

Semiconductors

Analog Renaissance 2.0 - Semis You Can Own Through the Next 4 Cycles

July 9, 2019

Key Takeaway

We updated our Analog Renaissance Report from 2017. Four takes: 1) Consolidation is better and faster than we thought, 2) Big get bigger, rich get richer, 3) Expect more M&A, 4) Our 3-to-5-yr EPS Bull case is 50%/100% above CY19 consensus. We think the drivers are 15-yr secular ones (Consolidation + Tectonic Shift to IoT), and that TXN and ADI are ownable through the next 4 cycles. ON is our top mid-cap play.

Many have Semiconductor Scars, but Evidence Compelling that Analog is Changing...

FCF/Shr for our analog group took a hit during the financial crisis, but stayed positive through the whole crisis, furthermore it largely increased monotonically through the 2015 and 2018 inventory corrections, and for 2018, is at the highest levels ever. Capital return per share has grown with FCF, FCF margins are expanding and fixed costs are declining. EBIT margins for our analog sample set increased by 1,000 bps over the past 5 years and remain near all time highs, despite the inventory correction.

Two Secular Trends Driving the Change

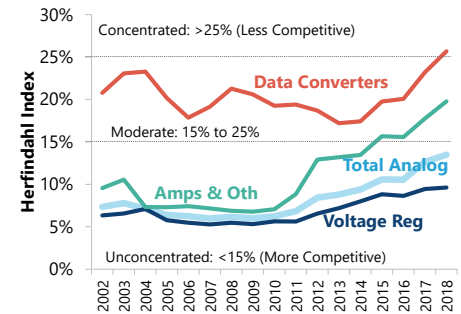
We think there are two main secular drivers for analog companies that will remain in play for the next 10 years: 1) Consolidation - which is not only driving pricing power, but also leverage on OpEx; 2) Richer Product Mix - Our "4th Tectonic Shift in Computing" framework shows that growth in computing is shifting away from a highly concentrated handset and PC customer base with massive pricing power, to a set of highly fragmented IoT customers (Industrial, Auto, IoT) with low pricing power.

Four Updates to our Original Analog Renaissance Report

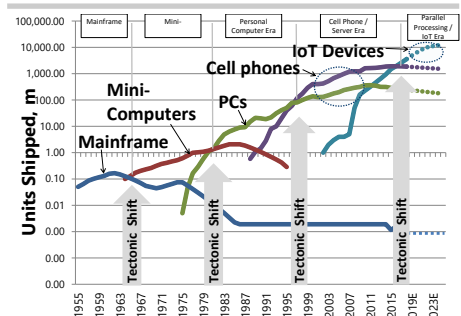
- 1) Consolidation is Better Than We Thought. In this report we look at segment HHI vs aggregate. Through this lens, the industry looks more concentrated, and is consolidating faster than we originally thought.
- 2) Big Get Bigger - Rich Get Richer. We show that over the past 5 years, the analog companies with the largest revenues, market share and composite HHI also had the highest share gain and largest positive change in operating margin. We view TXN and ADI as the best ideas on this theme. Our 3-yr EPS bull-case for ADI and TXN is \$8.47 and \$8.09, 60% above CY19 consensus.
- 3) Expect More M&A. We estimate there are still over 100 analog companies that account for over 50% of the analog market. Our updated M&A framework indicates MTSI, SLAB, SMTC, LSCC, POWI, VICR, CRUS, DLG are potentially attractive targets.
- 4) EPS Sensitivity Analysis 50-100% EPS Upside over 3-to-5 years. ...for our larger cap analog companies - We think TXN and ON have the best chance to hit our bull case based on the high percentage of their manufacturing that they do in-house, which should allow for lower cost structure and better fixed cost absorption. In TXN's case, we also think it benefits from scale (See #2 above).

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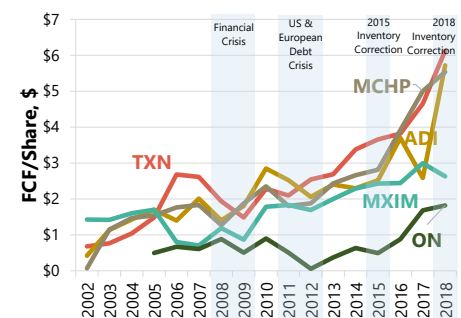
Analog Subsegment HHI Increasing and More to Go



Growth Coming from Fragmented Customers = Richer Rev Mix



Impressive FCF/Shr Growth Even During Recessions + Inventory Corrections



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^Prior trading day closing price unless otherwise noted.

