-5%	0-5%	10-15%
2379.TW	Realtek	138	OW	Wifi/connectivity chips	<5%	<5%	<5%	<5%
603160.SS	Goodix	74.62	OW	Touch and fingerprint IC	0%	0-5%	15-20%	70-80%

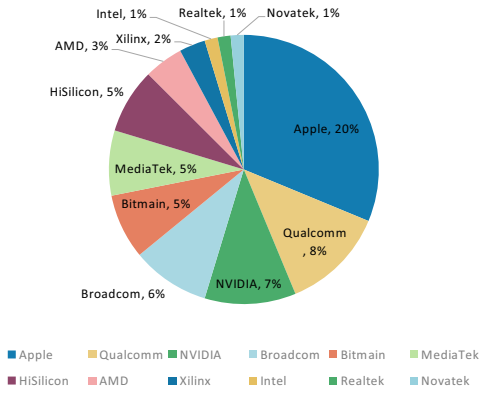
Source: Thomson Reuters, Company data, Morgan Stanley Research, last close as of December 6, 2018

Exhibit 81: Smartphone Chipset Supply Chain: TSMC has higher exposure to Apple and Huawei, than to Samsung

OEM	Market segment	Allocation	Major Foundry	Chipset
Huawei				
	High-end	50%	TSMC	Hisilicon
	Middle	25%	Samsung	Qualcomm
	Low-end	25%	TSMC	MediaTek
Samsung				
	High-end, Middle	50%	Samsung	Samsung in-house
		40%	Samsung	Qualcomm
	Low-end	10%	TSMC	MediaTek/Marvell
Apple				
	High-end	100%	TSMC	Apple in-house
Oppo/Vivo/Xiaomi				
	High-end, Middle	65%	Samsung	Qualcomm
	low-end, middle	35%	TSMC	MediaTek

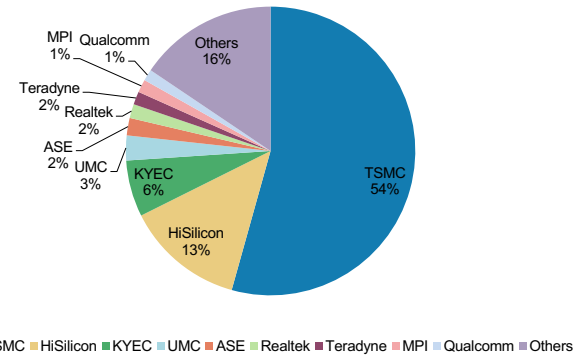
Source: Company Data, Morgan Stanley Research estimates

Exhibit 82: TSMC revenue mix; Apple and HiSilicon are key customers for 7nm



Source: Company Data, Morgan Stanley Research estimates

Exhibit 83: CHPT revenue has high exposure to high-end smartphones

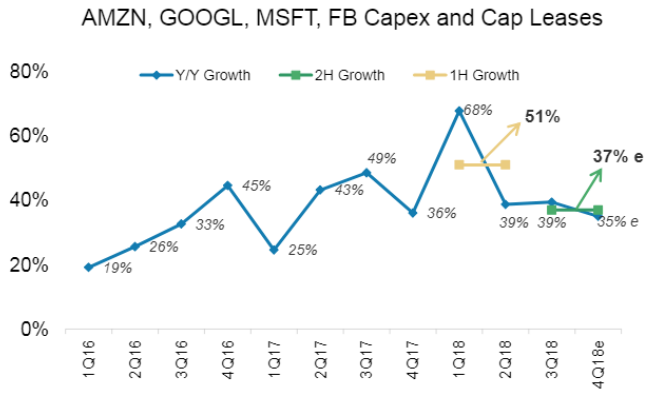


Source: Company Data, Morgan Stanley Research estimates

Issue 5 - Data Center Capex Digestion in 2019 represents another drag for semi growth

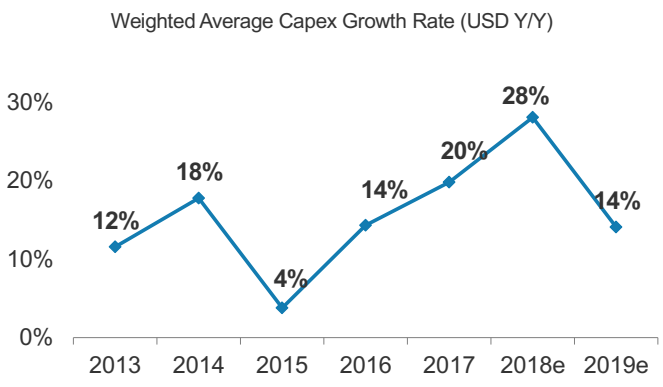
Data Center has been one of key growth avenues for semiconductor companies in 2018 with Autos, Industrial and smartphones downticking and PCs and Consumer continuing to be lackluster. However, the growth has been more weighted towards the first half of the year, which may be misleading as this lead to cloud capex growth to ~30% in 2018. We turned cautious on the cloud capex demand starting from mid 2018, as we see the weakness spreading from China datacenter to US hyperscalers and then to enterprise. From the cloud side, we believe there's an overbuild on the datacenter, especially from some US hyperscalers. After the 3Q18 earnings calls, the overall cloud slowdown confirms our thesis. In 3Q'18 US hyperscale cloud capex growth decelerated ~10pts from 1H18 to ~40% Y/Y, confirming the digestion period. Morgan Stanley's cloud capex tracker points to a deceleration from 28% growth in 2018 to 14% in 2019 (Exhibit 84andExhibit 85).

Exhibit 84: US Hyperscale Growth Decelerating to ~40% growth in 2H18 from ~50% in 1H



Source: Company data, Morgan Stanley Research.Note that the historical figures in this chart were revised to reflect Amazon's gross capex

Exhibit 85: Data Center capex growth- Early estimates for 2019 imply a 14pt deceleration from 2018



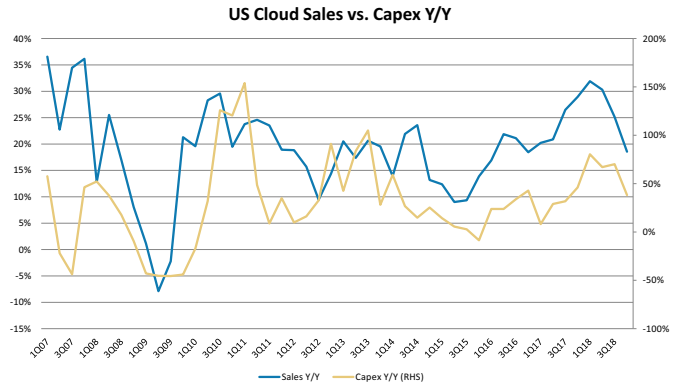
Source: Company Data, Thomson Reuters, Morgan Stanley Research, IRS, US Department of Treasury (average FX rates). Includes AMZN, AAPL, BABA, BIDU, CRM, FB, GOOGL, MSFT, SINA, T, Tencent, TWTR, VZ, YNDX. Companies reporting in non-USD converted to USD at the average annual FX rate
esearch Source

When will cloud growth bottom out? 3Q earnings releases from the top seven hyperscalers and multiple hardware vendors have prompted multiple questions from investors globally. Recall, we started to call a cloud deceleration back in June, from China (BAT) further to US hyperscalers (Microsoft, Amazon) and enterprise (Supermicro). Based on the top seven hyperscalers' earnings announcements, correlation between hyperscalers' earnings growth and cloud capex growth is somehow surprisingly high.

Globally, some companies have stated expectations for cloud deceleration in the next few quarters, but expect growth to resume in 2H19. We are unsure of the assumptions behind the argument, since we don't have the visibility into more than one quarter. However, we look at the historical cloud capex cycle to try to gauge the timing of the bottom and the magnitude of the deceleration. The shortest cloud capex downcycle

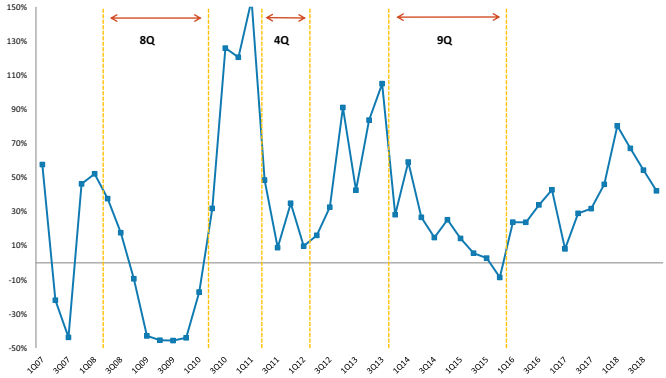
lasted for four quarters in 2011-2012, and the last downcycle lasted for two years in 2014-2015. The timing of the downcycle depends on how sharp the downturn is – a Y/Y decline in cloud capex could result. If cloud capex can resume growth in 2H19, this implies quite a sharp slowdown in 1H19.

Exhibit 86: US Cloud sales vs capex Y/Y has high correlation- what does this imply to the hyperscalers' growth?



Source: Company Data, Morgan Stanley Research

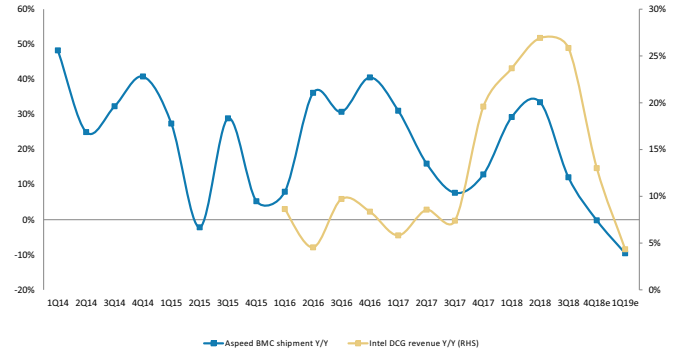
Exhibit 87: US cloud capex Y/Y on a quarterly basis - downcycle lasts for 4 to 9 quarters, while we are around the peak in 1H18



Source: Company Data, Morgan Stanley Research estimates

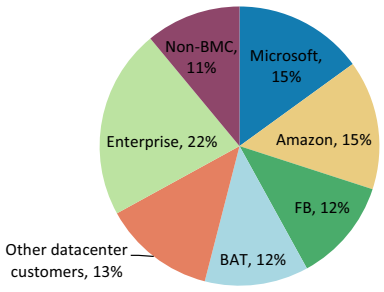
How to track cloud demand? Besides the global datacenter capex trend (on a quarterly basis), we believe Aspeed (5274. TWO, EW, covered by Daniel Yen) is a good proxy to track the cloud demand on a monthly basis given monthly sales announcement. The company has around 90% revenue exposure to server (with its baseboard management controller) , and has nearly 100% market share in Amazon, Facebook, Microsoft, Baidu, Alibaba, Tencent, Lenovo, Inspur and Dawning. Recall, we downgraded the stock in mid of 2018, citing China weakness, and the saw more downside on US cloud after a couple of weeks later. We also track Intel's DCG revenue. Combining data from both, we find the Y/Y growth could see signifiant slow down into 1Q19.

Exhibit 88: Aspeed's BMC shipment growth vs. Intel DCG revenue



Source: Company Data, Morgan Stanley Research estimates

Exhibit 89: Aspeed: Customer mix



Source: Company Data, Morgan Stanley Research

In Exhibit 90 we highlight companies that have the most exposure to the Data Center Infrastructure space.

Exhibit 90: Companies Under Coverage Most Exposed to Data Center Infrastructure

US IT Hardware	Ticker	Rating	YTD Return
Analyst: Katy Huberty			
Seagate	STX	Overweight	-5%
US Semiconductors			
Analyst: Joe Moore			
Inphi	IPHI	Equal-Weight	-5%
Intel	INTC	Equal-Weight	2%
Micron	MU	Equal-Weight	-15%
NVIDIA	NVDA	Overweight	-22%
Western Digital	WDC	Equal-Weight	-48%
Xilinx	XLNX	Overweight	30%
Marvell	MRVL	Equal-Weight	-29%
Broadcom	AVGO	Equal-Weight	-7%
Infinera Corp	INFN	Equal-Weight	-31%
US Communication Systems			
Analyst: James Faucette			
Arista	ANET	Equal-Weight	-2%
Cisco Systems	CSCO	Overweight	22%
F5 Networks	FFIV	Underweight	27%
Juniper	JNPR	Underweight	-3%
Analyst: Meta Marshall			
Ciena Corporation	CIEN	Equal-Weight	52%

US Telecom Services	Ticker	Rating	YTD Return
Analyst: Simon Flannery			
CyrusOne	CONE	Overweight	-3%
Digital Realty	DLR	Overweight	2%
Equinix	EQIX	Equal-Weight	-15%
QTS Realty	QTS	Equal-Weight	-24%
Asia Hardware & Semiconductors			
Analyst: Howard Kao			
Inspur	000977.SZ	Underweight	-12%
Quanta	2382.TW	Overweight	-19%
Wistron	3231.TW	Equal-Weight	-20%
Analyst: Daniel Yen			
Aspeed	5274.TWO	Equal-Weight	-30%
Analyst: Sharon Shih			
Landmark Optoelectronics	3081.TWO	Overweight	-43%
Korea Technology			
Analyst: Shawn Kim			
Samsung Electronics	005930.KS	Equal-Weight	-21%
SK Hynix	000660.KS	Underweight	-15%

Source: Morgan Stanley Research, Thomson Reuters

Some details about reported cloud capex from 3Q18 earnings call: Reported cloud capex for AMZN, MSFT, GOOGL and FB in aggregate implies a deceleration from 51% growth in 1H18 to 39% in 3Q confirming a slowdown in cloud capex. We expect a further deceleration in US hyperscale spend in 4Q to 35%, and see the digestion period lasting into 2019. Microsoft reported capex including capital leases of $4.3B in Q3 vs. MSe at $4.9B. Going forward, Microsoft expects capex growth to moderate for the remainder of its fiscal year. Similarly, Facebook reported capex below MSe ($3.3B vs. MSe of $3.8B) and subsequently lowered its current year capex guide to $14-14.5B from $15B. Furthermore, FB provided 2019 capex guidance of $18-20B implying a deceleration from ~110% expected growth in 2018 to 33% Y/Y growth in 2019, but still strong on an absolute basis. Amazon reported capex including cap leases only slightly below MSe; however, Amazon trailing 12 month capital lease growth was up only 9%, which is down from 20% in 2Q18 and 69% at the end of 2017 implying a slowdown in data center spending - which Amazon partly attributed to efficiency improvements. Google capex of $5.3B was in line with MSe as growth slowed for the 2nd consecutive quarter.

Issue 6 - How will CPU processor market share battle shake out between Intel and AMD?

We expect Intel to retain its dominance in CPUs in 2019. While Intel has occasionally stumbled, the company's unprecedented dominance in PC and server microprocessors over multiple decades is in part due to superior product design. There are threats that seem remote today that were once seen as threatening - ARM servers, Power PC processors. Those threats have largely gone by the wayside, while higher end processors that seemed to have the value of high incumbency such as SPARC or MIPS have been surpassed. This is at least in part due to Intel's strong execution in migrating to the most efficient architectures while maintaining backward compatibility.

Though Intel's processor manufacturing prowess is now being called into question given numerous delays with 10nm but certainly over decades the company has maintained a strong lead in process technology. Intel's 14 nm still has driven a material clock speed advantage over competing product at 14 or 16 nm, and while the 2019 outlook remains uncertain until we see benchmarks of 7 nm product, we don't think the gap is that long. Even in 2019, while certainly Intel's lead will narrow, we don't really see the timelines of Intel 10 nm vs. TSMC (covered by Charlie Chan) as that far apart. Intel's challenge is not just building 10 nm at the same time that TSMC builds 7 nm - Intel is of course capable of this - the challenge is building it at the truly massive scale that Intel requires, which AMD and TSMC do not.

Intel continues to have fairly large competitive moats in its core market. We continue to think that threats to Intel's dominance in PC and server markets are continually overstated. Alternative architectures face a massive hurdle for adoption, with the need for software transitions, product customization, fairly long software qualification cycles limiting adoption. Customers that we have talked to in the data center are fairly happy with Intel - they would always like cheaper products, of course, but as long as Intel continues to deliver the technology increases that they need, there is not a particular hunger for an alternative. NVIDIA GPUs did succeed where other alternative architectures have failed, but that was because of a new workload with dramatically different requirements - and even that opportunity was only enabled by the fact that graphics chips had already been deployed on a mass scale with a software ecosystem, and by the fact that NVIDIA was willing to invest for several years before revenue inflected.

Even within the x86 architecture, we think that there are barriers. Enterprises that plan to use AMD often have rigorous qualification processes - which also affects cloud businesses serving enterprise ecosystems. During periods when AMD offered unequivocally superior products - in the 2006 time frame - enterprises started to make those investments, but having roughly equivalent product has a fairly low payoff. Even if AMD discounts 20% at the microprocessor level, that becomes a 4-5% discount at the server or PC price point, which limits enthusiasm.

Having said that, we expect AMD to see incremental traction in 2019 helped by the launch of its EPYC 2 chip. We have been writing about AMD's server roadmap for some

time, with a view that it was a very competitive chip, but that the product would drive some incremental revenue in 2018 and 2019; however, we have cautioned that 1) it would take time to drive revenue, 2) that introducing a point product with functional equivalence to Intel was one thing, but that customers would look to the longer term roadmap before going through the effort of enterprise adoption, and 3) that ongoing execution could be a risk given that AMD spends a fraction of the R&D budget of both Intel and NVIDIA, while competing with both, with some dependence on Global Foundries. Certainly point 1 is still true: adoption of server processors - even in cloud - will take time. But the roadmap looks strong, particularly if the 7 nm products live up to the early promise.

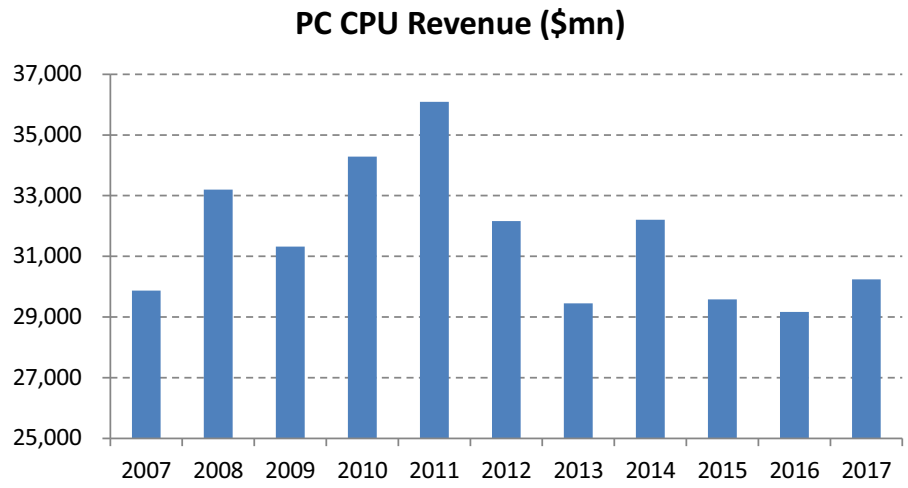
On the Server front, we expect that most of the progress in the first two years will be with hyperscale cloud, which makes up about 25% of the server market, with cloud being slightly larger than enterprise for Intel, and top 7 customers to make up about half of that (for the purposes of market share, we eliminate the communications portion of Intel's DCG segment). To get to 10% unit market share overall largely from penetration of that 25% segment implies very substantial progress, especially considering that the company has yet to announce wins with the two biggest spenders, Google and Amazon. We think that AMD will hit its 10% market share target in servers in mid 2020, but we would note that in recent conversations with management they have described mid single digit unit share as $100-125 mm in 4q18, in the way that they define it - implying server revenue of roughly 2x that in 6 more quarters.

Zen 2 (the architecture that will ultimately be EPYC 2 as well as future client microprocessors) shows some interesting architectural innovation. From an architectural standpoint on Zen 2, the company has improved the branch predictors, improved the prefetch algorithms, has added a 256-bit floating point register vs. prior 128 bit to boost floating point performance and has a better execution pipeline. The company has focused on improving security; Zen already offered in line encryption, and with Zen 2 they will increase the number of unique encryption keys and mitigation of side channel attacks, which has been a big issue this year.Consistent with what has been in the press, the company will extend its “chiplet” design process, using multiple smaller die in a package. But this time, the company will package eight 8 nm microprocessor die with a single 14 nm I/O die, given that the I/O logic does not scale.

First details on 7nm Epyc 2, targeting 100% performance improvement vs. Epyc 1. AMD at its"Next Horizon" event last month gave a compelling reminder of the benefits and achievements of EPYC 1, which are considerable (though as we have noted, despite those achievements revenue is still fairly small, at about $55 mm/1.6% market share last quarter and about twice that in 4q). The company also gave broad brush benchmarks of EPYC 2, starting with the impressive performance claim of doubling the performance per socket – of course, the devil is in the details, and 8 die-per-socket compares to 4 die for EPYC – and 4x the floating point performance. In a financial analyst breakout, the company expressed significant confidence that EPYC 2 would be adopted much more quickly than EPYC 1, given the software transitions that have already taken place, AMD's increased credibility in the market, and Intel's ongoing roadmap disruption. The company indicated that even with the larger number of die, gross margins for EPYC 2 should be higher than EPYC 1, which points to much higher average selling prices. Timing for EPYC 2 is still unclear, and will be key. All that the company has said is that they sampled the product in 3q18, and will have 2019 availability, and they repeated that today. Our

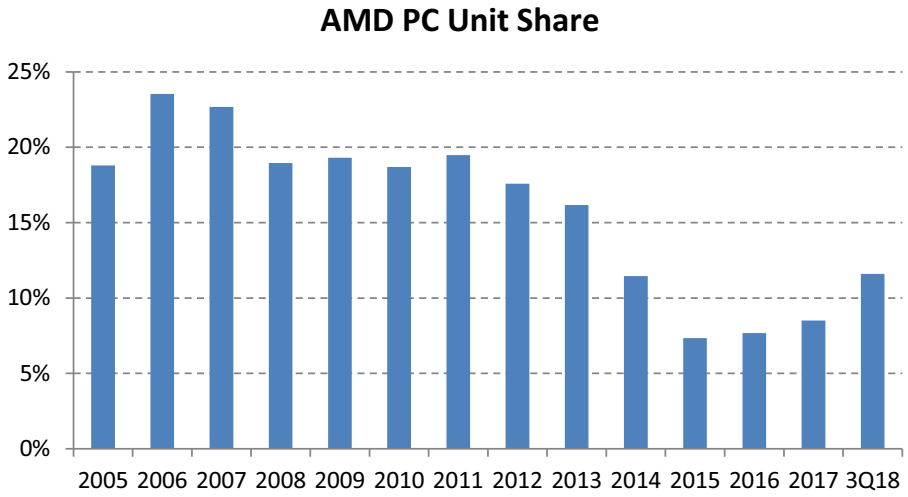
understanding from talking to supply chain partners is that volume availability starts in mid year, which would be consistent with the company's objective of getting to double digit market share by mid 2020.

Exhibit 91: PC CPU (Desktop + NOtebook) is a $30bn market



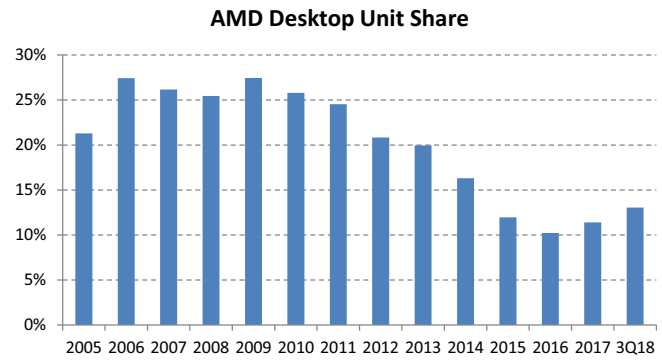
Source: Mercury Research, Morgan Stanley Research

Exhibit 92: AMD's PC unit share peaked at 24% in 2006 and then steadily declined to 8% in 2016; AMD's Ryzen CPUs helped it regain ~350 bp in 2017/18 to 11.6% in Q3'18...



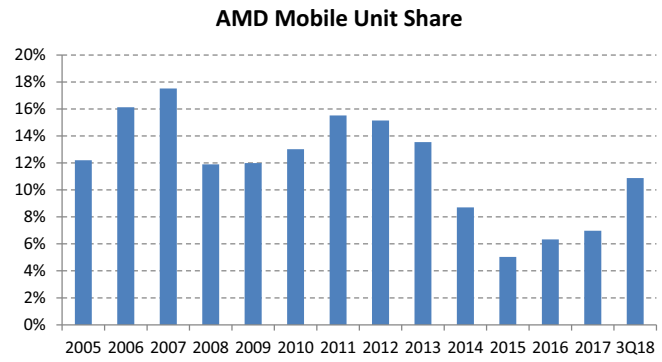
Source: Mercury Research, Morgan Stanley Research

Exhibit 93: ...with desktop up 110 bp this year to 13.1%...



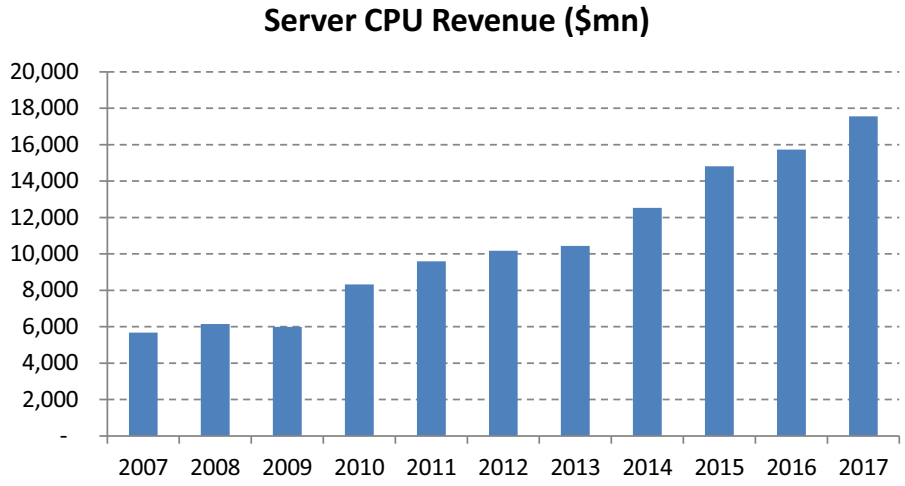
Source: Mercury Research, Morgan Stanley Research

Exhibit 94: ...and Notebook up 400 bp to 10.9%



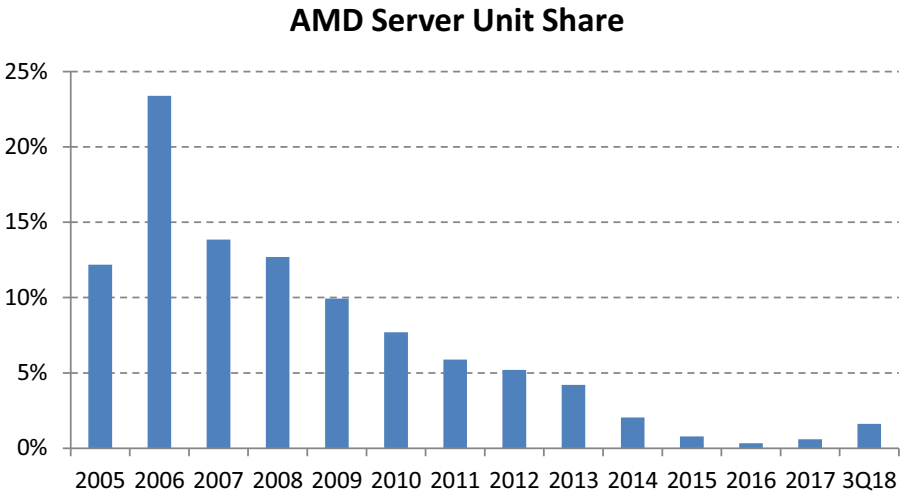
Source: Mercury Research, Morgan Stanley Research

Exhibit 95: Server CPU market is approaching ~$20bn in 2018



Source: Mercury Research, Morgan Stanley Research

Exhibit 96: In Servers, AMD's unit share peaked at 23.5% in 2006 but then declined to just 0.3% in 2016 and since then increased to 1.6% in Q3'18 driven by launch of its EPYC CPU



Source: Mercury Research, Morgan Stanley Research

Implication to key foundry TSMC: AMD has announced its new 7nm CPU will be ready to launch next year. It will go first to servers in 1H19 and to desktops in 2H19. AMD management claims significant performance gains vs. the Zen+ structure based on 12nm, but we think it will take time to ramp. Therefore, we think the 7nm CPU will now consume only 30k wafers in 2019, below our original estimate of over 100k wafers.

Exhibit 97: AMD foundry TAM Analysis table

(%)	2014	2015	2016	2017	2018e	2019e	2020e
Server CPU							
GF 14nm/12nm					95%	65%	10%
TSMC 7nm					5%	35%	90%
Desktop CPU							
GF 14nm/12nm					100%	85%	50%
TSMC 7nm					0%	15%	50%
NB CPU							
GF 14nm/12nm					100%	100%	80%
TSMC 7nm					0%	0%	20%

(US$mn)	2014	2015	2016	2017	2018	2019	2020
AMD x86 CPU revenue contribution to TSMC							
Server CPU					14	209	704
Desktop CPU					-	117	446
NB CPU					-	-	155
Total TSMC x86 CPU wafer revenue					14	326	1,306
7nm wafer price (US$)					12,000	11,000	10,000
Implied 7nm wafer demand (k wafers)					**1**	**30**	**131**
TSMC total revenue in USD					34,202	35,897	39,839
% of TSMC total revenue					**0.0%**	**0.9%**	**3.3%**

Source: Company Data, e =Morgan Stanley Research estimates

Issue 7 - Increasing penetration of AI/Machine Learning and Autonomous Driving are 2 key secular growth themes for Semis

Machine learning adoption is proliferating from the Data Center to the Edge

Machine learning is at a relatively early stage for the broader industry. But over the next 3-5 years, we would expect the emphasis to shift from the semiconductor tools used for algorithm development/training, towards the solutions that machine learning can generate - solving computer vision, natural language interpretation, and other areas that replace human capital. As much attention as there has been on self-driving cars, it is important to recognize that there are many other tasks that are much simpler and easier to implement than driving a car that are new and exciting. We see markets such as the Amazon Go concept store built around computer vision; surveillance cameras that can identify faces, license plates, or even crimes in progress; medical radiology interpretation; and commercial delivery drones as great examples of emerging applications.While the immediate ramifications are more narrow - largely centered on GPUs and memory today - we see broadening demand growth longer term with new applications driving demand for analog and sensor technologies as machine learning moves closer to the edge.

What Is the Distinction between "Training" and "Inference"?

The building of the neural network database normally happens offline, not in a real time environment This is called **"Training"**, which is hugely computationally intensive, and traditional linear microprocessors aren't optimal for solving those types of computations. The world's best microprocessors, which are still the best solution to the vast majority of computing problems, are limited when it comes to building neural nets recursively. Graphics chips are more efficient for that narrow application set, and NVIDIA has been investing aggressively for a decade believing in this opportunity.

"Inference" is the real-time usage of neural network databases that are created by those "training" algorithms. Once the neural network is trained, that network is accessed in real time - sometimes by the cloud, or sometimes in a device.

Until recently, Inference workloads were done almost entirely on Intel microprocessors, but as those tasks become more complex, we see substantial use of AI "accelerators". We will see the first use cases of specialized Inference hardware in 2017, a good lead indicator for the next 3-5 years. This is certainly orders of magnitude larger than the training opportunity in unit terms, albeit at much lower price points. But ultimately, the best Inference engine is going to be in many places, including at the heart of the autonomous vehicle. Inference is going to remain highly fragmented, as there are high precision Inference tasks, and simpler Inference tasks. Compared to training, there is typically much less computational intensity, but more focus on low power and low latency (since Inference is real time). Still, it's a very important market that could ultimate be bigger than training, and 2017 should establish the roadmap.

What are the semiconductor building blocks for Machine learning? Machine vision is in some respects simply another form of deep learning "inference", which is essentially the classification of the visual data through application of the neural network database that is "trained" through the deep learning process. As such, the solutions normally seen for inference are going to get the early wins for machine vision. But as the end market applications mature and grow, we would expect to see more specialized solutions tend to dominate.

Microprocessors (Intel, AMD) or applications processors (QCOM, AAPL): Today, much of what we would characterize as inference for machine vision is done on various microprocessors. We expect this to change, over time, as traditional microprocessors are suboptimal for video data sets (which are highly parallel in nature). But for today, the dominance of CPUs in cloud and in devices. We also note that many of the early prototype "self driving cars" are based on large clusters of microprocessors, mostly from Intel.

Graphics (NVIDIA, Intel Xeon Phi, AMD): Graphics chips are better for video data streams given the higher degree of parallelism vs. traditional microprocessors. And NVIDIA has the advantage that most neural networks are trained on its devices. Graphics chips are also more programmable than custom chips. Still, there are some limitations - we don't think that the same chip can be optimal for training (double precision floating point data, highly throughput intensive, insensitive to latency concerns) and inference (8 bit integer data, not computation/throughput intensive, highly latency sensitive, with minimal power consumption a key). Still, we do expect NVIDIA to get many of the early wins due to the company's prevalence in training.

Field programmable gate arrays (Xilinx, Intel/Altera): FPGAs are uniquely well suited to machine vision tasks, given their high degree of inherent parallelism, lower latency, and better power consumption compared to graphics. Ease of use has been a challenge in cloud, where customers are less familiar with FPGA design, but closer to the edge we see FPGAs having a strong role, and we think that Xilinx actually has more ADAS revenue than any other semiconductor vendor. The company, along with its ecosystem partners such as AWS and developer community, remains focused on further developing the software environment for FPGA-based products in the data center by building more software stacks, libraries, etc.

The challenge will be that as volumes grow and technology matures, there will always be some pressure to move to standard products which offer lower unit prices (at the expense of design flexibility). In addition, Xilinx's upcoming 7nm "Versal" products that incorporate ARM cores and other functionality further improve FPGA based solution's value proposition vs CPUs/GPUs. Xilinx projects that in normal inference tasks they are 43x faster than a microprocessor, and 2x faster than a graphics chip. But if you lower the latency requirement to 7 ms, Xilinx becomes 2.5x more powerful than the graphics chip (and 72x more powerful than a microprocessor). If you further lower the latency requirement to 2 ms, Xilinx has 8x higher throughput than a GPU, and a microprocessor simply cannot do it.

Custom ASICs and application-specific standard products (Intel/Mobileye, Intel/Movidius, Ambarella, Tesla's internal design, Google/AMZN's own solutions). As potential volume grows, and time passes enough for the design cycles to catch up to

technology needs, products specifically designed for machine vision tasks should play a more significant role. Intel has acquired a couple of the first movers (Movidius in drones/surveillance, Mobileye in cars), which seem promising. Tesla has made it clear that they are developing their own solution for the next generation autopilot. Perhaps the greatest rerating potential comes from Ambarella, who has spent the last 4 years developing computer vision analytics chips to partner and ultimately integrate with its video processing solutions. Google is currently on the 3rd generation of their TPU ASIC solutions, caters to both Training and Inference workloads and AWS also unveiled their Machine Learning Inference ASIC "Inferentia" at its re:Invent conference in Las Vegas last month (AWS unveils ARM Server CPU and Inference ASIC).

Evolution of ADAS to Autonomous Driving - Key Semi Beneficiaries

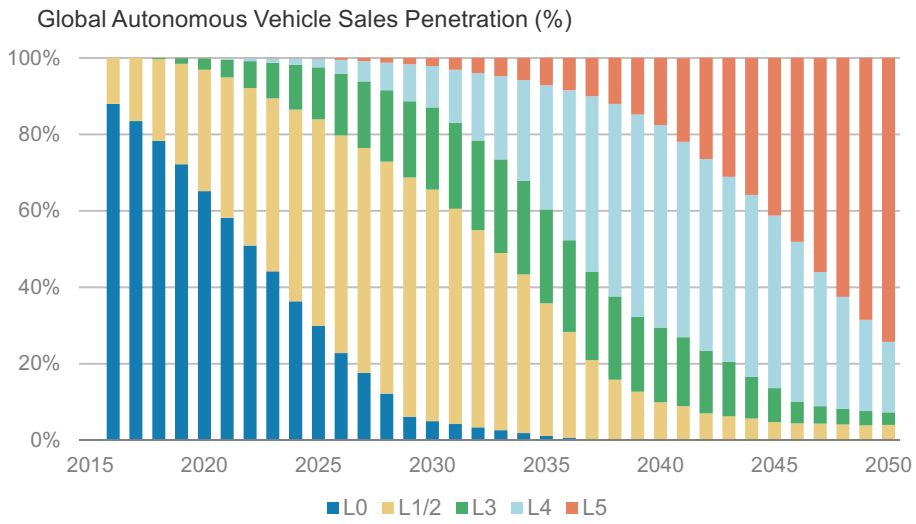
Autonomous driving remains a focus area for Auto OEMs with the road to fully autonomous vehicles developing in stages as incremental safety applications are layered in and enabling technology becomes cheaper. Autonomous driving should also lead to increased adoption of more processing as well as various sensors such as Vision, Radar and LIDAR (to some extent) as well as penetration of new technologies such as Vehicle-to-Vehicle (V2V) communication, propelling the semiconductor $ content in vehicles to over $1000 from current $400 level over the next 5-10 years driven by increasing penetration vehicles capable of supporting ADAS level 3/4/5 technology (Exhibit 98 to Exhibit 100).

Exhibit 98: Semi content in autos is expected to increase 2-3X over the next 5-10 years as adoption of level 4/5 semi/full autonomous cars picks up



Source: NXP

Exhibit 99: ADAS penetration rates



Source: Morgan Stanley Research

Exhibit 100: Industry Body SAE's Definitions of Six Levels of Autonomous Driving Are Widely Used, with Control Moving Progressively Away from the Human Driver and Towards the System

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

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Source: SAE, Morgan Stanley Research

Below we highlight a number of semiconductor suppliers that we expect to benefit from the evolution of advanced ADAS to full autonomy over the next 5-7 years:

Ambarella (AMBA, OW, covered by Joseph Moore): The semiconductor stock that we think offers the most upside with exposure to these trends is AMBA, a small cap stock that is struggling with multiple negative issues in its legacy business, but which has introduced dedicated computer vision solutions this year. While autonomous prototypes are likely to lean heavily on programmable solutions such as graphics chips, microprocessors, or field programmable gate arrays from (respectively) NVDA, INTC, and XLNX, we expect dedicated solutions to play a role. Currently, we expect AMBA to win business complementing NVDA solutions, with the main GPU offloading image resolution / perception tasks to the specialized chip. Establishing this business should

drive substantial strategic value for the stock with the current enterprise value of $940M (which reflects the well understood challenge of the legacy businesses). The company also has a full software stack - with no particular monetization plan around that – which could drive material incremental value.

Intel (INTC, EW, covered by Joseph Moore): We didn't love INTC's acquisition of MBLY from a stock perspective, as it pulled INTC farther from the value story that we have been hoping for, but MBLY remains a very valuable asset in the ADAS space, and it appears to be executing to its product roadmaps, with its EyeQ 5 products sampling later this year. MBLY is the leader in current production ADAS systems, and has clearly stated aspirations of moving towards full autonomy. One difference from the other companies on this list is that MBLY is a complete systems solution, not just a semiconductor solution. This likely will be an advantage in some cases, allowing MBLY to supply turnkey solutions that solve important problems; it could be a disadvantage in others, where we see automakers striving to create their own differentiated solutions. Still, MBLY establishes a very strong beachhead for INTC, not just for MBLY solutions, but for its microprocessors, Altera FPGAs, and in vehicle data communications.

NVIDIA (NVDA, OW, covered by Joseph Moore): Many of the Level 4 / 5 prototypes are based on NVDA solutions, where the company has benefitted from its dominant position in machine learning "training". Recently, the company has started to introduce products more specifically tailored for the automotive market, such as Xavier, which has brought down the power consumption profile materially. While INTC / MBLY's large exposure to production ADAS systems will be a substantial competitor, the flexibility and programmability of a GPU will continue to be an important factor. To migrate from prototypes to production vehicles will require more development, but the company is a strong position.

Xilinx (XLNX, OW, covered by Joseph Moore): XLNX FPGAs offer the flexibility to get ADAS systems to market quickly with more tailored solutions than a programmable processor, and we believe that the company is #2 in ADAS semiconductor revenue today behind MBLY. While the company has not staked an aggressive claim to higher levels of autonomy, its integrated MPSOC solutions integrate a high end ARM microprocessor – functionally identical to the processor in NVDA's Xavier – surrounded by an FPGA fabric, which may ultimately prove to be the right way of solving these challenges. We think that this is a generally underappreciated aspect to the XLNX story.

NXP (NXPI, EW, covered by Craig Hettenbach): is a strong player in the fast growing ADAS market and eventually we expect the company to have a solid position with fully autonomy as well. The company has leadership in Radar (first to release a single chip 77 GHz RADAR solution) and a strong position in MCUs/Application processors and V2X. In Radar, NXP participates both in transceivers and processors with 9 of the top 10 OEMs and importantly has already won designs for 80% of its 2019 revenue plan. In V2X, the company can address about $30 of content across ethernet, software defined radio (DSRC modem), security via its secure element and i.MX application processors.

Analog Devices (ADI, EW, covered by Craig Hettenbach): ADI expects the amount of sensor content required (including radar, lidar, and other components) for autonomous driving and ADAS to be a key contributor of doubling their $ content opportunity from $250 to $500. ADI provides 77/79 Ghz RADAR technology based on CMOS, rather than silicon-germanium (SiGe), that offers flexibility for integration of emerging applications

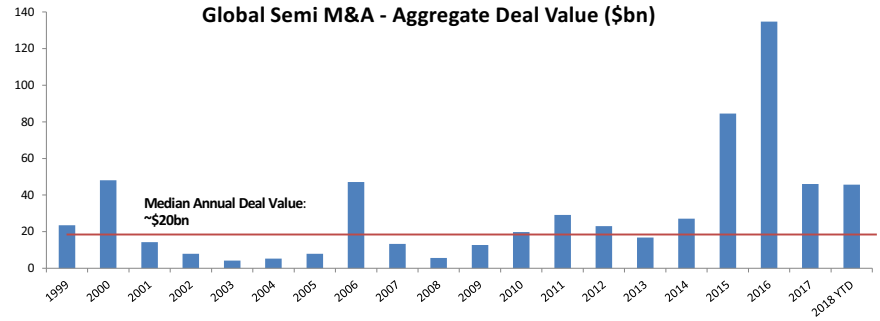
when moving toward autonomous driving. 77Ghz wavelengths are shorter thus supporting smaller antenna designs while enabling precise measurement and working to prevent crash situations or to provide warnings of approaching threats. The company anticipates the roll-out of 77 Ghz products in the next few years. In addition, the company also acquired LIDAR technology from Vescent Photonic, which aids solid-state scanning LIDAR capabilities.