Please see analyst certifications, important disclosure information, and information regarding the status of non-US analysts on pages 48 to 55 of this report.

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Links to Related Research

1Q19 Wrap: Semi Cycle Pattern Trumping Tariff Tiffs

Analog Renaissance - Are the Old Semiconductor Investing Tools Broken?

The 4th Tectonic Shift in Computing: To a Parallel Processing / IoT Model

FCF and Capital Return Handbook - 2018 Edition

Section 1. Summary

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Summary – Stocks to Own Through the Next 4 Cycles

Many Investors Have Semiconductor Scars...

Semis have a bad reputation with many long-time technology investors. It is easy to understand why - those with any history remember how bad it could get, high capital intensity, negative leverage, unpredictable inventory corrections, along with excessive option usage and irresponsible M&A. Being at the back of the supply chain meant visibility for Semis is barely one layer deep into their own distributors, so management teams would typically not see an inventory correction until after it happened. When the correction hit, Semis would report negative levered revisions, with deeper cuts to estimates than most dreamed. The cuts played through in the stocks - between 2000 and 2002, the SOX (Philly Semi Index) declined by 80% peak-to-trough, and during the financial crisis, it declined by 60%. Any tech investor who has been around for more than a decade can tell you a half-dozen stories about semiconductor management teams that *"drove me off a cliff."*

...but Evidence is Compelling that Analog is Changing

We think the evidence is compelling that things are changing, particularly for the analog stocks. Chart 2 shows FCF/Shr for a group of our largest "Analog Renaissance" plays. FCF/Shr took a hit during the financial crisis, but stayed positive through the whole crisis. During the US and European debt crises, FCF/Shr declined a bit, but by and large not as much as during the financial crisis. FCF/Shr largely increased monotonically through the 2015 and 2018 inventory corrections, and for 2018, are at the highest levels ever, despite two quarters of downward revisions in 2H18. Capital return per share has grown with FCF, and many have the policy to return 100% of it to shareholders (all earnings go to shareholders...novel concept, right?). FCF margins continue to expand and fixed costs as a percent of sales are on the decline, which has translated to more predictable and stable operating models. Finally, EBIT margins for our sample set increased by 1,000 bps over the past 5 years and remain near all time highs. The important question is whether these are cyclical or secular phenomena.

FCF/Shr increased for TXN, ADI, MCHP and ON during the 2018 inventory correction, and for TXN, MCHP and MXIM during the 2015 inventory correction

Two Secular Trends Driving the Change

We think they are secular, and that the two main drivers of 1,000 bps of operating margin expansion over the past 5 years will be in place for the next 10, namely: 1) Consolidation - which is not only driving pricing power, but also leverage on OpEx. The beauty of analog is that product cycles are measured in 10's of years, so consolidation today carries benefits for a decade. We would expect continued improvements to the analog business model for the next 10 years even if consolidation stopped today (we don't think it will). 2) Richer Product Mix - Our "4th Tectonic Shift in Computing" framework shows that growth in computing is shifting away from a highly concentrated handset and PC customer base with massive pricing power, to a set of highly fragmented IoT customers (Industrial, Auto, IoT) with low pricing power. We've shown that Tectonic Shifts in Computing typically last for 15 years, and we believe that this shift to an IoT/Parallel Processing model has at least another 10 years to go.

Four Updates to our Original Analog Renaissance Report

This report is an update to our original "Analog Renaissance" report published in 2017. We offer three new analyses with this report: 1) Consolidation is Better Than We Thought. We originally looked at the Herfindahl Index (HHI - measure of industry concentration) for the whole analog industry. Our original analysis showed that the industry was becoming more

concentrated, but that in aggregate it was still at a low level. In this report we look at the HHI for the individual analog segments, which paints a picture of the group that is more concentrated than we originally calculated. This "higher resolution view" of consolidation better explains the 1,000 bps margin expansion over the past 5 years. The whole industry benefits from this phenomenon, but when we calculate the "composite HHI" for each company (HHI weighted by segment), ADI, MXIM, TXN and MCHP appear particularly advantaged.

2) Big Get Bigger - Rich Get Richer. Perhaps a socially unacceptable concept, but the cold, hard truth is this is what happened in HDD and DRAM (see Appendix 3 for the HDD and DRAM case studies) as those markets consolidated, and what is happening to the analog industry today. We show that over the past 5 years, the companies with the largest revenues, market share and composite HHI also had the highest share gain and largest positive change in operating margin. We view TXN and ADI as the best ideas on this theme.