ON Semiconductor (ON, UW, covered by Craig Hettenbach): ON Semiconductor's play on ADAS/full autonomy is though its strong position in image sensors. The company dominates the automotive image sensor space with 50% market share, more than 3X peers including Omnivision and Sony. ON is see increasing opportunities, with cameras per car expected to double to 2.5 by 2020 e.g. Tesla currently has 9 image sensors and will required additional 10 radar transceivers. The autonomous driving will drive the SAM 10X from $25 per vehicle for L2 to $200 for L4. Management anticipates sustainable competitive advance in automotive with $1bn+ of pipeline for at least 3 years. Overall, Autos and Industrial represents ~80% of the company's image sensor businesses.

Issue 8 - Semi M&A update: It feels like we are in the ninth inning

M&A has slowed considerably in 2017/18 after a very robust period in 2015-16. Specifically, there have been $45n in announced deals this year, flat y/y and down significantly compared to an average of $110bn in 2015 and 2016. Ongoing uncertainty around China tariffs and trade tensions, as well as a downcycle in the semis, are likely to give strategic acquirers pause on the M&A front. Furthermore, two recently completed deals (MCHP/MSCC and MRVL/CAVM) could be said to have failed to live up to initial expectations and illustrate some of the risks to M&A in contrast to positive sentiment in prior years when most deals were successfully integrated and EPS accretion helped to drive positive stock performance,

Exhibit 101: Global Semiconductor M&A by Year



Source: Bloomberg, Company Data

In looking at developments in M&A in the group, high GMs (typically an indication of strong technology/leadership market position) accompanied by high opex that can be rationalized has appeared to enhance the potential strategic attractiveness of companies. Despite having limited growth prospects, a number of SMID cap companies are spending opex at the ratio of 35%-50% of sales as they strive to compete with their larger peers.

Exhibit 102: M&A screen with market capitalization greater than ~$400mn, GM>40% and OM<30%

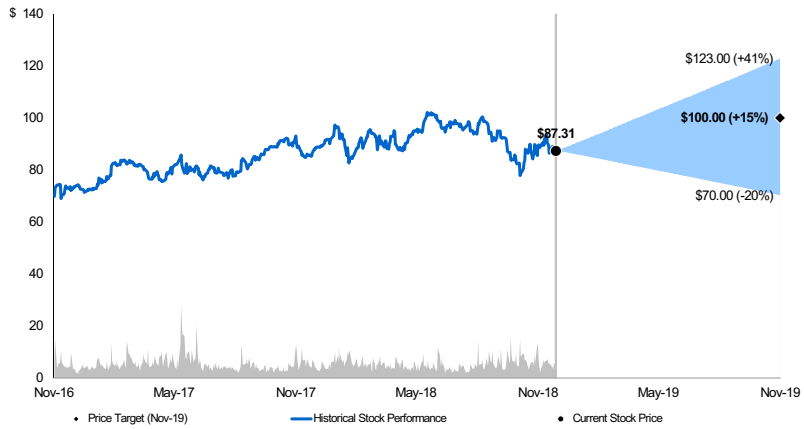
								NTM Valuation			
Ticker	Company	Market Cap	GM	OM	Opex	3YR Sales CAGR	5YR Sales CAGR	P/E Today	P/E Dec 2017	EV/EBITDA Today	EV/EBITDA Dec 2017
QCOM	QUALCOMM	69,845	55%	23%	32%	-4.6%	-4.0%	15.0	18.0	12.9	7.9
AMAT	APPLIED MATERIALS INC	31,298	45%	25%	20%	12.3%	11%	9.6	12.5	7.5	10.8
LRCX	LAM RESEARCH CORP	21,007	46%	25%	21%	22.5%	22%	9.2	12.4	6.2	6.4
AMD	ADVANCED MICRO DEVICES	19,888	38%	10%	28%	17.8%	4%	39.0	-	21.8	19.3
QRVO	QORVO	7,559	47%	29%	19%	6.4%	21%	9.5	10.7	6.8	7.8
IDTI	INTEGRATED DEVICE TECH	6,197	64%	29%	34%	10.4%	14.1%	24.5	17.1	18.6	10.6
TER	TERADYNE	5,827	58%	24%	34%	8.2%	7.8%	13.6	18.5	8.0	6.7
CY	CYPRESS SEMICONDUCTOR	4,611	47%	23%	24%	15.5%	28.0%	10.6	14.1	8.9	8.4
ENTG	ENTEGRIS	3,675	47%	23%	24%	12.5%	17.3%	13.4	19.1	8.5	6.8
SLAB	SILICON LABORATORIES	3,537	61%	21%	39%	10.9%	8.7%	21.8	25.8	16.2	13.7
MKSI	MKS INSTRUMENTS	3,500	48%	26%	22%	36.2%	25.2%	9.3	14.3	5.7	5.6
SMTC	SEMTECH	3,081	62%	29%	32%	9.6%	1.6%	19.7	17.1	12.8	10.2
IDCC	INTERDIGITAL INC	2,429	81%	22%	59%	-11.7%	-1%	80.3	33.6	10.6	12.2
CCMP	CABOT MICROELECTRONICS	2,406	50%	27%	23%	36.6%	20.9%	14.1	22.1	5.9	10.3
CRUS	CIRRUS LOGIC	2,151	50%	16%	33%	0.2%	9.2%	14.7	10.8	7.6	7.7
BRKS	BROOKS AUTOMATION INC	1,890	42%	13%	29%	13.5%	11%	26.5	17.9	14.7	13.4
POWI	POWER INTEGRATIONS	1,798	52%	19%	33%	6.6%	3.9%	26.7	23.1	19.3	16.7
AEIS	ADVANCED ENERGY INDUSTRIES	1,578	54%	28%	27%	20.2%	6%	11.1	13.6	7.0	7.8
IPHI	INPHI	1,454	71%	13%	58%	6.1%	23.5%	21.7	21.3	10.9	18.2
MXL	MAXLINEAR	1,414	64%	25%	39%	8.6%	26.3%	18.9	15.7	14.8	7.4
FORM	FORMFACTOR	1,072	43%	15%	28%	23.1%	17.8%	12.7	11.9	10.9	7.3
LSCC	LATTICE SEMICONDUCTOR	904	57%	17%	41%	-1.0%	3.5%	19.8	20.6	11.5	N/A
NANO	NANOMETRICS	683	57%	21%	36%	19.9%	17.5%	14.7	14.9	7.4	7.0
COHU	COHU INC	678	43%	14%	29%	18.8%	13%	11.1	13.2	6.6	3.7
RTEC	RUDOLPH TECHNOLOGIES	622	54%	23%	31%	7.0%	9.1%	12.9	18.2	6.9	N/A
ACLS	AXCELIS TECHNOLOGIES INC	577	40%	13%	27%	13.4%	17%	16.9	16.2	8.0	N/A
QTNA	QUANTENNA COMMUNICATIONS	556	50%	9%	41%	37.9%	34.7%	19.2	65.1	11.7	52.8
CEVA	CEVA	493	91%	15%	76%	9.9%	10.8%	-	-	-	-
PI	IMPINJ	369	49%	-13%	63%	15.2%	16.7%	(40.6)	(42.1)	-40.2	-

Source: Thomson Reuters, Morgan Stanley Research, Company Data

Risk Rewards

Analog Devices (ADI, Equalweight, PT $100)

We downgrade ADI to Equal-weight due to near-term risks to estimates.



Source: Thomson Reuters, Morgan Stanley Research

Price Target $100

We value ADI at 17x CY20e EPS of $5.90.

Bull $123

19x CY20e Bull case EPS of $6.50

Cross selling opportunities result in higher revenue growth. The company exceeds its opex savings target. Valuation multiple trends higher towards high end analog peer group median of 19-20X as the company pays down debt.

– 9.3% revenue growth in CY20
– GM increases to 72.4% in CY20
- CY20 EPS of $6.50

Base $100

17x CY20e EPS of $5.90

2.3% revenue CAGR over CY18-20

– 4.1% revenue growth in CY20
– GM comes in at 71.1% in CY20
- CY20 EPS of $5.90

Bear $70

14.5x CY20e Bear case EPS of 4.81

Sales decline 5.9% in 2020 due to slowdown in broad-based markets and weakness in the company's consumer business (13% of sales).

– 5.9% revenue decline in 2020; GM of 69.6%

Investment Thesis

- We downgrade ADI from Overweight to Equal-weight as more aggressive guidance relative to peers sets a high bar for 2019 into the face of increasing risks to the semi cycle. In particular, we see risks to the company's industrial (50% of sales) and comm (20%) end markets. On a longer-term basis, we still view ADI as a core holding in the group, due to exposure to the right end markets and superior margins and FCF generation.

Potential Catalysts

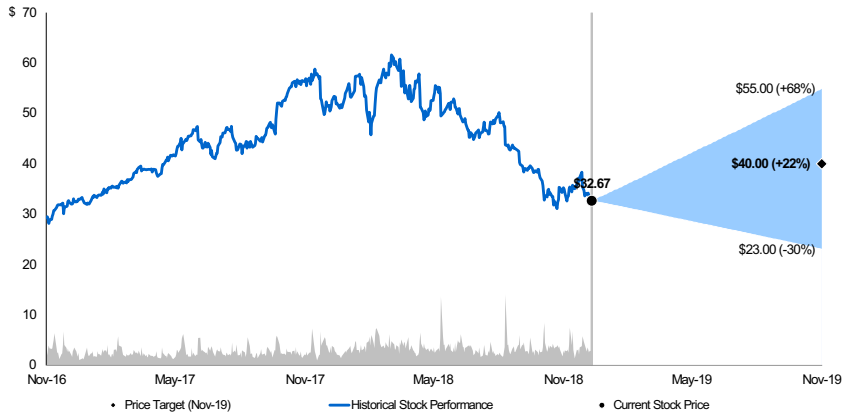
- The ramp of 5G infrastructure provides a needed tailwind to growth in 2019
- The next leg of cost savings ($100mn) from Linear as ADI consolidates its manufacturing footprint
- The company realizes revenue synergies through the deal by cross selling Linear's power management products to its existing customer base earlier than expected, including increased traction through distribution

Risks to Achieving Price Target

- Macroeconomic downturn leads to a significant slowdown in broad-based markets
- The company stumbles in integrating Linear Tech
- Increasing competition in autos around BMS

Applied Materials (AMAT, Equal-weight, $40PT)

Risk Reward Snapshot: Applied Materials (AMAT, Equal-weight, PT $40)



Source: Thomson Reuters, Morgan Stanley Research

Price Target **$40**

Base case scenario; 12X FY20e EPS of $3.35 plus cash, in line with peer LRCX.

Bull **$55**

13x 2020e MW EPS of $4.20

Equipment market surge is maintained, particularly in logic, with multiple participants and the company exceeds targets with accelerating margin expansion; we project:
– Revenue increase 8.4% in 2020e
– Margins expand as mix shifts toward foundry and services business continues to grow

---

Base **$40**

12.0x FY20 EPS of $3.35, in line with LRCX

Semi systems revenue falls through 19 and 20, Display declines in FY19, while Services continues to grow
- Revenues expand 3.2% in 2020
– Gross margins expand 70bps from 2019 to 2020
– 2020e EPS of $3.35
– Semiconductor systems down 2.8% in 2020
– Services up 10.6% in 2020

Bear **$23**

~9x 2020e MW EPS of $2.50

Equipment market slows down on sluggish end demand growth, particularly in foundry, as end customer migration to advanced process nodes falls
– Revenues down 17.4% in 2020
– Gross margins remain low as mix doesn't shift towards foundry

Investment Thesis

- Overall we believe that semicap growth is slightly higher than semis with lower valuations
- We see some company specific earnings growth drivers: 1) reacceleration in transistor formation around 10 nm innovations drives higher growth in Applied's highest margin business; 2) display production equipment TAM expands significantly around the OLED transition, 3) execution on margin and growth initiatives is likely to improve after the distraction of the failed Tokyo Electron merger

Key Value Drivers

- Applied should grow significantly faster than capital spending driven by the increase in patterning steps that is required in the next 2-3 years
- We see some contraction in spending in 2019, but Applied should continue to gain share of spending, while still growing in display and services
- China sovereign semiconductor program drives longer term optionality

Catalysts

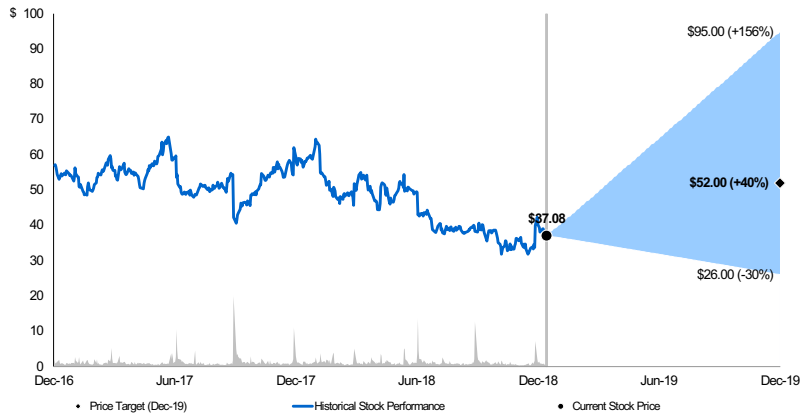
- We see a risk of sluggish end demand growth in 2019
- China sovereign opportunities turn into actual bookings

Risks to Achieving Price Target

- The primary risk to Applied, relative to other semicaps, would be weaker spending in foundry; recovery in foundry spending is key to our margin recovery outlook.
- Applied also has high memory exposure; our expectation is some contraction in memory spending this year; we expect memory margins to stabilize, but that remains uncertain.

Ambarella (AMBA, Overweight, $52 PT)

We become more constructive on the stock as Ambarella gets customer concentration problems behind them and computer vision applications drive multiple expansion; OW



Source: Thomson Reuters, Morgan Stanley Research estimates

Price Target **$52**

Sum of the parts: 3x Base Case CY2020e Sales+ net cash + $500mn valuation for the pre-revenue autonomous business

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Bull **$95**

Sum of the parts: $2 bn for computer vision, ~18x 2020e EPS for core business, $10.5 cash

In the bull case, Ambarella computer vision products firmly establish themselves as a leader for the nascent autonomous driving market.

-Computer vision chips live up to their initial promise, as providing breakthrough levels of video analytics vs. current state of the art; development relationships with tier one auto suppliers in 2019 (with revenue still several years away), with 2019 small revenue traction in surveillance and drones.

– Core business grows more meaningfully in 2019, as adoption of CV in surveillance drives strong growth.

Base **$52**

Sum of the parts: 3x Base Case CY2020e Sales+ net cash + $500mn valuation for the pre-revenue autonomous business

Initial progress in computer vision leaves optionality for autonomous driving

– Computer vision lives partially up to initial promise, but with normal growing pains/implementation delays; view for revenue in 2019 from surveillance/drones, with still possible automotive CV but no tangible traction

– Meanwhile core video processing growth resumes as consumer headwinds subside; GMs remain at ~60% through CY19

– $500mn strategic value for pre-revenue autonomous driving/ADAS business following demonstration of full self driving vehicle, relative to multibillion dollar investments in driver assistance businesses

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Bear **$26**

Sum of the parts: ~2x CY2020e Sales+ net cash

Bear case assumes minimal computer vision success, and further challenges in the core business.

Investment Thesis

- We like Ambarella's fundamental position and think that bears generally underestimate the company's leadership. We think that the company's products at the high end of the market are unique.
- Home security, wearables, drones, automotive driver assistance will all add growth on top of existing core market growth (core markets: surveillance, dash mounted autos, OEM auto surround view/digital rear view mirrors).

Key Trends

- Ambarella's product leadership/barriers to entry higher than generally perceived
- Longer term, automotive driver assistance is one of the most exciting opportunities, but design win cycles take years
- Computer vision applications puts the company into much more strategic markets

Potential Drivers

- Automotive customer relationships announced by early 2019
- IP Security systems adopt computer vision, driving 2-3x increase to average selling price

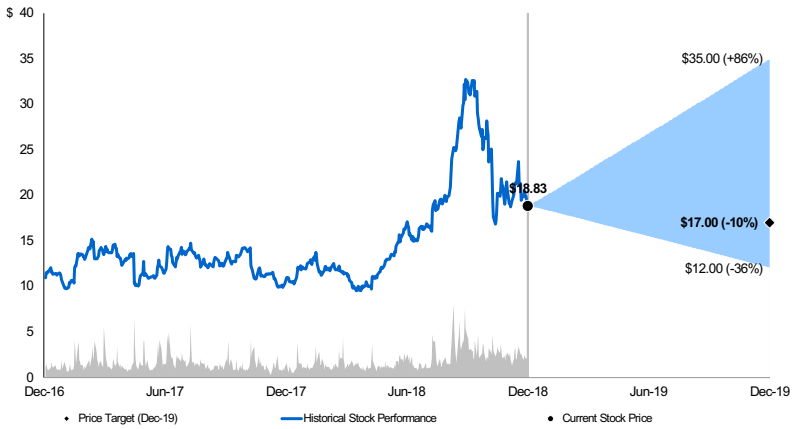
Risks to Achieving Price Target

- Legacy pressures could spread to surveillance and autos, with most of the R&D now going to computer vision
- Low visibility and relatively high customer concentration
- China surveillance roughly 25% of sales, directly impacted by trade tensions

Single digit revenue growth ex-GoPro in CY19, continued weakness in drones. Computer vision products fail to make any real impact even with surveillance and drone customers. R&D persists in 2019, but would likely see reduced rate of investment thereafter.

Advanced Micro Devices (AMD, Underweight, $17 PT)

Our 2020 estimates for AMD reflect the Zen bull case, but we still can't see upside for the stock



Source: Thomson Reuters, Morgan Stanley Research estimates

Price Target **$17**

Our $17 PT for AMD equals 23x base case FY20e EPS of $0.76, a few turns below where growth small-mid cap semis have traded at it in recent years.

Bull **$35**

36x bull case FY20e EPS of $0.96

Bull case assumes strong execution and a turnaround story for AMD. In computing and graphics, Polaris/Vega and Zen help AMD regain material market share in both GPU and CPUs over the next 18 months. Success in Zen breeds sustainable wins in performance desktops and servers.

Base **$17**

~23x base case FY20e EPS of $0.76, a few turns below where growth small-mid cap semis have traded at it in recent years

We see Zen driving share gains for AMD in compute in the near term after multiple years for share decline to Intel. This drives ~$4bn in compute revenue in 2020 for AMD spread across $1.7bn in desktops, $1.2bn in notebooks and ~$1.1bn in servers. Non-GAAP GM to come in at 41.3% in 2019 and 43.2% in 2020. Non-GAAP EPS to come in at $0.60 in 2019 and $0.76 in 2020.

Bear **$12**

Based on ~ 2x EV to CY20 Sales of $6.83 bn

AMD fails to keep up with the moving target presented by Intel, and Intel drives significant gains from its 10 nm portfolio in 2H19/20. AMD continues to struggle to get to non GAAP profits other than in the seasonally strongest quarters, and continues taking large non GAAP charges.

Investment Thesis

- Zen helps AMD gain share in the PC and server market over the next 2 years, especially given 10nm manufacturing challenges at Intel. Our base case assumes ~$2.7bn in CPU revenue in 2019. On the other hand, we expect to see ~20% decline in the GPU business in 2019 given lack of incremental GPU demand for crypto mining and no competitive response to Nvidia's Turing GPUs.

Key Value Drivers

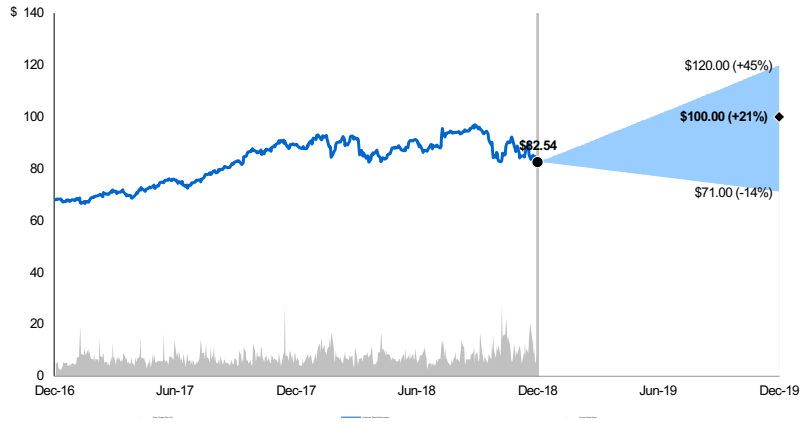
- We view the console cycle as largely paralleling the Xbox 360/PS3 ramps, with units peaking in year 3 with lower price points in later years. Most played games today are almost all sequels of 360/PS3 titles, emphasizing the lack of TAM expansion.
- On the positive side, the company has largely executed to its product roadmaps, and continues to innovate in multiple markets on a shoestring budget; the earnings pressures are a function of being in a tough situation.
- We think the company's recent renewal of focus on high end x86 cores is the right strategy, but we don't expect Zen to enable AMD to make significant and sustainable PC and Server CPU markets beyond 2019/20.

Risks to Achieving Price Target

- PC and Zen server share gain accelerates as Zen adoption picks up; Intel's competitive response at 10 nm is less impressive than our expectations.
- Console cycle turns out to be stronger than expected.

Amphenol (APH, Overweight, $100 PT)

Best franchise in connectors and long-term investment in the group, with the stock also looking more attractive on a relative basis given our cyclical concerns in semis



Source: Thomson Reuters, Morgan Stanley Research

Price Target $100

We value APH at 23x CY20e EPS of $4.33. The 23x multiple is more or less in line with its 3 year median, a touch below the multiple expansion for S&P 500 echoing our concerns surrounding the semi cycle.

Bull $120

25x 20e EPS of $4.79

6.8% revenue CAGR over 2018-20 period driven by incremental share gains in the core connector market as well as increase in pace of M&A in connectors and the faster growing sensor market. APH sees incremental 2x expansion in multiple versus the base case.

– GM increases 20bp Y/Y to 33.8% in CY20

Base $100

23x 20e EPS of $4.33

Above industry average growth, driven by continued strength in Autos / Industrials / Aerospace with recovery in IT & Data Comm and supplemented by acquisitions.

– ~4.5% revenue CAGR from 2018 to 2020
– Industrial: flat in CY19 and 5.1% growth in CY20
– Automotive: 6% growth in CY19 and 9.6% growth in CY20
– Mobile Devices: 2.6% growth in CY19 and flat in CY20
– Mobile Networks: 10.4% growth in CY19 and ~10% in CY20
– IT & Data Comm: up 4% in CY19 and 3.7% in CY20
– GM: 32.6% in 2019 and 32.8% in 2020
– CY19 EPS of $3.99 and CY20 EPS of $4.33

Bear $71

18x 20e EPS of $3.92

An inventory correction hits its industrial segment and weakness in smartphones leads to lower sales growth

– 2.0% revenue CAGR through 2020; GM of 31.8% in CY19

Investment Thesis

- We rate APH Overweight. While risks are increasing through the supply chain, the lower lead times of Amphenol products and lower exposure to distribution should help the company manage this dynamic better than the analog and MCU groups. A steady stream of acquisitions also provide incremental growth opportunities.
- The company is an execution machine, growing mid single digits organically and high single digits including M&A. Along the way, Amphenol's share in connectors has increased to over 10%% from 5% a decade ago and it has only missed earnings once during this period. Furthermore, management now has its eyes set on the $125bn sensor market via acquisitions, which should keep its growth engine humming.

Potential Catalysts

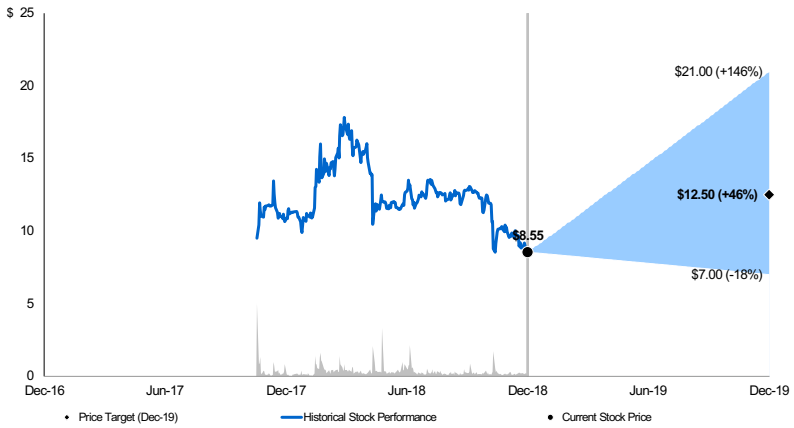
- 5G infrastructure buildout, leading to upside in the company's mobile networks business (8% of sales).
- Upside to revenue and EPS driven by accretion from opportunistic M&A
- Entry into the sensor market, which triples the company's TAM. Amphenol has a strong track record of rolling up fragmented industries

Risks to Achieving Price Target

- Any execution missteps on M&A
- An inventory correction in the components market
- Heightened expectations, with the stock trading at the high end of its valuation range.

Aquantia (AQ, Overweight, $12.5 PT)

Rated OW on significant growth potential driven by technology shifts and strong competitive positioning in target markets, coupled with solid operating leverage as business scales



Source: Thomson Reuters, Morgan Stanley Research

Price Target **$12.5**

Our price target of $12.5 represents 2.2X EV to 2020 Sales estimate of $174mn, a discount to peers to account for Aquantia's lower profitability in the near term

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Bull **$21**

3.5X EV to 2020 Sales estimate of $195.6mn

- Adoption of multigig technologies in Enterprise and Access markets is faster than expectations; Data Center business comes in above our conservative estimate in 2019; company sees higher operating leverage as a result
- Revenue to grow ~30% in 2020 to $195mn
- EBIT margin comes in at 14% in 2020
- Non-GAAP EPS of $0.75 in 2020

Base **$12.5**

2.2X EV to 2020 Sales estimate of $174mn

- We expect to see solid growth in Enterprise and access market even with low penetration assumptions; conservatively model Data Center business to decline next year; Aquantia to benefit from operating leverage in 19/20 time frame
- Revenue growth of 15.5% in 2020
- Data Center business declines 3% in 20, Enterprise up 15% and Access up 35%
- GM reach 59.2% in 2019 and 59.4% in 2020
- Non-GAAP EPS of $0.26 in 2019 and $0.44 in 2020

Bear **$7**

1.3X EV to 2020 Sales estimate of $158mn

- Ramp of multigig technologies is slower than expected; Intel loses share to competitors, which results in a drag for Aquantia Data Center business Revenue to grow 5% in 2019 to $158mn
- EBIT margin comes in at 5% in 2020
- Non-GAAP EPS of $0.21 in 2020

Investment Thesis

- Aquantia posts 15%+ revenue growth over the coming years driven by transition to high data transmission in the Data Center (from 1G to 10G) and Enterprise/Access markets (1G to multi-gig)
- Aquantia retains its competitive lead over Broadcom and Marvell given its first mover advantage and solid relationships with market leaders
- Substantial operating leverage in late 2019 time frame as the company penetrates further into Enterprise and Access markets (PC/Service provider access)

Potential Catalysts

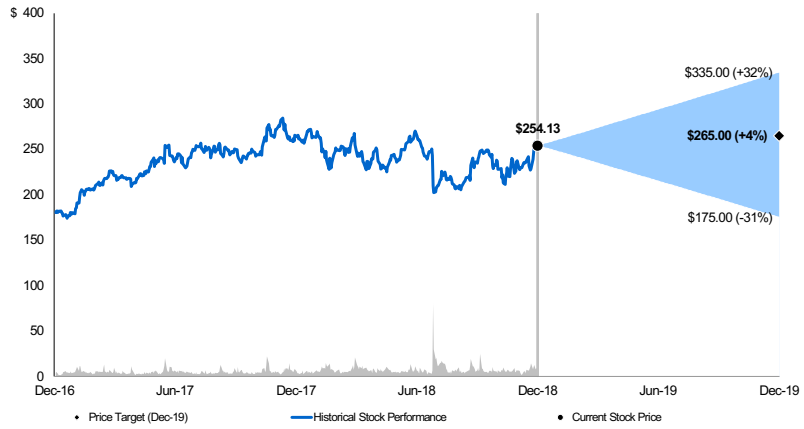
- Multigig technology penetration in Enterprise and Access markets comes in better than our expectations
- Data Center business stabilizes post the price cuts in 2017/18 due to Intel MAC integration with Purley leading to revenue upside vs our estimates in 2019
- The company announces wins in automotive next year, which likely doesn't impact estimates near term but boosts sentiment for the stock

Risks to Achieving Price Target

- Adoption of Multigig PHYs in Enterprise and Access markets comes in below expectation
- Intel ends its exclusive relationship with Aquantia with its 2018 RFQ, which likely hits AQ's revenue stream couple of years down the line
- Potential for business volatility due to inventory corrections at Intel or Cisco
- Operating expenses come in high than expectations as Aquantia continues to spend aggressively on new growth avenues such as Autonomous driving and 100 G at Hyperscale Data Center

Broadcom Inc. (AVGO, EW, $265 PT)

We resume coverage of AVGO at Equal-weight: Strong core franchises and attractive valuation appear balanced by moderating demand and risks in wireless



Source: Thomson Reuters, Morgan Stanley Research

Price Target $265

We value AVGO at 11.5x CY2020e Pro-forma EPS of $23.05. Our target multiple of 11.5X is at the low end of large cap semis TXN (17X), QCOM (16X) and INTC (12X), reflecting questions around AVGO's move into software

Bull $335

13.5x 2020e ModelWare Bull EPS of $24.89

Revenue growth surprises to the upside and Broadcom exceeds its operating margin target boosted by CA cost savings. The stock's valuation multiple expands as investors regain confidence in its M&A strategy.

Base $265

11.5x 2020e ModelWare Base EPS of $23.05

Posts 16% revenue growth in CY19 driven by addition of CA

– ~16% revenue growth in 2019 and ~3% in 2020
– GM up 20bp Y/Y to 69.8% in 2020 and up 150 bp to 69.6% in 2019
– CY19 of $20.82 and CY20 EPS of $23.05

Bear $175

9x 2020e ModelWare Bear EPS of $19.61

Revenue growth disappoints and CA opex cuts underwhelm. The stock's valuation multiple falls to 9x.

– Revenue down 7% in 2020; GM of 68.1%

Investment Thesis

- We are Equal-weight AVGO as weaker demand in key markets of wireless and storage offset our favorable view of the company's market leadership in key businesses (66% weighted market share across 60% of revenue in duopoly structures), high profitability and strong FCF generation.
- We expect the stock's valuation multiple to remain depressed near term until investors get more comfortable with the company's M&A strategy in software. From here, we see EPS revisions as the primary driver of stock price.

Potential Catalysts

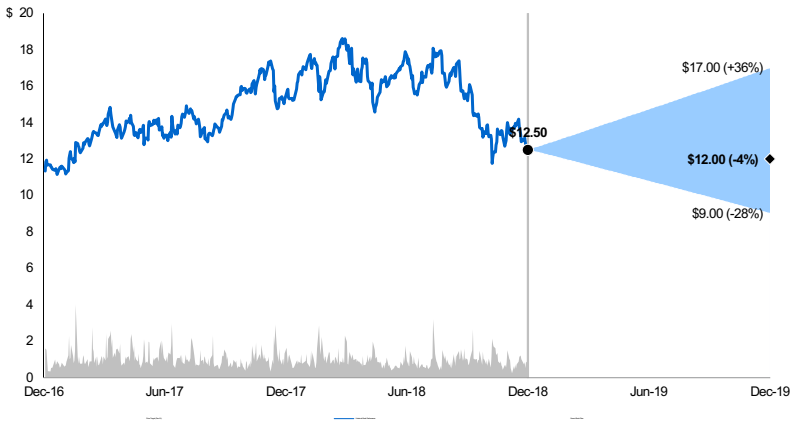
- Increasing adoption of carrier aggregation, antenna filtering in RF and 5G adoption by 2020
- Upside to estimates on stronger than expected accretion from the CA deal
- Very strong growth in the dividend, with the next increase expected in December

Risks to Achieving Price Target

- Increased competition in premium filters, an important growth driver
- Execution on the CA acquisition
- Potential weakness in Hyperscale cloud capex and traditional enterprise spending impacting Storage and Wired

Cypress Semiconductor (CY, Underweight, $12 PT)

We are Underweight CY on the view that strong memory growth and profitability are unsustainable and expect the stock to underperform given our Cautious view on the semi cycle



Source: Thomson Reuters, Morgan Stanley Research

Price Target $12

Our PT of $12 represents a P/E of 12.5X on CY20e MW EPS of $0.97 (includes stock based compensation). This implies a P/E of ~15X on the company's MCD business and ~8X on MPD.

Bull $17

14X CY19e EPS of $1.20

Upside to growth in MCU and Connectivity, driven in part by stronger adoption of USB Type C and share gains in PSoC/MCUs. We also include an M&A premium in our bull case given consolidation in semiconductor industry.
– ~8% sales growth in CY2020
– GM reach 49.2% in CY20

Base $12

12.5X CY20e EPS of $0.97

Steady growth in MCU, increase in Type C products and strength in the BRCM IoT business. Decline in memory given secular pressure on NOR and SRAM.
– 5.6% revenue decline in CY19 and ~3% growth in CY20
– Microcontroller and Connectivity: 6% growth in CY20
– Memory Products: down ~3% in CY20 due to transfer of NAND business to JV with Hynix
– GM reach 46.5% in CY19 and 47.2% in CY20
– CY19 and CY20 EPS of $0.90 and $0.97

Bear $9

11x CY20e EPS of $0.83

Memory weakens with double-digit declines in NOR. Growth in MCU and Connectivity segment disappoints.
– Revenue declines ~3% in CY20; GM of 46.2% in CY20

Investment Thesis

- We have a Cautious view on the Semis group and expect the stocks of companies with higher commodity exposure and lower margins to Underperform. While Cypress has executed well since CEO Hassane El-Khoury took over in 2016, we have concerns that strength in its memory business has inflated earnings and is about to deteriorate. We expect a sharp deceleration in growth in semis, which would provide a test to the company's target of a 7%-9% revenue CAGR through 2021 (well ahead of peer targets in the low to mid single digits range).

Potential Catalysts

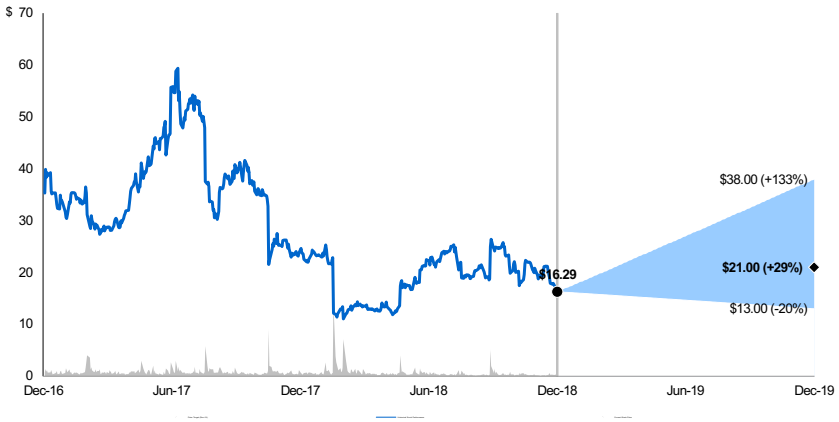
- A reversal in NOR pricing, negatively impacting growth and margins
- Increased competition in Connectivity (IoT) negatively impacts growth and/or margins
- Any slowdown in automotive, the company's largest end market at over 30% of sales

Risks to Achieving Price Target

- Potential strategic value in a consolidating semi industry
- Upside to GMs if product mix improves
- Potential upside to growth in USB Type C

Impinj (PI, Equal-Weight, $21 PT)

We like Impinj's secular growth prospects in RAIN RFID technology, but are Equal-weight on a balanced risk/reward in the stock.



Source: Thomson Reuters, Morgan Stanley Research

Price Target $21

Our price target is derived using 2.5x EV to sales multiple on 2019 sales estimate of ~$165mn. Our target multiple is a discount to our coverage universe that trades at ~4EV/S, reflecting reduced visibility into Impinj's growth.

Bull $38

~4X EV/S on our 2020 bull case sales estimate of $184mn

Bull case has accelerating adoption in Retail/Healthcare verticals and greater than expected adoption in newer markets of Technology, Airlines, Automotives, and Consumer. In addition, Impinj realizes significant operating leverage

– Revenue growth comes in at 32.2% in 2020
– GM of 53.6% in 2020

Base $21

2.5X EV/S on our 2020 base case Sales estimate of ~$165mn

Base case is derived from a recovery in revenue growth driven by increasing RFID penetration

– Revenue to grow ~16% in 2019 and 18% in 2020
– GM at 50.8% in 2019 and 52.1% in 2020

Bear $13

~2X EV/S on our 2020 bear case sales estimate of $140mn

Slowdown in target markets of Retail/Healthcare and adoption in other verticals underwhelms. Increasing competition from other RAIN RFID players such as NXP, Alien, ST Micro

– Revenue comes in at $140mn
– GM of 50.6%

Investment Thesis

- RAIN RFID represents a large and fast growing market opportunity – 22% CAGR to over $10bn+ by 2020.
- Impinj has leading market share (60%+) and differentiates by offering integrated platform solutions across Tags, Readers, Gateways and Software.
- Only pure play on increasing RFID technology adoption, with only 1% TAM penetration (large runway for growth). However, the company's execution has been uneven over the past year and it is now far from profitability, keeping us Equal-weight the stock

Potential Catalysts

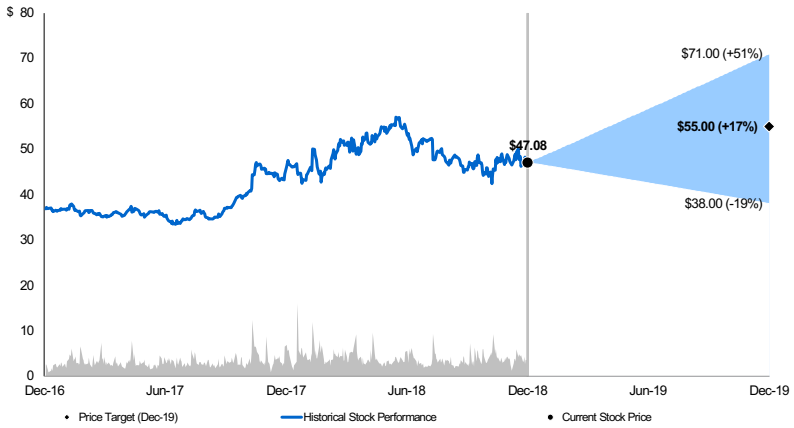
- Acceleration of RFID adoption in core markets of Retail/Healthcare driven by new use cases
- RFID adoption in newer markets of Data Center, Travel, Automotive and Consumer comes in above expectation
- Inflection in Connectivity and Software revenue that helps expand margin profile of the company

Risks to Achieving Price Target

- Potential for quarterly business volatility given lumpy deployments
- Slowdown in pace of RFID adoption
- Customer concentration - Top 3 OEMs/ODMs (Avery, Shang Yang and Smartrac) account for 45% of sales
- Any increase in competition: Tags (NXP, Infineon), Reader ICs (ST Micro and Phychips) and Readers/Gateways (Zebra and Alien)

Intel (INTC, Equal-weight, $55 PT)

We see DCG deceleration and competition from AMD in CPUs as a headwind to growth and to pressure margins



Source: Thomson Reuters, Morgan Stanley Research

Price Target **$55**

Base case scenario

Bull **$71**

15x 2020e EPS of $4.74

PC average selling prices continue to rise , Data center reaccelerates, driving multiple higher

– Data center continues to grow double digits and PC revenues grow modestly through higher average selling prices

– Better growth drives higher gross margin, minimizing cash flow gap

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Base **$55**

12x MW 2020e EPS of $4.59, discount to the group given headwinds on the CPU share front

PCs return to y/y declines in FY19 and Data center growth decelerates to sub 10% in 2019 after growing 20%+ in 18. We project:

– MW Gross Margins: 62.4% in 2020e

– 2020 EPS of $4.59

– Mixed success in key non x86 initiatives (foundry, smartphones)

- Multiple below the group due to large gap between earnings and free cash flow

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Bear **$38**

11x 2019e EPS of $3.43

Assumes average selling price and units both decline 5% in 2019 due to mix shift to lower end notebooks, without offsetting volume, and servers slow dramatically

– Revenues declines at ~5% CAGR over 2018-20

– Multiple compression as concern builds about margin degradation in 2019

Investment Thesis

- Primary revenue drivers are PCs which decline 2-5%, and data center up HSD, driving minimal revenue growth long term
- We are reasonably upbeat on long term prospects for the data center group but think the grow trajectory of the business is in the HSD range
- Non PC/server initiatives such as memory likely continue to disappoint
- Process node transitions taking longer; 10nm has been delayed a number of times now to 2H19

Potential Catalysts

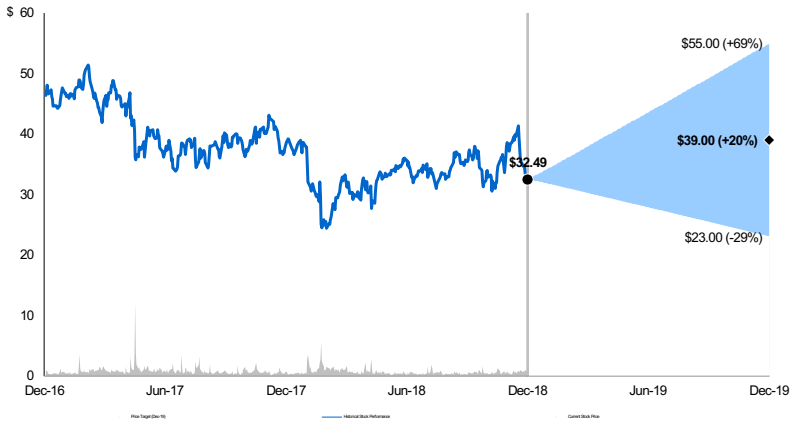
- Rebound in PCs leads to better than expected performance in client computing group
- Competition from AMD's ZEN CPU fades away in 2019, which could lead to further increase in microprocessor pricing
- Data center growth remains in double digits in 2019

Risks to Achieving Price Target

- AMD competition is formidable, which could lead to share loss in high performance PCs and servers as well ASP pressure
- Mild strain from record high inventory and receivables levels.