3) Expect More M&A. While the industry has benefited from consolidation, we estimate that over 100 companies still account for over 50% of the analog market. Chart 19 shows the M&A framework we introduced in March 2015 (Semiconductor M&A Handbook - More to Come). The framework suggests that M&A has a high probability of success when companies with low cost structures and higher valuation multiples (Southeast on chart) acquire companies that have higher cost structures and lower valuation multiples (Northwest on chart). This framework indicates MTSI, SLAB, SMTC, LSCC, POWI, VICR, CRUS, DLG as being potentially attractive targets.

4) EPS Sensitivity Analysis 25-100% EPS Upside over 3-to-5 years. We show that over the past 5 years, the larger analog stocks have posted a revenue CAGR of 5% and operating margin expansion of 250 bps per year. Our base case assumes 6% revenue CAGR and 100 bps of op margin expansion per year, and our bull case assumes 9% revenue CAGR and 200 bps of op margin expansion per year, which translates to EPS growth for our 3-yr Base/Bull case scenario of 25%/50%, and for our 5-yr Base/Bull case scenario of 50%/100%. We think TXN and ON have the best chance to hit our bull case based on the high percentage of their manufacturing that they do in-house, which should allow for lower cost structure and better fixed cost absorption. In TXN's case, we also think it benefits from scale (See #2 above).

Top Ideas

Between the late 80-90s, INTC outperformed the market by 10x because it was a critical supplier in the PC Era, and between the late 90s- 20teens, QCOM and ARM outperformed the market by 10x because they were the critical suppliers into the Cellphone Era. We view the analog and MCU players as critical suppliers into the IoT Era and expect them to materially outperform the market during the IoT / Parallel Processing Era of Computing.

We think that the secular trends identified in this report are positive for the industry as a whole, but we would highlight TXN and ADI as the largest beneficiaries of these trends in the analog market, based largely on their size and relative market share. Simply put, the big get bigger and rich get richer. We would also highlight ON Semi as a top mid-cap idea based on its position as a consolidator in the discrete and lower-end analog market, which has the most to benefit in a benign pricing environment.

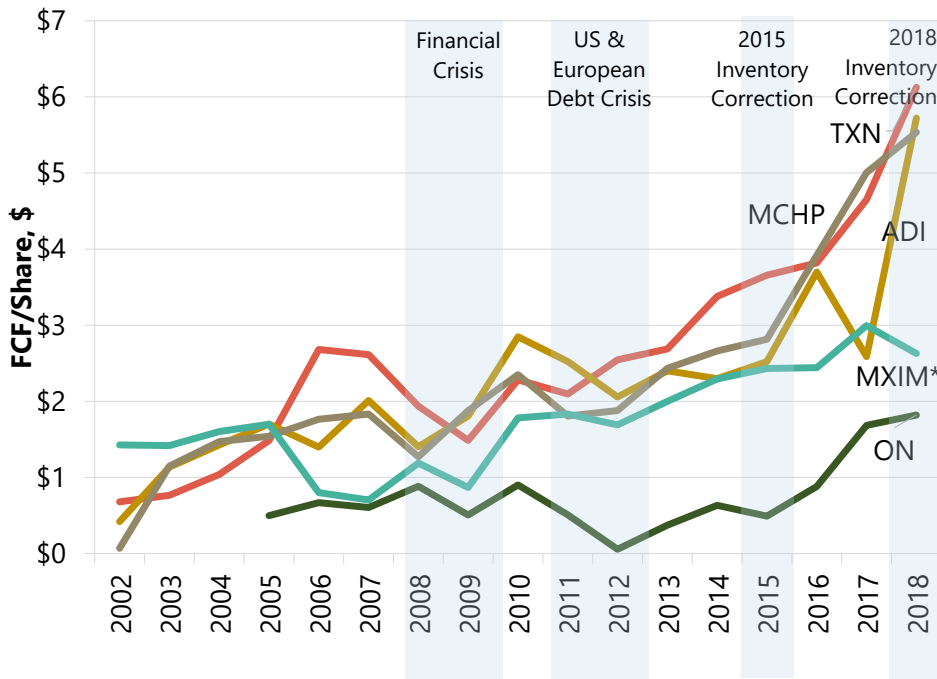
Chart 1 - Summary of Base and Bull Cases