Inphi (IPHI, Equal-weight, $39 PT)

100G Product Cycles offset by China optical business



Source: Thomson Reuters, Morgan Stanley Research

Price Target **$39**

Our price target of $39 represents 20X our base case CY20e EPS of $1.94; This target multiple is a discount to other higher growth small cap stocks such as Ambarella which trade at mid to high 20s P/E multiples given uncertainty about the pace of recovery for the China Long haul/Metro business.

Bull **$55**

22x Bull Case CY20e non-GAAP EPS of $2.50

Faster than expected growth in the company's core communication business driven by stronger than expected recovery in China optical. Adoption of Colorz and PAM4 comes in above our expectations.

Base **$39**

20x Base Case CY20e non-GAAP EPS of $1.94

China long haul/metro business starts to recover from Q2'18. In addition, Colorz/PAM4 revenue continues to grow in 2018 and ClariPhy sales remain on track to reach around $50mn in 19. For 2019, we model ~23% growth for the company and for 2020, we model 14.6% growth.

Bear **$23**

16x Bear Case CY20e EPS of $1.44

Slowdown in carrier capex spending. Competitive landscape toughens. 100G Colorz/PAM4 ramp is slower than expected. Corresponding lack of visibility drives multiple compression

Investment Thesis

- Growth in Metro and increasing adoption 200/400G adoption in Data Center are key drivers of growth for IPHI and we model the company to deliver over 20% revenue growth in 2019
- The company's core strength in high-speed analog design is driving its products for data centers and telecom, with strong growth potential over the next three years
- The company continues to outgrow the communications end market helped by technology shift towards coherent spending

Key Value Drivers

- Growth in worldwide Datacenter and Cloud infrastructure builds
- Continued worldwide build-out of 100/200/400G infrastructure
- Capex/Opex savings through the use of coherent optics drive upgrade of optical modules

Potential Catalysts

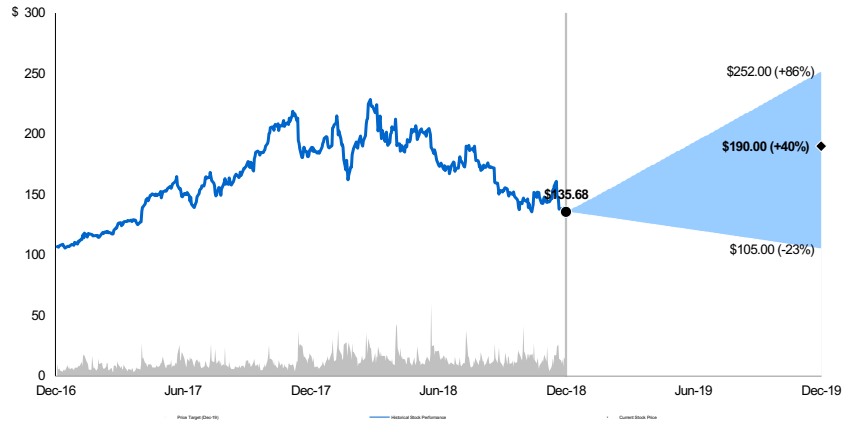
- Customer adoption of Inphi's PAM4 technology for 200/400G Data Center Interconnects
- Capex announcements from carriers for 100G ports and switches

Risks to Achieving Price Target

- China Optical business remains weak longer than expectations
- A stall in the worldwide build out of 200G/400G comms infrastructure
- 200G/400G PAM4 TAM comes in below our expectations
- Pick up in competition in 400G from competitors such as Broadcom, MACOM, and Semtech.

LAM Research (LRCX, Over-weight, $190PT)

Risk Reward Snapshot: LAM Research (LRCX, Overweight, PT $197)



Source: Thomson Reuters, Morgan Stanley Research

Price Target $190

Base case scenario.

Bull $252

~13x CY19e EPS $18.21 + cash

DRAM and NAND pricing continues to climb up, creating potential for much higher spending in 2018/19

- Why would this happen? Supply challenges around DRAM multipatterning, and 3D NAND supply challenges.
- Revenue grows 17.2% in CY19

Base $190

~12x CY19e MW EPS of $14.87, plus net cash, in line with historical multiples during comparable periods and reflecting multiple expansion in the group

We expect Lam's outperformance to continue, as wafer fab equipment growth decelerates but remains at healthy levels:

– Revenue grows 14% in 2018, down 6.5% in 2019, after 50% in 2017, which compares to 6-8% growth for overall wafer fab equipment industry

-We do assume that quarterly shipments peak in 2018, and that memory markets flatten out

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Bear $105

11x trough CY19e EPS of $8.22 + cash

Assumes a hard landing in memory, as we see 2016 style inventory depletion that impacts spending

- Expect to see multiple expansion as EPS is no longer at peak

Investment Thesis

- We expect Lam to continue to outgrow overall spending levels by having exposure to markets that benefit from current device trends
- Where we differ is that we forecast memory cash flows, which remain high, drive a soft landing in spending
- Other factors such as China's sovereign interest in semiconductor manufacturing, Intel's ramp of internal memory manufacturing, and potential competition for new semiconductor device structures within foundry have potential to drive upside to forecasts

Key Value Drivers

- Memory pricing remains strong, we think Lam still grows slightly due to outsized exposure to new device structures (3D, advanced packaging, and multiple patterning)
- We also see Intel 10 nm innovation driving potential motivation to spend from foundry competitors
- We expect slight multiple expansion as memory concerns ease through the year; still expect a low multiple vs. the sector.

Potential Catalysts

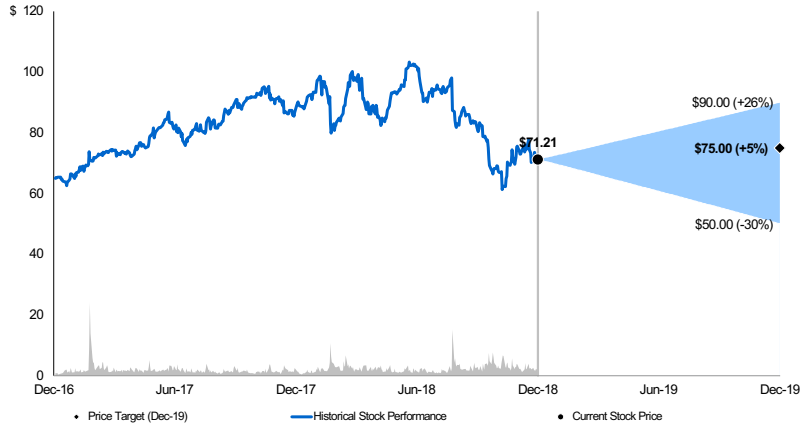
- Stronger memory prices (a positive lead indicator)
- Competitive spending arms race on 10nm for foundry
- Potential China sovereign memory fab announcements

Risks to Achieving Price Target

- The biggest risk is to memory; we model for a mild correction to memory prices starting in 2q18, but a more severe correction would change spending patterns
- While AMAT and LRCX should have strong product offerings that benefit from EUV, it's an inescapable conclusion that litho regains share of spend. The ramp of EUV is a challenge for the US competitors in the 2019

Microchip Technology (MCHP, Equal-weight, $75 PT)

We are Equal-weight MCHP and highlight growing risks around the semi cycle



Source: Thomson Reuters, Morgan Stanley Research

Price Target $75

Our PT of $75 represents a 11X multiple on MW CY20e EBITDA (includes impact of stock based compensation), a 2X discount to high end Analog/MCU peers given higher leverage post the Microsemi deal.

Bull $90

12x our MW CY20e EBITDA of $2.45bn

Revenue growth comes in above expectation driven by strong traction for Microchip's new products in 16- and 32-bit MCUs as well as benefit from analog cross selling. Microsemi's organic growth surprises to the upside. Non-GAAP GM cross the company's target. Cost synergies from the Microsemi transaction comes in above initial expectation.

– Including Microsemi's contribution, 9.8% revenue CAGR from 2018-2020
– GM of 62.5% in 2020

Base $75

11x our MW CY20e EBITDA of $2.35bn

As we enter the later stages of the Semi cycle growth decelerates for core Microchip from double digits to MSD, while organic growth for Microsemi comes in flattish.

– ~3% revenue growth in 2020 (including MSCC)
– GM: of 62% in CY20
– CY20e EPS of $6.83 and EBIT of $2.17bn

Bear $50

10x our MW CY20e EBITDA of $2.07bn

Macroeconomic slowdown drags down Industrial/Automotive markets, with GM falling y/y in CY19.

– 3.7% revenue CAGR over 2018-2020
– GM of 60.7% in CY20

Investment Thesis

- We view Microchip as a long-term share gainer in the analog and MCU space, highlighting the company's broad product portfolio (MCUs, analog, connectivity, memory, licensing), strong profitability, and solid execution track record. However, we have a mixed view of the MSCC deal as high debt (5x net leverage) and slower growth (Microsemi's organic growth is flattish) offset opex synergies. In addition, we flag growing signs of cyclical risks near term.

Potential Catalysts

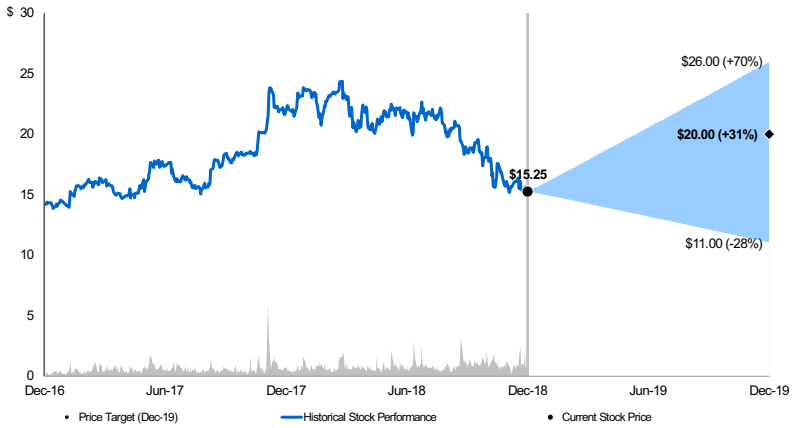
- Acceleration in growth in 32-bit MCUs, helped by ARM-based products
- Incremental growth from IoT, where Microchip is very well positioned
- Upside to analog growth, helped by cross selling
- EPS accretion from the Microsemi deal comes in above initial targets

Risks to Achieving Price Target

- A prolonged downturn in the semi cycle
- MSCC integration doesn't go according to plan
- Customer pushback on pricing, where Microchip has taken initiatives to raise pricing
- Macroeconomic demand comes in above expectation

Marvell Technology (MRVL, Equal-weight, $20 PT)

See opportunity for continued margin upside, even as revenue growth remains modest



Source: Thomson Reuters, Morgan Stanley Research

Price Target $20

Base case scenario.

Bull $26

17x Bull Case CY20e MW EPS of $1.50

– Revenue comes in at $3.86bn
– The company exceeds gross margin targets around better cost reduction, pricing.
– The company returns to growth driven by growth in Networking and SSDs.

Base $20

~15x CY20e MW EPS $1.31, in line with semiconductor peers

– We expect revenue to come in at ~$3.6bn
– GM expands by ~50 bp to 65.8% in CY20

Bear $11

11x Bear Case CY19e MW EPS of $1.00

– Business deteriorates given secular challenges in HDDs and share risks in SSDs, while growth in networking comes in below par.
– Stock overshoots to the downside closer to its tangible book value.

Investment Thesis

- We expect the company to sustain its market share in storage but don't expect to see much growth
- Expect MSD to HSD growth in networking driven by newer products
- Continued improvement in GM and disciplined opex investments drives profitability higher

Potential Catalysts

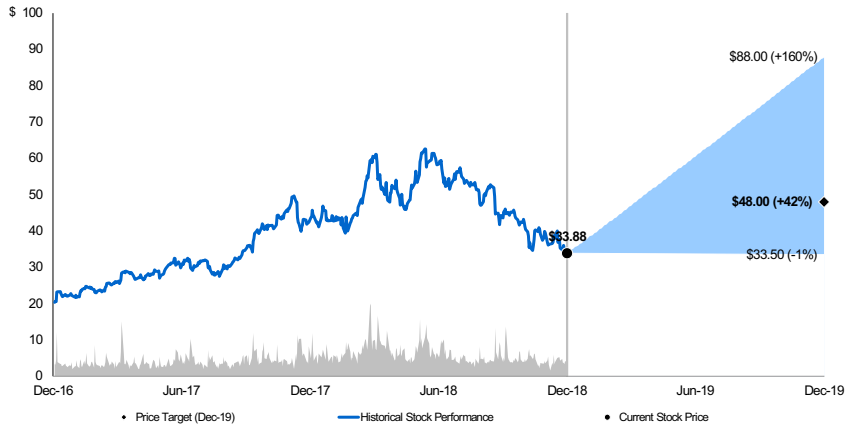
- Company see a revenue growth in Networking driven by continued growth in 10G and pick up in 25G.
- Accretion from Cavium comes in above expectation

Risks to Achieving Price Target

- Cavium integration doesn't go according to plan
- Severe weakness in storage continues for longer than we expect.

Micron (MU, Equal-weight, $48 PT)

We see significant improvement in commodity prices driven by higher capital intensity, and recovery in company specific execution



Source: Thomson Reuters, Morgan Stanley Research

Price Target **$48**

Base case scenario

Bull **$88**

~8x $11.00

2018e bull case EPS

Strong memory cycle returns throughout 2018 and into 2019 in both segments. DRAM remains in allocation mode around stronger content in mobile and a pickup in PCs. **NAND** similarly remains in shortage on stronger enterprise demand; Gross margin improvement continues driven by scale and utilization rates, Inotera cost improvements, TLC NAND ramp, and 20 nm DRAM cost improvements.

Company behavioral changes make investors believe there are sustainable profits to be had here; companies leave fab utilization below 100% even during relatively profitable periods, slow capacity shrinks further, make no additional capacity announcements.

Base **$48**

DCF based on implied average EBIT margins of 28% over the long term, beyond cash generation of NTM peak. For more details please check - Thinking Longer Term: What's in the Price?

We see pricing correcting mildly beyond our current window of visibility, but still see solid returns overall, as capital spending has declined significantly, setting up a sustained period of slower supply growth. **NAND** is less consistent than **DRAM** through 2018, but still offers good economics as supply growth is impaired by the 3D transition and MU retains best margins in the industry. Micron improves execution, moving DRAM closer to industry cutting edge. **We would concede that a through cycle # is a difficult number to triangulate** as earnings oscillate from $0.06 in FY16 to a $10+ run rate now, **but the average earnings power of the company in the last few years has oscillated at about this level**. $3.60 is the average level of annualized EPS over the last 16 quarters, and we would see the sustainable rate of earnings higher than that given industry tailwinds; the large differential between depreciation (currently 15% of revenues) and capex (which the company has indicated will average about 30%

Investment Thesis

- We expect DRAM pricing to remain at profitable levels through 2018, though with some declines resuming in mid year. We see demand growth on the back of seasonality, memory elasticity/higher content per unit, and low customer inventories, and very slow supply growth in DRAM given declines in 2016/17 capex.
- We continue to believe that memory stocks have a relatively well defined earnings cycle, though highs and lows are likely to be higher than they have been historically.

Short-term Catalyst

- DRAM and NAND cost per bit improvements becomes meaningful as 20nm and 3D NAND ramps, while average selling prices increase.

Long-term Catalysts

- We still see 2018 as a good earnings year for the industry, though not as uniformly robust as we saw in 2017.
- Micron has some optionality if they can continue to improve profitability in NAND, which has been below peers.

Risks to Achieving Price Target

- Pricing can turn quickly; sell through in the holiday period will be a critical lead indicator to 2018 supply/demand.
- Spending has increased faster than our expectations, and in a steady state is likely excessive - but the amount of capacity transition currently should help keep markets strong, as supply comes offline during transitional periods.

of revenues over the longer haul) would keep the through cycle multiple at well below the market rate.

Bear **$33.5**

Replacement value of the fabs ($) minus net debt.

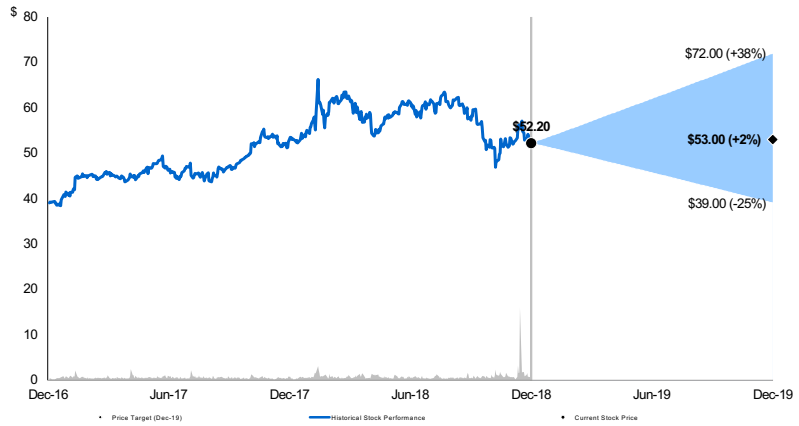
Tangible book value is ~$25 but understates the replacement cost of the acquired fabs. We estimate $35.71 of replacement value, then substract out the net debt of the company. If earnings were to disappear this would likely be viewed as a floor.

Overall in our bear case, despite slow supply growth, **DRAM** prices collapse, in a scenario very similar to 2012 (when record slow supply growth did not lead to good returns). Modest weakness in **NAND** in midyear, worsened by capacity announcements that create 2014 concerns.

Micron continues to trail behind its Korean competitors as key transitions (DRAM to 18 nm, NAND migration to 3D) continue to be slow.

Maxim Integrated Products (MXIM, Equal-weight, $53 PT)

We like the improvements in Maxim's margins and end market mix, but are Equal-weight reflecting valuation



Source: Thomson Reuters, Morgan Stanley Research

Price Target $53

We value MXIM at 17x CY20e EPS of $3.12.

Bull $72

~22x Bull Case CY20e EPS of $3.28

Assumes stronger growth in autos and industrial.

– Revenues grow at 4.4% CAGR over CY18-20 period and GM expands from 60.6% in CY14 to 69.0% in CY20.

Base $53

17x P/E on CY20 EPS, reflecting a 30% discount to the multiple ADI paid for Linear Tech

Growth in autos and inflection in industrial is partially offset by a correction in consumer.

– Revenue up 4.5% in CY20
– Consumer: ~1% growth in CY20
– Industrial: down ~2% in CY19 and up 3.5% in CY20
– Comm & Data Center: down 1.6% in CY19 and up 4.8% in CY20
– Automotive: up ~10% in CY20
– Computing: 9% decline in CY19 and 1% increase in CY20
– GM: +50bp y/y to 68.5% in CY20
– EPS: $3.12 in CY20

Bear $39

~15x Bear Case CY20e EPS of $2.60

A downturn in the semi cycle drives a decline in sales.

– Revenues decline at a CAGR of -2% into CY20 and GM down 150bp y/y to 66.5%
– An acquisition of MXIM does not play out, but recent headlines put a floor in the stock's valuation multiple

Investment Thesis

- We are Equal-weight MXIM. The company has made strong progress in improving the mix of its business and expanding margins, but we think this is now discounted in the stock.

Potential Positive Risks

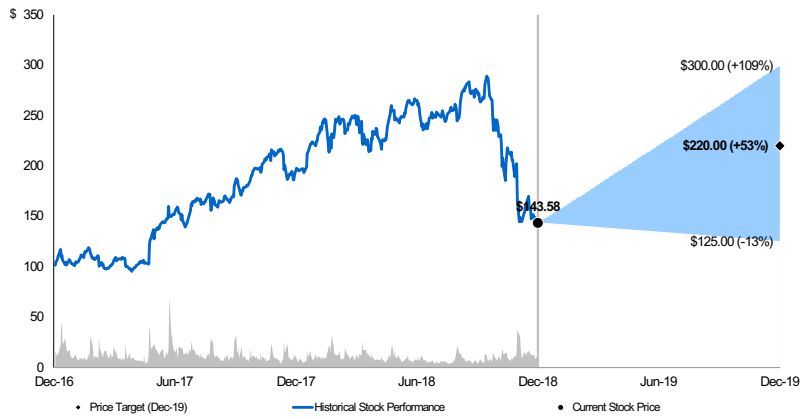
- A potential sharp inflection in growth in BMS for EVs
- Secular growth drivers in factory automation and robotics, combined with potential shares gains in distribution.

Potential Negative Risks

- Competition in handsets from other analog companies as well as internal efforts at key customer Samsung.
- Cyclical risk of an inventory correction following recent overheating and lead time extension in analog
- Ongoing overhang on growth from legacy comm equipment exposure.

NVIDIA (NVDA, Overweight, $220 PT)

Trading at a discount to high growth tech sectors, shorter-term drivers in gaming offset crypto weakness, and progress in data center and Inference expands the long-term opportunity



Source: Thomson Reuters, Morgan Stanley Research

Price Target $220

Base case scenario.

Bull $300

Data center and gaming growth accelerates taking CY20e EPS to $8.70. 34.5x CY20 EPS estimate

Bull case has accelerating gaming growth with Tegra revenues moving sharply to the upside as Autos gains traction, while Data Center sales continue to show strong growth

– Higher margin data center and pro visualization growth accelerates
– Nvidia increases its dominance in discrete GPU taking share from AMD while maintaining ASPs.
– Auto gains traction and improves in CY2019/20

Base $220

~30x our CY20 EPS estimate of $7.45. 30x is at the high end of comps, consistent with NVIDIA having one of the highest growth rate in the group

Base case assumes deceleration in gaming, but continued hyper growth in data center

–Revenue growth comes in 26% in FY19, 3% in FY20 and 15% in FY21
– Continued growth from Data center (HPC and Deep learning)
- Valuation remains high due to open ended nature of virtual reality, autonomous driving, and data center opportunities

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Bear $125

~22x CY20 EPS estimate of $5.77

Two key debates both go the wrong direction, causing investors to question future prospects for growth.

– Gaming slows down leading to lower revenue growth and product mix shift to Tegra (Autos) brings overall margins lower.
– AMD through its promotional efforts takes back GPU market share and/or causes Nvidia to reduce its GPU prices to compete.
– GPU sales into supercomputers and data center slow

Investment Thesis

- We expect core business to continue to grow nicely, with continued momentum in the company's data center business and gaming driven by the launch of the company's next gen GPUs.
- Strong growth drives high valuation: Stock reflects a fairly high P/E multiple on the core business at 30x next year. This reflects several open ended growth opportunities in data center, ADAS/autonomous driving and virtual reality.

Potential Catalysts

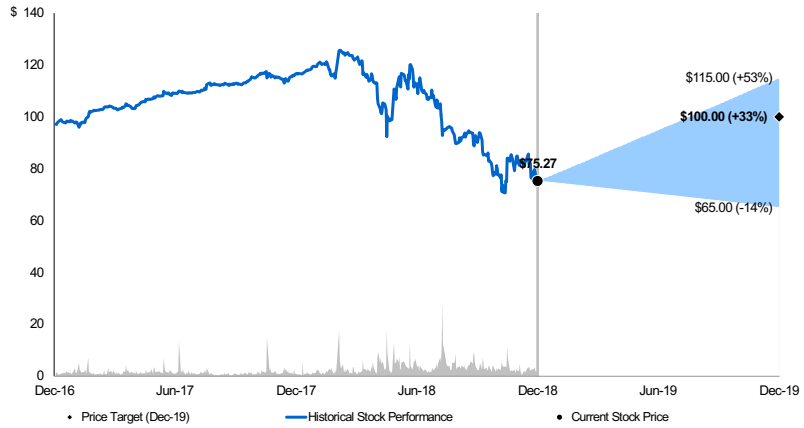
- Launch of next gen Turing gaming GPUs drives near term growth; NVIDIA will have significant card revenue initially with "founders edition." How sustainable is the early adopter surge?
- Data center continues to be a major focus as key cloud customers focus on "deep learning"
- Potential inflection in Auto revenue as ADAS level 3-5 vehicles go into production

Risks to Achieving Price Target

- Significant investment in new but unproven opportunities
- Continuation of sluggish PC market (~50% of revs)
- AMD reemerges as a viable GPU competitor after a period of disarray

NXP Semiconductor (NXPI, Equal-weight, $100 PT)

We are Equal-weight NXP, with secular growth in auto dollar content balanced by weakness in parts of its secure identification and interface businesses



Source: Thomson Reuters, Morgan Stanley Research

Price Target $100

Our PT of $100 for NXP represents ~12.5X our modelware CY20e EPS of $8.07 (includes stock based compensation). A 12.5X P/E is a discount to median target multiple we use for high end analog/MCU group of TXN, ADI, MXIM given NXP's lower GM.

Bull $115

~14X on CY19e EPS of $8.35

Our Bull case EPS of $8.35 assumes GM expansion beyond base case, share gains within general purpose and Auto MCUs, higher Global SAAR and stronger than expected adoption of mobile payments by china smartphones OEMs. ~6% revenue growth in CY20 and the company's operating margins (including stock based compensation expense) in high 20%.

Base $100

~12.5X Base Case 2020e EPS of $8.07

Revenue growth is driven by increasing adoption of NXP's ADAS solutions (V2V & Radar) in Autos
– ~4% revenue growth in CY20
– GMs expand by 70 bp to 53.2% in 2019 but expand by 60p to 53.8% in 2020
– CY19e EPS of $7.16 and CY20e EPS of $8.07

Bear $65

10x Bear Case 2020e EPS of $6.52

Macro environment weakens and competitive pressures in identification emerge. Muted growth drivers and weaker than expected growth across all segments results in revenue decline in 2019. Operating margins and gross margins below target model.

Investment Thesis

- NXP has attractive exposure to secular growth themes such as increasing penetration of ADAS and mobile payments. More so, both NXP and FSL are leaders in the automotive market (one of the fastest growing verticals in semis), with a combined #1 position. However, this is balanced by the sharp contraction in its Secure Identification Solutions business and legacy comm processor exposure, as well as cyclical risks in the SCD business.

Key Value Drivers

- HSD growth in the company's Automotive business and MSD growth in the Secure Connected Devices segment over the long term
- Continued growth in automotive content per vehicle

Potential Catalysts

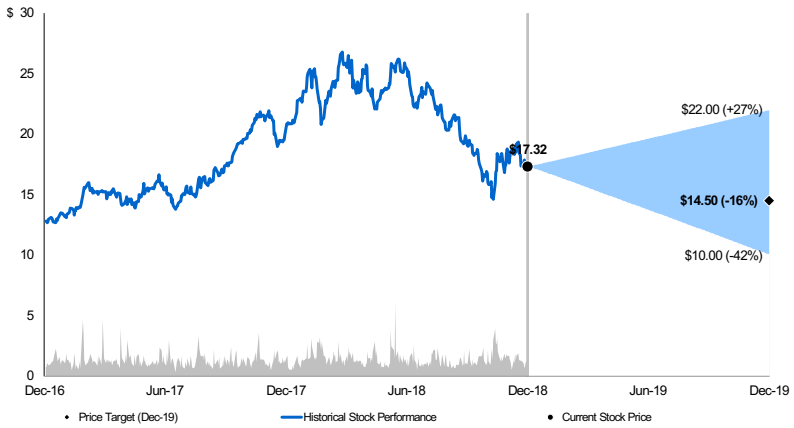
- Faster than expected adoption of ADAS and V2V technology in autos
- Increasing pace of cash returns to shareholders
- the ramp of 5G infrastructure

Risks to Achieving Price Target

- Competition in ID and Mobile payments from Infineon, ST Micro, among others
- Declining auto production if the macro weakens
- Inventory correction in broad-based MCUs

ON Semiconductor (ON, Underweight, $14.5 PT)

We are Underweight ON due to increasing cyclical risk, especially in the company's discrete business



Source: Thomson Reuters, Morgan Stanley Research

Price Target $14.5

We value ON at 8x P/E on our 2020 EPS estimate of $1.82, representing a discount to peers to reflect lower GMs and higher financial leverage.

Bull $22

~11x 2020e EPS of $2.02

A better than expected demand environment and continued growth in automotive drives MSD-HSD growth. The company benefits from additional Fairchild synergies and the stock's multiple expands above the long-term median of 10X.

– Revenue comes in at ~$6.29bn in 2020
– GM increases by 70 bp over 2018-20 to 38.9%

Base $14.5

~8x 2020e EPS of $1.82

2.7% revenue growth in 2020 driven by MSD growth in automotive, LSD growth in industrial, and LSD declines in Communication markets.

– Revenue comes in at $6.1bn in 2020
– GM decreases 40 bp over 2018-20 to 37.7%
– CY19 and CY20 EPS of $1.62 and $1.82

Bear $10

7x 2020e EPS of $1.44

Sales growth remains subdued, pressured by a weaker macro and continue weakness in PCs. The pricing environment goes from favorable in 2018 to normal in 2019, serving as a drag on GM.

– Revenue comes in at $5.6bn in 2020; GM of 36.2%

Investment Thesis

- We moved to Underweight ON in early August. Signs of overheating in the supply chain are building, setting the stage for an inventory correction by Q4 or in 2019. In particular, ON's main product of discrete semis have seen a greater extension in lead times relative to the broader analog market. As lead times begin to normalize, we expect customers and distributors to reduce inventory. Furthermore, we highlight that ON's business sees weaker fundamental performance relative to peers in downturn.

Potential Positive Catalyst

- Increased momentum in ADAS and new traction in SiC in autos
- New traction in servers in the data center

Potential Negative Catalyst

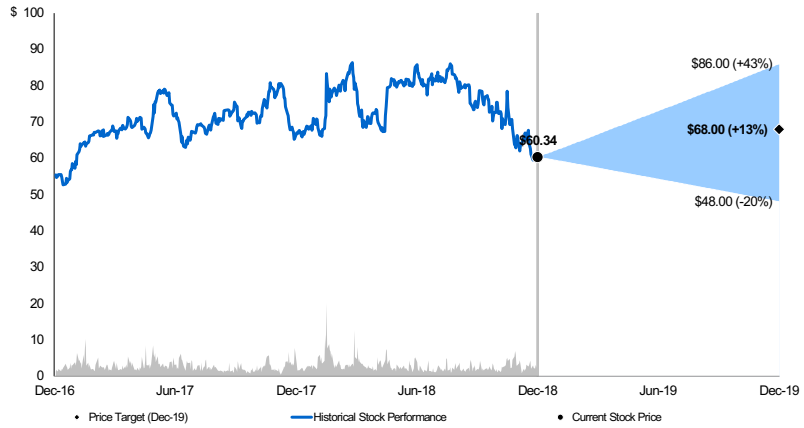
- A correction in the Industrial market, where ON's revenue growth is 2.5X that of growth seen at OEMs
- High internal inventory and increasing lead times
- Risk from competition in China, following NXP's sales of its Standard Products business to JAC Capital

Risks to Achieving Price Target

- The company manages to bring lead times back to normal without impacting sales
- The macro environment remains strong and supportive to growth

Qorvo Inc. (QRVO, Equal-weight, PT $68)

We are Equal-weight QRVO as its improving position in RF and margin expansion opportunity is balanced by inconsistent execution



Source: Thomson Reuters, Morgan Stanley Research

Price Target **$68**

We value QRVO at 10.5x our ModelWare CY2020e EPS of $6.44 (includes stock-based compensation). Our target multiple of 10.5x is a discount to the analog/MCU group Qorvo's heavy reliance on the mobile end market (75% of sales) and volatile operating performance

Bull **$86**

12.5x 2020e ModelWare EPS of $6.89

Revenue growth surprises to the upside driven by faster RF market growth as well as share gains. The stock's valuation multiple expands as investors gain confidence in Qorvo's execution and ability to continue to gain share in RF. Growth in IDP remains in the mid teens range.

– 7.5% revenue growth in 2020
– GM increases to 50.4% in 2020

Base **$68**

10.5x 2020e ModelWare EPS of $6.44

Qorvo posts 2.1% revenue growth in CY20 after 6.4% growth in CY19. Recovery on the GM front.

– 4.7% revenue growth in 2020
– GM up to 49.4% in 2020
– CY19 and CY20 EPS of $6.06 and $6.44

Bear **$48**

9.5x 2020e ModelWare EPS of $5.02

Revenue growth disappoints and management execution remains uneven. The stock's valuation multiple falls.

– Revenue is down 3.6% y/y in 2020; GM of 47.4%

Investment Thesis

- We are Equal-weight Qorvo as the company's above-average growth, improving profitability, and increasing FCF generation are balanced by its high exposure to the volatile mobile market and meaningful customer concentration. In RF, Qorvo is steadily improving its competitive position and we think the company is likely to gain share on the back of its multiplexers/integrated products. A key for the stock and valuation multiple is for Qorvo to begin to demonstrate more consistent operating performance.

Potential Catalysts

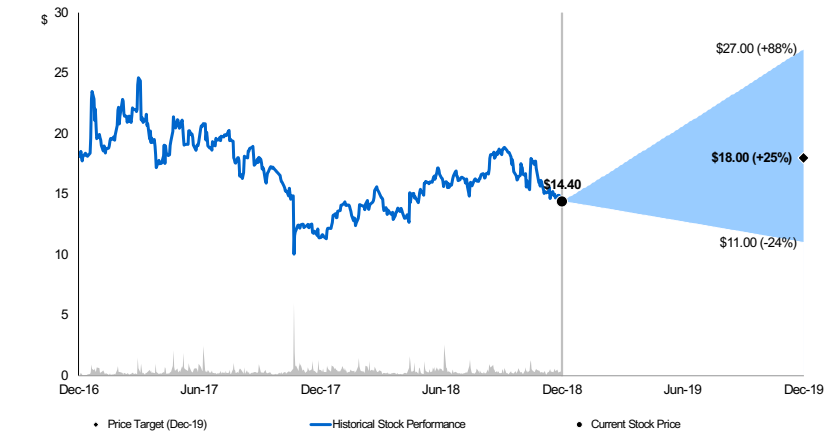
- Faster than expected adoption of carrier aggregation in China, given the traction seen in its multiplexer products in the region.
- Stronger demand for flagship phones from China smartphone OEMs where Qorvo has higher exposure than RF peers
- Further share gains in BAW based integrated RF products
- Qorvo is acquired, with potential suitors interested in the company's RF technology and integration capabilities.

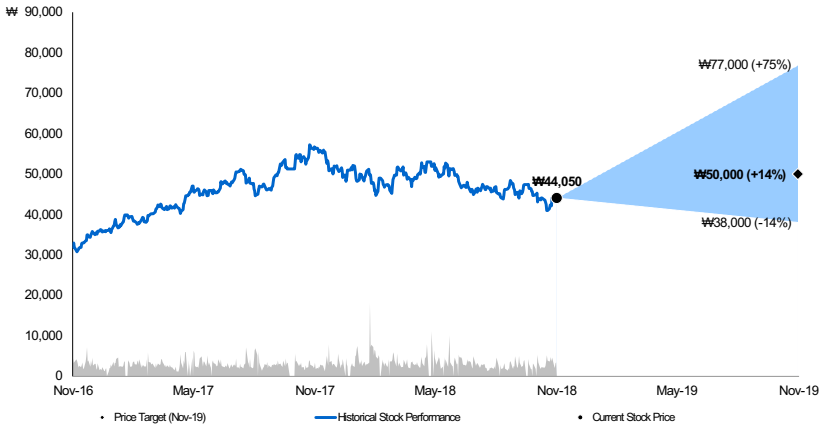
Risks to Achieving Price Target

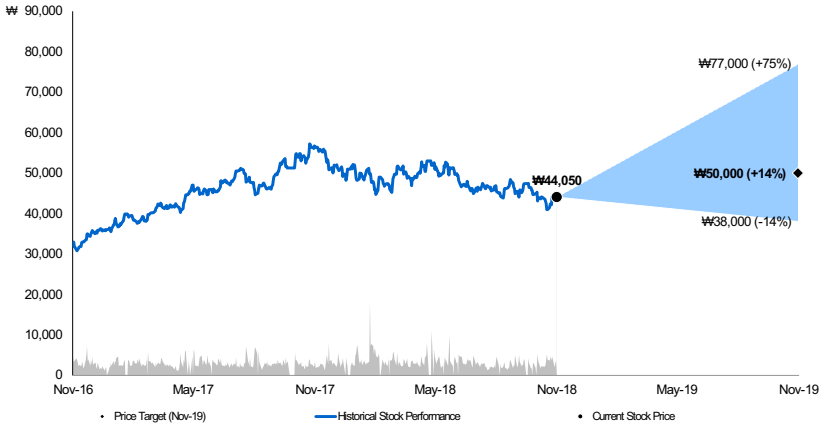
- Smartphone growth comes in below our expectations.
- Increasing competition in RF both in premium filters and in SAW/TC-SAW filters (QCOM/Murata).
- The correction in China smartphone supply chain worsens through the year
- Execution on the second tranche of merger synergies, mostly related to manufacturing.

Quantenna Communications (QTNA, Overweight, PT $18)

We are OW on Quantenna, the technology leader in carrier grade access point Wi-Fi. We see significant revenue opportunities in the next 2 years, with leverage, with penetration into multiple new service providers, and continued long term growth from penetrating new markets such as retail and enterprise access points.Common shares appear fairly valued considering cyclical risks in memoryCommon shares appear fairly valued considering cyclical risks in memory







Source: Thomson Reuters, Morgan Stanley Research
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Price Target **$18**

Investment Thesis

- We are OW on Quantenna, embracing its technology leadership in access point Wi-Fi. While competitors emphasized portable Wi-Fi technology over the last several years, Quantenna has focused on providing the best performance access point technology, just as that technology becomes critical to service providers focused on multiple video streams in the home
- We estimate >20% growth in each of the next 2 years, with leverage, as the company expands penetration to multiple new service providers, and longer term expands beyond service provider. We see continued growth beyond the forecast horizon, as Quantenna is still a small company relative to the available market, with a superior product

Potential Catalysts

- New service provider wins in 2018
- 10G product camp in 2018 offers leadership "8x8" capability with a new feature set, and a doubling of average selling price
- Competitor restructuring should also be a positive backdrop for potential new wins

Investment Thesis

- Share gains in components businesses (DRAM, NAND, and OLED) continue to drive Samsung's earnings. However, we believe margins are approaching peak levels, as component pricing may come under pressure due to growing industry supply.
- The smartphone market is mature and no longer growing, and the mobile division is past peak margins. However, the mobile business and consumer electronics are stable cash cow businesses for Samsung.
- 12M forward P/B implied valuation of 1.0x

We value QTNA at 14x 2020e non GAAP EPS of $1.26, slightly below small cap comms peers; we see growth prospects in 2018 and beyond, with better prospects for leverage post 2018

Bull **$27**

~14x CY19e Bull case EPS of $1.94

Stronger uptick in service provide deployments and higher than expected contribution from enterprise and retail market. Valuation multiple trends higher, implying ev/sales closer to small cap peers and a similar multiple on better revenue/earnings.

– 30% revenue growth CAGR in over CY18-20

– GM increases to 52.9% in CY20

Base **$18**

~14x 2020 non GAAP EPS of $1.26, slightly below small cap comms peers

~20% revenue CAGR over 2018-20 driven by penetration of new service provider customers, and higher average selling prices as the market moves to 10G

– Strong 2018 ramp with new service providers & new 10G product with 2x average selling price

– GMs stable with significant operating leverage

- 2018 multiple should remain high in 12 months, given opportunity to expand beyond service provider with still incremental operating leverage

–See the stock trading in line with other small cap growth semis in 12 months on P/E

Bear **$11**

1x CY20e sales of $280mn plus cash

Competitive encroachment limits new traction in 2018/19

– 8x8 leadership does not happen, either due to delays with the Quantenna 8x8 product, or unexpected leapfrogging from Broadcom or Qualcomm

-Company would struggle to meet margin targets given the investment scale

-We still see high end Wi-Fi technology having high strategic value

-8% revenue growth in 2019 and 3.4% in 2020

Price Target **W50,000**

Base-case scenario. Rounded from multistage residual income model, supported by P/B of 1.0x.

Bull **W77,000**

1.5x 2019e BVPS

High-performance computing drives sustained memory pricing strength and capital returns exceed expectations: We assume demand for memory and OLED continues to grow robustly with stabilization in the macro environment and failure of China's entry.

Base **W50,000**

1.0x 2019e BVPS

NAND prices fall sharply in a downcycle, while DRAM prices begin to decline: We expect memory demand to remain strong in the long term, but supply growth poses risks to pricing for NAND in 2018 and DRAM in 2019-20.

Bear **W38,000**

0.7x 2018e BVPS

Prolonged consumption slowdown, US FANG (Facebook, Amazon, Netflix, and Google) correction and China competition disrupts OLED and memory profitability: We assume weaker macro conditions stall near-term global

is in line with the company's past 10-year mid-cycle level. While this is inexpensive relative to its history and peers, we believe a looming memory down cycle poses downside risks.

Key Value Drivers

- Supply-demand outlook for memory and OLED.
- Smartphone market share and margins.
- Capital returns of 50% FCF.

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Key Value Drivers

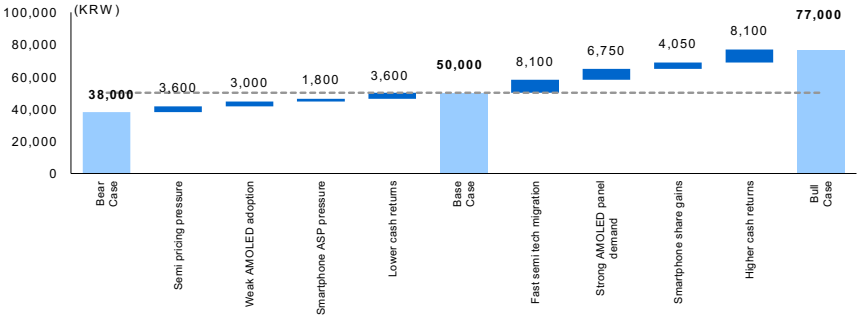
- Supply-demand outlook for memory and OLED.
- Smartphone market share and margins.
- Capital returns of 50% FCF.

Risks to Achieving Price Target

- Service provider consolidation could be disruptive, delaying key deployments
- Long term, we expect continued competition from Wi-Fi peers such as Broadcom, Qualcomm, or Intel
- While service provider relationships provide unusual long term visibility, service provider/OEM supply chains still have normal semiconductor variances

consumption of IT products. We also assume demand for server content slumps amid a slowdown in data center growth.

Exhibit 103: Bear-to-Bull Key Drivers: Product Penetration and Cyclical Growth



Source: Morgan Stanley Research estimates

Price Target W50,000

Base-case scenario. Rounded from multistage residual income model, supported by P/B of 1.0x.

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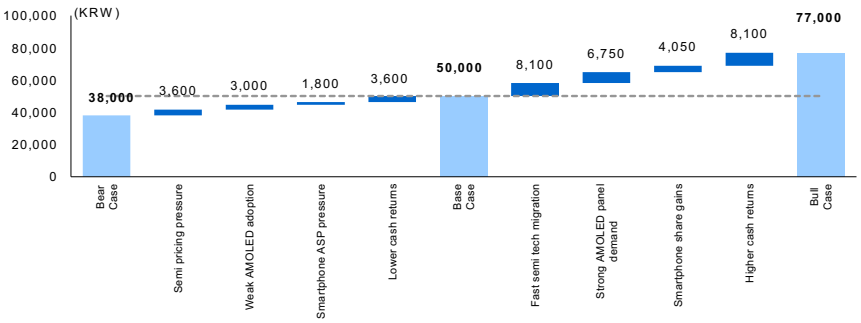
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Exhibit 104: Bear-to-Bull Key Drivers: Product Penetration and Cyclical Growth



Source: Morgan Stanley Research estimates

Risks to Achieving Price Target

- **Upside:** New technology developments, especially in memory and foldable display. Longer-lasting memory upcycle on hyperscale data center growth.
- **Downside:** Product and memory cycle, including Apple and new Chinese smartphone competition. Earnings growth – concentration in semiconductors.

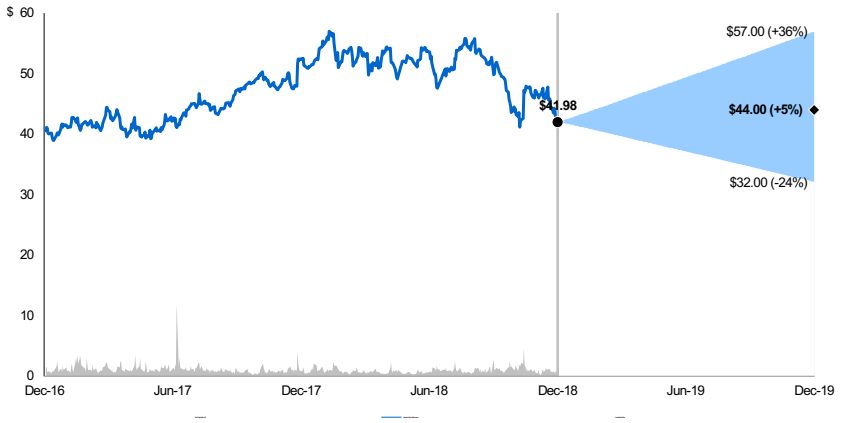
SK Hynix

Risks to Achieving Price Target

- **Upside:** New technology developments, especially in memory and foldable display. Longer-lasting memory upcycle on hyperscale data center growth.
- **Downside:** Product and memory cycle, including Apple and new Chinese smartphone competition. Earnings growth – concentration in semiconductors.

Sensata Technologies (ST, Underweight, $44 PT)

We recently downgraded ST to Underweight due to deteriorating fundamentals in its core auto and industrial markets and reflecting its high leverage



Source: Thomson Reuters, Morgan Stanley Research

Price Target **$44**

We value ST at 10.0X EV/EBITDA on our CY20 estimate. This is just above its trough multiple over the last couple of years. It is also 1X turn above where TEL is trading today, which could prove to be generous for ST.

Bull **$57**

~11.5X EV/EBITDA multiple on 2020e

Revenue growth approaches the high end of the company's target excluding the impact of the divested valves business.

– 5.5% revenue CAGR over the 2018-20 period
– GM increases 60bp Y/Y to 37.2% in CY20

Base **$44**

10.0X EV/EBITDA multiple on 2020e

Revenue growth toward the low end of its target as weaker auto sales in China and production adjustments begin to weigh. Modest OM expansion.

– 3.4% revenue CAGR into 2020: Performance Sensing: 0.6% decline in CY19 (~3% point impact form the sale of the valves business) and 5.4% growth in 2020 . Sensing Solutions: 0.6% growth in CY19 and 12.7% growth in 2020
– GM: up 40bp Y/Y to 36.6% in CY19 and flat in 2020
– CY19 and CY20 EPS of $3.87 and $4.00

Bear **$32**

9.5X EV/EBITDA multiple on 2020e

Growth declines as weaker auto and industrial demand triggers an inventory correction, more than offsetting content growth.

– -1.3% revenue CAGR through 2020; GM of 35.1% in CY20

Investment Thesis

- We are Underweight ST and our EPS estimate is 4% below the Street in 2019, reflecting lower revenue and margins. The company's execution has improved over the past year, with an increase in growth and upside in margins related to acquisition synergies driving better than expected EPS. However, we highlight numerous headwinds that have emerged since late summer (including reduction in growth forecasts at Tier 1 auto suppliers, disappointing China auto sales, and a slowdown in factory automation/Industrial) that we expect to weigh on Sensata.

Potential Positive Catalysts

- Adoption of tire pressure monitoring sensors in China
- Increased traction in Electric Vehicles (EVs)
- Growth in Lidar in the next few years

Potential Negative Catalysts

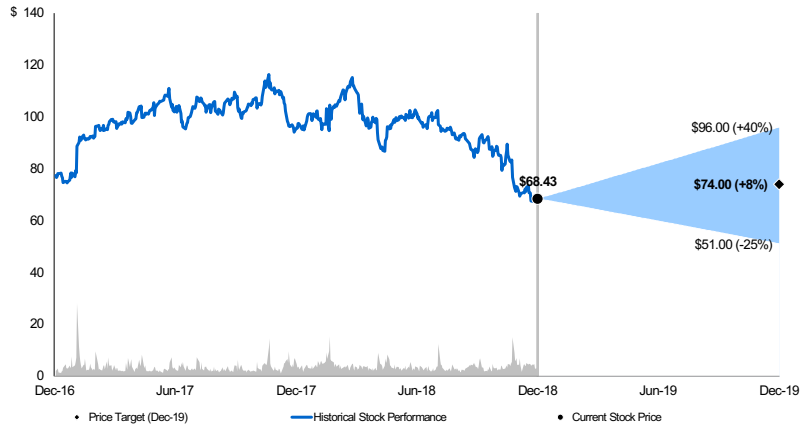
- Weaker than expected auto sales in China
- An inventory correction in the Industrial market
- Deterioration in the HVOR market, which has been Sensata's key growth driver

Risks to Achieving Price Target

- The auto supply chain avoids the correction that we anticipate
- The company increases its stock buyback authorization
- Sensata finds an attractive acquisition that moves the needle.

Skyworks (SWKS, Equal-weight, $74 PT)

We upgrade SWKS to Equal-weight following a string of negative estimate revisions that drove underperformance in the stock



Source: Thomson Reuters, Morgan Stanley Research

Price Target $74

We value SWKS at 10x our ModelWare CY2020e EPS of $7.42 (includes stock-based compensation). Our target multiple of 10x is a discount to the analog MCU group given our expectation for slower growth going forward and high (75%) exposure to the volatile mobile market with significant customer concentration

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Bull $96

12.5x 2020e ModelWare EPS of $7.72

Revenue growth comes in above our expectations on a rebound in the RF market. Steady growth in broad markets and increased cash returns to shareholders boosts its multiple.
– ~7% rev growth in 2020
– GM increases 60bp Y/Y to 51.4% in 2020

Base $74

10x 2020e ModelWare EPS of $7.42

Skyworks posts ~5% revenue growth in CY20. Growth in its mobile products lags RF peers given the lack of BAW filters in its portfolio. In addition, Qualcomm become more competitive in integrated RF products.
– ~5% revenue growth in 2020
– GM up 10 bp Y/Y to 50.9% in 2020
– CY19 and CY20 EPS of $6.88 and $7.42

Bear $51

8x 2020e ModelWare EPS of $6.38

Revenue growth disappoints and management fails to diversify its business. The stock's valuation multiple derates further.
– Revenue is down ~2% in 2020; GM of 48.9%

Investment Thesis

- We move to Equal-weight on SWKS as weakness in smartphones is now better reflected in estimates and the stock. While we still see lingering risks, we acknowledge that sentiment has already swung to very bearish on SWKS. We could get more constructive on the stock if the company's broad markets business continues to perform well and 5G serves as a catalyst for increased 5G $ content. Conversely, market share loss to Qualcomm in RF and pricing pressure from Apple could lead us to revisit our Underweight view.

Potential Catalysts

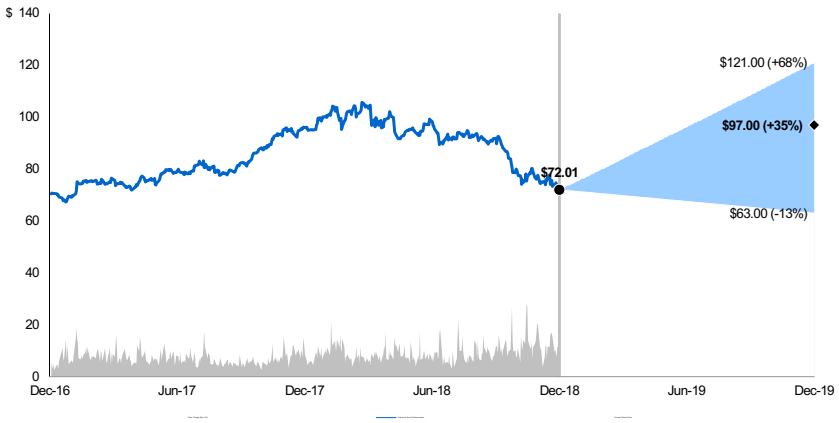
- Increasing cash returns to shareholders, with a focus on buybacks
- Faster that expected growth in the Avnera business
- Volume adoption of 5G in 2020, which could begin to be discounted in the stock by mid 2019

Risks to Achieving Price Target

- Share loss in integrated products as Qorvo further expands its portfolio and leverages BAW technology.
- Increasing competition from Qualcomm in RF.
- Customer concentration and potential pricing pressure from Apple (45% of total sales).

Te Connectivity (TEL, Overweight, $97 PT)

We are Overweight on upside to OMs and TAM expansion from Sensors



Source: Thomson Reuters, Morgan Stanley Research estimates

Price Target $97

Our PT of $97 represents an 15x multiple to CY20e EPS of $6.48, 2 turns below TEL's median over the last year.

Bull $121

16.5x CY20e EPS of $7.32

Stronger growth in core connector market driven by strengthening demand environment supplemented by faster pace of M&A in connectors as well as faster growth in sensors.
– 4.3% revenue CAGR from CY18-CY20
– GM increases 110bps Y/Y to 35.4% in CY20

Base $97

15x CY20e EPS of $6.48

Strength in Transportation drives sales growth. Continued Improvement in OM driven by company's TEOA initiatives.
– Transportation: 2.6% growth in CY19 and 5.3% growth in CY20
– Industrial: flat in CY19 and up 3.4% in CY20
- Communications: up ~3% in CY20
– GM: up 10bps Y/Y to 34.4% in CY20

Bear $63

12x CY20e EPS of $5.28

The cycle turns downs and as a result industrial weakens and production declines in autos weigh on growth.
– Revenue declines 1.8% in CY20; GM of 32.4% in CY19 and CY20.

Investment Thesis

- We are Overweight on TEL due to attractive operating leverage. We model >250bps of OM expansion to 18.5% in CY20 from CY14, a new peak and above TE's historical target model. TE appears well positioned in the automotive market (~40% of sales) to drive high single digit growth due to increasing $ content and new business in sensors.
- We like the opportunity for multiple expansion as margins expand and sensors supplement growth, with the potential to increase to ~15x from ~12.5x today.

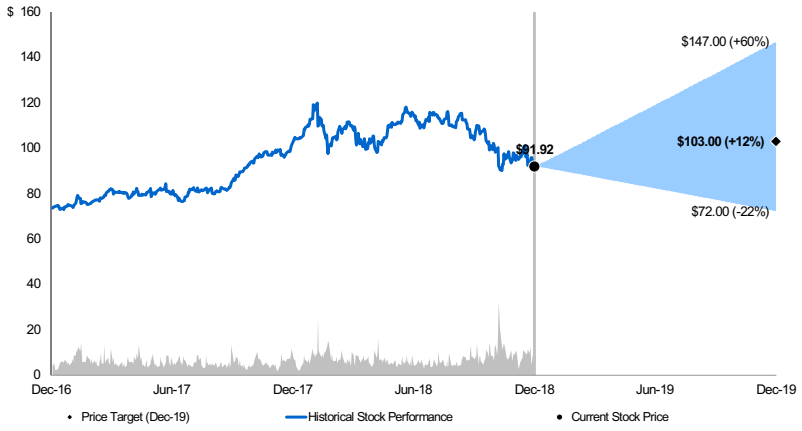
Potential Catalysts

- Faster than expected growth in the $70bn sensor market, including new design wins in autos.
- More aggressive stock buyback pace.
- Margin expansion related to the planned manufacturing footprint reduction in Industrial.

Risks to Achieving Price Target

- Any slowdown in autos, TEL's largest end market.
- Weaker growth in China, in particular industrial.
- Uneven execution, inhibiting the multiple expansion we expect.

Texas Instruments (TXN, Equal-weight)



Source: Thomson Reuters, Morgan Stanley Research

Price Target $103

Our PT of $103 represents 17x our CY20e EPS of $6.06, based on the average historical multiple for analog companies.

Bull $147

21x Bull Case 20e EPS of $6.98

Rebound in macroeconomic environment drives analog snapback, to new highs in operating margins. TXN grows 2020 revenue by 12.5% as its customers replenish inventories in addition to strong end demand growth. High incremental margins drive significant margin expansion and FCF remains high as TXN reaps the benefits from underutilized capacity. TXN achieves 66.2% GMs and 45.5% OMs in 2020.

Base $103

17x Base case 2020e EPS of $6.06

Assumes analog business declines slightly next year, in line with high performance analog peers, reflecting macro headwinds

– Analog: 0.6% growth in CY19 and 3.2% growth in CY20
– Embedded processing: 5.3% decline in CY19 and 5% growth in CY20
– TXN achieves 64.7% GMs and 42.8% OMs in 2020, much stronger than prior downturns

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Bear $72

15x Bear Case 20e EPS of $4.79

Global macroeconomic weakness drives significant declines in TI's core analog business, and wireless decline is faster than anticipated, as macro erodes further.

– 8.2% revenue decline in 2020
– Gross margin and Operating margin at 62% and 38.3% levels in 2020

Investment Thesis

- Revenue exposure to slower growth markets vs. analog peers, with "other" (DLP, ASIC, calculators, legacy wireless) accounting for ~10% of revs, and less exposure to industrial/autos than peers
- TXN has led the way in terms of cash return, which has led to valuation improvement. It's hard to improve cash returns from 100% of FCF
- To its credit, the company has largely shunned recent hype around markets such as IoT, though it still has broad capabilities, which should help the risk profile vs. peers
- Despite high likelihood of fundamental improvement, valuation premium to peer group leaves less room for upside, particularly in the sub-5% type of growth environment we project for the company in CY16 to CY18.

Positive Business Drivers

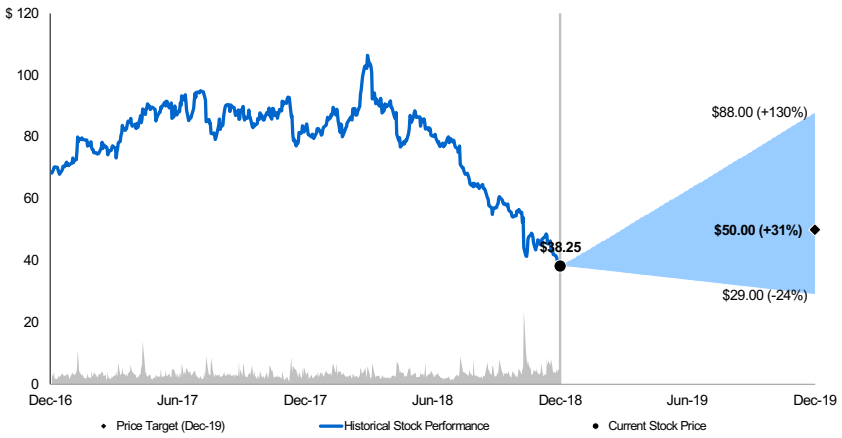
- Returning basically 100% of free cash flow to shareholders through dividends and repurchases
- Can grow 25% with minimal capex
- Business model increasingly built around analog/embedded strengths

Risks to Achieving Price Target

- Other (low teens% of revs) consists of low growth businesses
- More exposed to PCs, smartphones, and wireless infrastructure than some other analog names

Western Digital (WDC, Equal-weight, $50 PT)

More diversified portfolio captures demand in flash and cloud partially offset by NAND downturn



Source: Thomson Reuters, Morgan Stanley Research

Price Target **$50**

Derived from the base-case scenario.

Bull **$88**

~11x FY20e EPS of $8

Faster realization of merger synergies and prolonged tightness in NAND supply. NAND supply remains extremely tight with accelerating demand on the back of product launches (e.g. iPhone) and secular tailwinds in enterprise. Long lead times for capital equipment and conversion of NAND to DRAM capacity push out meaningful supply additions to late FY19 improving investor sentiment around sustainability of EPS. Demand from hyperscale cloud providers re-accelerates in CY18 and industry holds steady pricing in competitive segments like notebooks and capacity enterprise. WD trades at the high-end of SanDisk's historical P/E range on off-peak earnings in light of enterprise HDD share gains and signs of WD's leading cost structure on 3D NAND.

Base **$50**

1.2x EV/CY2020 Sales

More diversified product portfolio drives balanced growth but NAND declines and increased competition pressure gross margin. Gross margin declines toward the high-end of the long-term target as loosening supply pressures NAND price through CY18. HDD fundamentals remain weak and softer flash prices accelerate the transition away from disk. We are moving from P/E to EV/Sales as we feel its more appropriate given where we are at in the cycle

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Bear **$29**

.85X EV/CY2020 Sales

Faster decline of NAND prices, combined with more competitive HDD industry pricing pressures gross margin. Gross margin falls near the mid point of the target 33-38% range as the industry increases NAND supply faster than demand and HDD industry digests excess inventory built over the last year and a half. Investors give less credit to the NAND business which pushes the stock toward the low-end of past two year HDD trading ranges.

Investment Thesis

- We expect NAND prices to drop 31% in FY19 on improving NAND supply which drives our 15% below consensus EPS forecast. Disagreements with NAND JV partner Toshiba Memory Corp. add to uncertainty.

Key Debates

- Can Western Digital maintain a similar cost advantage in 3D NAND as in 2D NAND? The evidence is tipping in WD's favor with 75% of bits on 3D in 2017 compared to recent expectations of 50%. WD will exit CY2017 with the vast majority of shipments on 3D and with prospects of improving cost advantage and margin upside next year.
- What is the long-term unit growth outlook? Unlike HDD peers, we see modest long-term revenue growth on the back of rising demand for SSDs across end markets and cloud growth supporting both HDD and SSD form factors. Guidance for 4-8% long-term growth appears reasonable and the company is expected to deliver above this range in the current year. That said, NAND price volatility raises the risk that revenue declines in FY19 before recovering in the following years.

Potential Catalysts

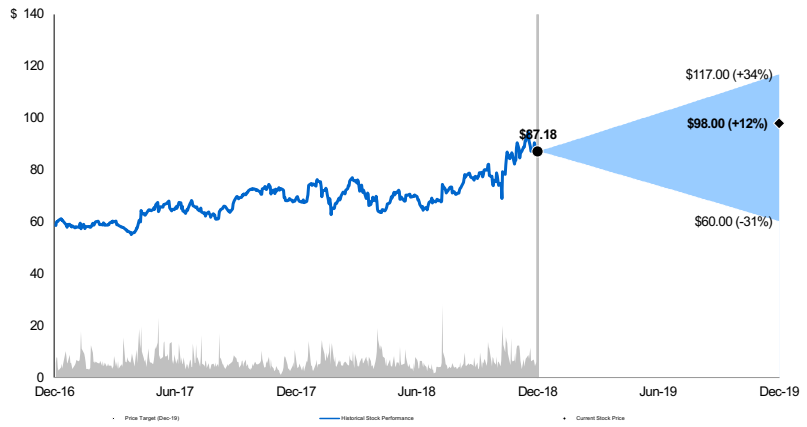
- + Greater than expected synergies from HGST and SNDK
- + Better than expected cloud demand
- + Faster execution on 3D NAND transition
- - Near-term datapoints on NAND supply/demand coming into balance
- - Competitors messaging higher NAND capex growth in 2018 and/or weakening SSD demand on the back of higher NAND prices.
- - Continued weak cloud and enterprise demand due to limited DRAM supply.
- - Disruption at Flash Ventures JV limits execution on 3D

Risks to Achieving Price Target

- 3D NAND transition takes longer and is costlier than planned and/or cost structure isn't as attractive as 2D
- HGST and SNDK synergies fall below plan
- Weakening demand results in pricing pressure
- Slowing areal density / technology transition lowers margins in HDDs

Xilinx (XLNX, Overweight, $98 PT)

We expect sales to grow MSD in FY19; Potential for share gains and a pick up in AI inference workloads offers the optionality of higher growth



Source: Thomson Reuters, Morgan Stanley Research

Price Target $98
Base Case scenario

Bull $117
25x CY 2020e EPS of $4.42 + cash, based on hypothetical strategic value.
Reflects a much faster ramp of server acceleration opportunities, as the role for FPGAs in those applications shows strong growth in FY19/20. This would drive substantial incremental earnings leverage, and would also likely result in multiple expansion.

Base $98
23x Base Case CY20e EPS of $3.98, premium to long term average on better growth prospects driven by share gains and increasing AI penetration, plus ~$7 in cash
A slight premium to current valuation, as the AI and share gain opportunities become evident in 2018/19. Sales grow ~17% in FY19 and 9% in FY20. EPS at $3.28 in FY19 and $3.68 in FY20.

Bear $60
15x Bear Case CY20e EPS of $3.55, plus ~$7 in cash
Weak end markets, reversal at 14 nm as Altera takes leadership share, no leverage. Stall in communications infrastructure end-market growth results in a revenue shortfall.

Investment Thesis

- Xilinx's lead in advanced nodes (28/20/16nm) should translate to superior growth for the company vs Altera (Intel) over the coming quarters
- Potential for share gains is improving as we have seen the company stretch its lead over Intel/Altera in the two most recent manufacturing nodes
- New growth opportunities in markets such as ADAS in automotive and use of FPGAs as accelerators in the data center. As machine learning continues to evolve, we see the market for "inference" moving away from microprocessors and towards specialty solutions, including Xilinx FPGAs
- We see overall growth in FPGAs modestly improving, as base stations fade in importance and new technologies start to penetrate autos, factories and data centers

Key Value Drivers

- We see continued share gains, as the company should show high 20 nm share and significant lead in 16nm
- We find the case for FPGA revenue gains vs. overall logic compelling, particularly as communications, enterprise, and industrial markets are relatively appealing vs. consumer/smartphone/PCs, but growth has been lackluster for the last several years as platforms in those businesses have standardized

Potential Catalysts

- Adoption of FPGAs for Inference AI workloads pick ups faster than expected

- ADAS penetration and Adoption of FPGAs in Data center is faster than expectations

Risks to Achieving Price Target

- China spending continues to be lumpy and unpredictable
- Intel becomes aggressive on the pricing front in a bid to protect market share
- ALTR's 40nm share gains are still a small headwind
- Significant slowdown in broad-markets of autos and industrial

Financial Summary

Exhibit 105: Samsung's financial summary

Income Statement				
FY Ending Dec. 31 (KRW bn)	**2017**	**2018E**	**2019E**	**2020E**
Sales	**239,575**	**249,439**	**247,350**	**257,548**
Cost of sales	129,291	130,270	126,046	131,986
Gross profit	**110,285**	**119,169**	**121,305**	**125,562**
R&D	16,356	17,919	17,235	17,940
SG&A	40,284	37,275	46,769	48,692
Operating profit	**53,645**	**63,976**	**57,301**	**58,930**
Non-operating income	13,285	11,411	10,509	10,801
Financial income	1,512	1,811	1,600	1,600
Gain on FX transact/translation	8,108	6,572	6,000	6,000
Other	3,665	3,029	2,909	3,201
Non-operating expenses	10,399	9,540	9,000	9,000
Financial expense	655	593	1,000	1,000
Loss on Fab transact/transl.	7,269	7,064	6,000	6,000
Other	2,474	1,883	2,000	2,000
Recurring profit	**56,531**	**65,847**	**58,810**	**60,732**
IBT	**56,531**	**65,847**	**58,810**	**60,732**
Income tax expense	14,009	17,581	14,114	14,576
Net Income from continuing business	**42,522**	**48,266**	**44,696**	**46,156**
Net income	**42,522**	**48,266**	**44,696**	**46,156**
Less Dividend to Pref Shr Holders	*711*	*1,161*	*1,161*	*1,161*
Net income less Div Pref Shr Holders	41,811	47,105	43,535	44,995
ModelWare Net Income	40,969	46,824	42,641	44,072

Balance Sheet				
FY Ending Dec. 31 (KRW bn)	**2017**	**2018E**	**2019E**	**2020E**
Cash & cash equivalents	30,886	76,561	109,897	121,745
St. investment assets	52,639	53,165	53,697	54,234
Accts & notes receivable	27,696	28,836	28,595	29,774
Inventory	24,983	25,173	24,356	25,504
Other	10,778	10,778	10,778	10,778
Total current assets	**146,982**	**194,513**	**227,323**	**242,036**
Investment assets	14,661	14,955	15,254	15,559
PP&E	111,666	120,016	122,213	124,270
Intangible assets	14,760	15,021	15,267	15,497
Others	13,682	9,682	6,182	3,182
Total assets	**301,752**	**354,187**	**386,239**	**400,544**
Accounts & Notes payable	22,984	23,158	22,407	23,463
Short-term borrowings	15,768	15,610	15,454	15,299
Curr. Portion of LT debt	1,133	1,133	1,133	1,133
Other current liabilities	27,291	25,881	24,541	23,268
Total current liabilities	**67,175**	**65,781**	**63,535**	**63,163**
Long-term borrowings	2,710	1,472	1,458	1,445
Other liabilities	17,375	16,565	15,762	14,999
Total liabilities	**87,261**	**83,819**	**80,755**	**79,607**
Paid in capital	898	898	898	898
Capital surplus	4,404	4,404	4,404	4,404
Retained earnings	215,811	258,251	293,366	329,941
Capital (adjusted)	(6,621)	6,816	6,816	(14,306)
Total shareholders' equity	**214,491**	**270,368**	**305,483**	**320,936**
Total Liab & Eqty	**301,752**	**354,187**	**386,239**	**400,544**

Key Ratios				
(%)	**2017**	**2018E**	**2019E**	**2020E**
Growth				
Sales	19	4	-1	4
Gross profit	35	8	2	4
Operating profit	83	19	0	3
Net profit	87	14	-7	3
Profitability				
EBITDA margin	32	36	34	33
Gross margin	46	48	49	49
Operating margin	22	26	23	23
Net profit	18	19	18	18
ROE	21	22	16	14
RNOA	36	34	29	30
Payout Ratio	14	20	22	21
Stability				
Total liabilities to equity	41	31	26	25
Net debt to equity	-30	-42	-48	-50
Current ratio (x)	2.2	3.0	3.6	3.8
Per-Share				
EPS (KRW)	6,847	7,843	7,143	7,383
BVPS (KRW)	35,825	45,269	51,152	53,740
DPS (KRW)	850	1,410	1,410	1,410

Cash Flow Statement				
FY Ending Dec. 31 (KRW bn)	**2017**	**2018E**	**2019E**	**2020E**
Net income	42,522	48,266	44,696	46,156
Non cash items - net	36,211	34,989	35,558	36,012
Depreciation	20,594	23,450	24,003	24,443
Changes in WC	(10,621)	5,437	(1,030)	(2,541)
Others	(5,951)	(6,000)	(6,500)	(7,000)
Operating Cash Flow	**62,162**	**82,692**	**72,723**	**72,628**
Acquisition of PP&E (CAPEX)	(42,792)	(31,800)	(26,200)	(26,500)
Proceeds from sale of PP&E	308	0	0	0
Change in current financial assets	887	(820)	(831)	(842)
Increase in intangible assets	(984)	(1,800)	(1,800)	(1,800)
Others	1,949	(810)	(803)	(763)
Investing Cash Flow	**(40,631)**	**(35,229)**	**(29,634)**	**(29,905)**
Increase(Decrease) in Debt	2,588	(1,399)	(173)	(171)
Dividends	(6,804)	(5,826)	(9,581)	(9,581)
Sale(Purchase) of Treasury Stock	(8,350)	(785)	0	(21,122)
Other	6	0	0	0
Financing Cash Flow	**(12,561)**	**(8,010)**	**(9,753)**	**(30,874)**
Net change in cash	**8,970**	**39,453**	**33,336**	**11,849**
Other change in cash	(1,441)	0	0	0
Beginning cash	32,111	30,886	76,561	109,897
Ending cash	**30,886**	**76,561**	**109,897**	**121,745**

Source: Company data, Morgan Stanley Research estimates

Source: Company data, Morgan Stanley Research (E) estimates

Exhibit 106: SK Hynix's financial summary

Income Statement

(W bn)	2017	2018E	2019E	2020E
Sales	30,109	41,953	39,749	41,802
Gross Profit	17,408	26,466	23,372	22,350
Operating Expense	3,686	4,794	5,962	6,270
EBITDA	18,748	28,336	26,536	27,309
Operating Income	13,721	21,673	17,409	16,080
Net Non-operating Income	-282	227	40	60
- Net Interest Income	-70	-26	40	60
Income Before Tax	13,440	21,899	17,449	16,140
Net Income	10,642	15,963	12,651	11,701
Margins				
Gross Margin	57.8%	63.1%	58.8%	53.5%
EBITDA Margin	62.3%	67.5%	66.8%	65.3%
Operating Margin	45.6%	51.7%	43.8%	38.5%
Net Income	35.3%	38.1%	31.8%	28.0%
Growth Rates				
Sales	75.1%	39.3%	-5.3%	5.2%
EBITDA	142.4%	51.1%	-6.4%	2.9%
Operating Income	318.7%	57.9%	-19.7%	-7.6%
Net Income	260.3%	50.0%	-20.8%	-7.5%

Cash Flow Statement

(W bn)	2017	2018E	2019E	2020E
Net Income	10,642	15,963	12,651	11,701
Depreciation & Amortization	5,026	6,664	9,127	11,229
Other Non-Cash Items	2,213	-988	-988	-388
Change in Net Working Capital	-3,190	-88	55	-305
Operating Cash flow	14,691	21,551	20,845	22,238
Capital Expenditure	-9,128	-15,975	-15,016	-12,013
Proceeds from sale of PP&E	245	245	245	245
Change in Other Assets	-3,036	-4,000	-600	-600
Net Cash Used in Invest Activities	-11,919	-19,730	-15,371	-12,368
Net Change in Debt	72	119	-25	-23
Net Change in Equity	0	0	0	0
Dividends	-424	-706	-2,322	-1,963
Others	0	0	0	0
Net Cash Flow From Financing	-352	-587	-2,347	-1,986
Other Cash Flow	-83	0	0	0
Net change in cash	2,336	1,234	3,127	7,885
Beginning cash	614	2,950	4,184	7,311
Ending cash	2,950	4,184	7,311	15,195

Balance Sheet

(W bn)	2017	2018E	2019E	2020E
Cash & Cash Equivalents	8,555	9,228	11,851	19,281
Receivables	5,588	6,415	6,078	6,391
Inventory	2,640	3,679	3,486	3,666
Other current Assets	528	6,616	8,899	10,652
Current Assets	17,310	25,938	30,314	39,990
Investment Assets	414	415	415	416
Property and Equipment	24,063	33,536	39,588	40,534
Fixed Assets	28,108	37,133	43,185	44,132
Total Assets	45,418	63,071	73,499	84,122
Trade Payables	4,864	6,642	6,167	6,356
Short Term Debts	193	212	233	256
Current Portion of LT Debts	581	569	558	547
Total Current Liabilities	8,116	10,397	10,527	11,442
Long Term Debts	2,080	2,060	2,039	2,019
Bonds	1,317	1,449	1,434	1,420
Total Long Term Liabilities	3,481	3,597	3,566	3,536
Total Liabilities	11,598	13,994	14,093	14,977
Paid-in Capital	3,658	3,658	3,658	3,658
Retained Earnings	27,287	42,544	52,873	62,611
Total Stockholders' Equities	33,821	49,078	59,406	69,144
Total Liabilities & SE	45,418	63,071	73,499	84,122
Net Debt	-4,383	-4,939	-7,586	-15,039

Ratio Analysis

(W bn)	2017	2018E	2019E	2020E
ROE (AOY)	36.8%	38.5%	23.3%	18.2%
ROE (EOY)	44.3%	47.2%	25.8%	19.7%
ROA	27.4%	35.1%	20.1%	43.1%
ROIC (AOY)	28.9%	29.4%	18.7%	15.9%
Asset Turnover	0.7	0.7	0.5	0.5
Day's Receivables	67.7	55.8	55.8	55.8
Day's Inventory	75.9	86.7	77.7	68.8
Day's Payables	139.8	156.5	137.4	119.3
Current Ratio	2.1	2.5	2.9	3.5
Debt to Equity (%)	34.3	28.5	23.7	21.7
Net Debt to Equity (%)	-13.0	-10.1	-12.8	-21.8
EPS (MW)	14,617	21,927	17,377	16,073
BVPS (MW)	46,449	67,407	81,595	94,971
DPS	1,000	3,289	2,780	3,215
P/E	5.2	3.3	4.2	4.5
P/BV	1.6	1.1	0.9	0.8
EV/EBITDA	2.6	1.6	1.6	1.3
Dividend Yield (%)	1.3	4.5	3.8	4.4
Share Price (KRW)	76,500	72,900	72,900	72,900
Shares Outstanding (000 AOY)	728,002	728,002	728,002	728,002

Source: Company data, Morgan Stanley Research estimates

Source: Company data, Morgan Stanley Research

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	COVERAGE UNIVERSE		INVESTMENT BANKING CLIENTS (IBC)			OTHER MATERIAL INVESTMENT SERVICES CLIENTS (MISC)	
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Overweight/Buy	**1156**	**37%**	**295**	**40%**	**26%**	**541**	**38%**
Equal-weight/Hold	**1405**	**44%**	**342**	**47%**	**24%**	**641**	**45%**
Not-Rated/Hold	**46**	**1%**	**7**	**1%**	**15%**	**7**	**0%**
Underweight/Sell	**555**	**18%**	**85**	**12%**	**15%**	**226**	**16%**
TOTAL	**3,162**		**729**			**1415**	

Data include common stock and ADRs currently assigned ratings. Investment Banking Clients are companies from whom Morgan Stanley received investment banking compensation in the last 12 months. Due to rounding off of decimals, the percentages provided in the "% of total" column may not add up to exactly 100 percent.

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INDUSTRY COVERAGE: Semiconductors

COMPANY (TICKER)	RATING (AS OF)	PRICE* (12/17/2018)
Craig Hettenbach		
Amphenol Corp. (APH.N)	O (08/09/2018)	$82.54
Analog Devices Inc. (ADI.O)	O (07/27/2016)	$87.31
Broadcom Inc. (AVGO.O)	E (11/28/2018)	$254.13
Cypress Semiconductor Corp (CY.O)	U (03/30/2017)	$12.50
Impinj Inc (PI.OQ)	E (06/19/2017)	$16.29
Maxim Integrated Products Inc. (MXIM.O)	E (01/30/2018)	$52.20
Microchip Technology Inc. (MCHP.O)	E (11/01/2017)	$71.21
NXP Semiconductor NV (NXPI.O)	E (03/19/2018)	$75.27
ON Semiconductor Corp. (ON.O)	U (08/09/2018)	$17.32
Qorvo Inc (QRVO.O)	E (06/27/2016)	$60.34
Sensata Technologies Holding N.V. (ST.N)	U (09/17/2018)	$41.98
Skyworks Solutions Inc (SWKS.O)	E (11/28/2018)	$68.43
Te Connectivity Ltd (TEL.N)	O (09/10/2014)	$72.01
Joseph Moore		
Advanced Micro Devices (AMD.O)	U (10/30/2017)	$18.83
Ambarella Inc (AMBA.O)	O (03/29/2016)	$37.08
Aquantia Corp (AQ.N)	O (11/28/2017)	$8.55
Inphi Corporation (IPHI.N)	E (01/19/2018)	$32.49
Intel Corporation (INTC.O)	E (01/27/2017)	$47.08
Marvell Technology Group Ltd (MRVL.O)	E (09/14/2015)	$15.25
Micron Technology Inc. (MU.O)	E (05/31/2018)	$33.88
NVIDIA Corp. (NVDA.O)	O (04/09/2018)	$143.58
Quantenna Communications Inc (QTNA.O)	O (11/22/2016)	$14.40
Texas Instruments (TXN.O)	E (05/30/2012)	$91.92
Western Digital (WDC.O)	E (11/26/2017)	$38.25
Xilinx (XLNX.O)	O (12/14/2016)	$87.18

Stock Ratings are subject to change. Please see latest research for each company.
* Historical prices are not split adjusted.

INDUSTRY COVERAGE: Greater China Technology Semiconductors

COMPANY (TICKER)	RATING (AS OF)	PRICE* (12/18/2018)
Charlie Chan		
ASE Technology Holding Co. Ltd. (3711.TW)	O (09/21/2018)	NT$59.80
ASM Pacific (0522.HK)	E (09/21/2018)	HK$76.50
Chipbond Technology Corp (6147.TWO)	O (07/20/2017)	NT$61.30
Chunghwa Precision Test Tech (6510.TWO)	E (08/07/2018)	NT$504.00
Global Unichip Corp (3443.TW)	U (11/05/2018)	NT$195.00
Jiangsu Changjiang Electronics Tech (600584.SS)	U (09/22/2015)	Rmb9.43
MediaTek (2454.TW)	U (11/16/2018)	NT$234.50
Nanya Technology Corp. (2408.TW)	E (07/17/2018)	NT$54.50
Phison Electronics Corp (8299.TWO)	E (12/14/2018)	NT$222.50
Silergy Corp. (6415.TW)	U (08/16/2018)	NT$491.00
Silicon Motion (SIMO.O)	E (12/14/2018)	$33.23
SMIC (0981.HK)	U (09/21/2018)	HK$7.41
TSMC (2330.TW)	E (11/16/2018)	NT$222.50
UMC (2303.TW)	U (11/16/2018)	NT$11.20
Universal Scientific Ind. (Shanghai) (601231.SS)	O (08/04/2015)	Rmb9.76
Vanguard International Semiconductor (5347.TWO)	O (02/08/2018)	NT$63.70
WIN Semiconductors Corp (3105.TWO)	U (07/24/2018)	NT$126.00
Daniel Yen, CFA		
ASMedia Technology Inc (5269.TW)	E (11/09/2018)	NT$478.00
Aspeed Technology (5274.TWO)	E (06/27/2018)	NT$543.00
Egis Technology Inc (6462.TWO)	E (11/21/2018)	NT$186.00
GigaDevice Semiconductor Beijing Inc (603986.SS)	U (04/30/2018)	Rmb68.50
Macronix International Co Ltd (2337.TW)	U (08/13/2018)	NT$18.55
Novatek (3034.TW)	U (11/16/2018)	NT$137.50
Parade Technologies Ltd (4966.TWO)	E (07/18/2018)	NT$445.50
Realtek Semiconductor (2379.TW)	O (08/03/2018)	NT$147.50
Shenzhen Goodix Technology Co Ltd (603160.SS)	O (07/24/2018)	Rmb76.82
Winbond Electronics Corp (2344.TW)	U (08/05/2018)	NT$13.90
WPG Holdings (3702.TW)	O (07/31/2017)	NT$36.00

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* Historical prices are not split adjusted.

INDUSTRY COVERAGE: Japan Semiconductors

COMPANY (TICKER)	RATING (AS OF)	PRICE* (12/18/2018)
Kazuo Yoshikawa, CFA		
Advantest (6857.T)	E (05/18/2018)	¥2,139
DISCO (6146.T)	E (07/22/2015)	¥13,440
Hitachi High-Technologies (8036.T)	O (12/04/2010)	¥3,505
Horiba (6856.T)	E (02/17/2017)	¥4,860
HOYA (7741.T)	E (09/05/2017)	¥6,509
Micronics Japan (6871.T)	U (10/01/2018)	¥757
Nikon (7731.T)	E (07/10/2017)	¥1,685
NuFlare Technology (6256.T)	U (07/10/2017)	¥5,310
Renesas Electronics (6723.T)	++	¥500
Rohm (6963.T)	O (12/12/2016)	¥7,100
SCREEN Holdings (7735.T)	E (04/01/2013)	¥4,890
Shimadzu (7701.T)	E (05/08/2018)	¥2,321
Tokyo Electron (8035.T)	E (07/06/2015)	¥13,510
Tokyo Seimitsu (7729.T)	E (08/11/2015)	¥2,966
Toshiba (6502.T)	O (07/06/2018)	¥3,290

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* Historical prices are not split adjusted.

INDUSTRY COVERAGE: S. Korea Technology

COMPANY (TICKER)	RATING (AS OF)	PRICE* (12/18/2018)
Shawn Kim		
LG Display (034220.KS)	E (06/18/2018)	W18,300
LG Electronics (066570.KS)	E (01/22/2018)	W66,900
LG Innotek (011070.KS)	U (11/21/2018)	W89,400
Samsung Electro-Mechanics (009150.KS)	E (11/21/2018)	W101,000
Samsung Electronics (005935.KS)	E (11/26/2017)	W32,200
Samsung Electronics (005930.KS)	E (11/26/2017)	W38,900
Samsung SDI (006400.KS)	O (05/30/2017)	W202,500
Samsung SDS (018260.KS)	E (06/23/2017)	W196,000
Seoul Semiconductor (046890.KQ)	U (04/04/2018)	W18,850
SK Hynix (000660.KS)	U (08/05/2018)	W61,100

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* Historical prices are not split adjusted.

INDUSTRY COVERAGE: Semiconductor Capital Equipment

COMPANY (TICKER)	RATING (AS OF)	PRICE* (12/17/2018)
Joseph Moore		
Applied Materials Inc. (AMAT.O)	E (08/09/2018)	$32.67
Lam Research Corp (LRCX.O)	O (12/14/2015)	$135.68

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