	Consensus CY19E EPS	Jefferies 3-yr Base	Jefferies 3-yr Bull	Jefferies 5-yr Base	Jefferies 5-yr Bull
ADI	\$5.27	\$7.23	\$8.47	\$8.80	\$11.36
MCHP	\$6.18	\$8.10	\$9.60	\$9.39	\$12.29
MXIM	\$2.53	\$3.16	\$3.71	\$3.79	\$4.91
ON	\$1.78	\$2.39	\$3.06	\$3.02	\$4.38
TXN	\$5.16	\$6.96	\$8.09	\$8.25	\$10.53

Source: Jefferies, FactSet

Chart 2 - Impressive FCF/Shr Growth For Analog Companies Even During Recessions + Inventory Corrections

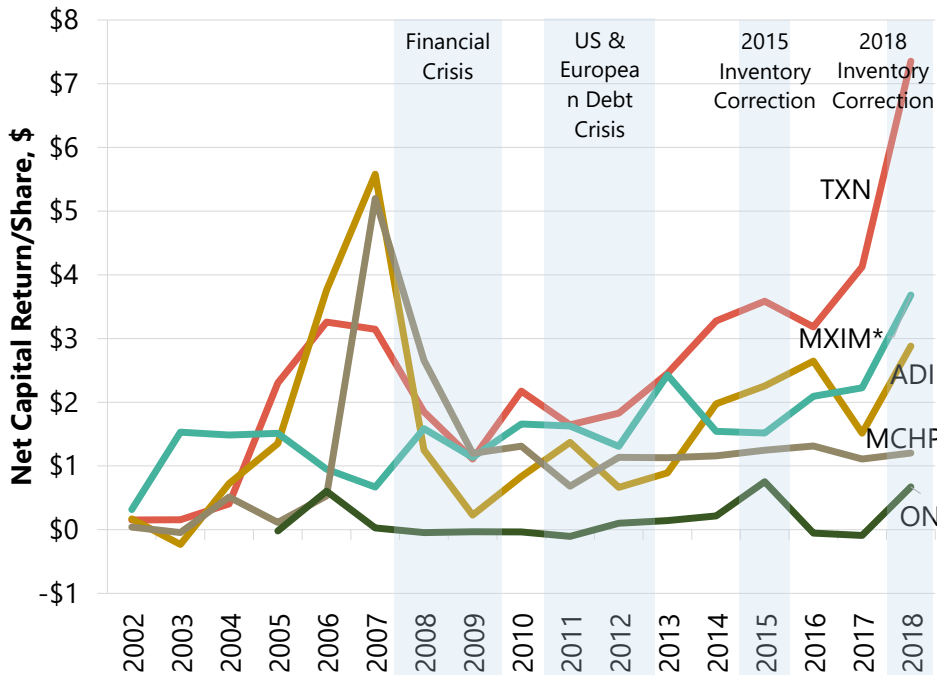
We plot Free Cash Flow per share for our sample of analog companies. We note that FCF/Shr took a hit during the financial crisis, but stayed positive through the whole crisis. During the US and European debt crises, FCF/Shr declined a bit, but by and large not as much as during the financial crisis. FCF/Shr largely increased monotonically through the 2015 and 2018 inventory corrections, and for 2018, are at the highest levels ever, despite two quarters of downward revisions in 2H18



Source: company data, Jefferies; *MXIM 2005, 2006 data sourced from FactSet

Chart 3 - Net Capital Return per Share

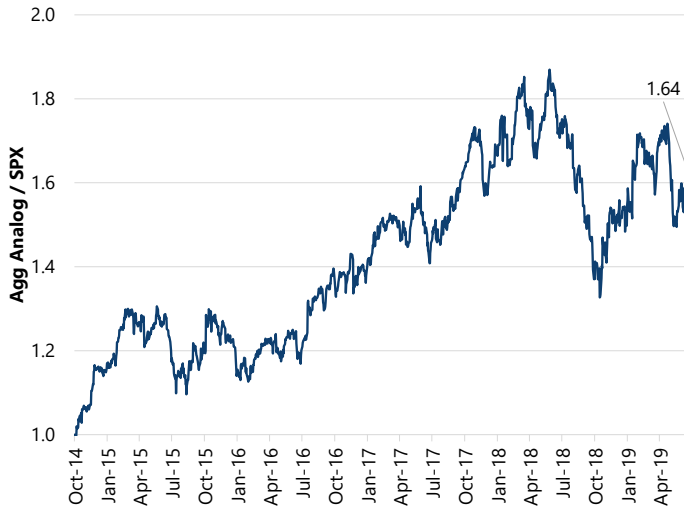
Capital return per share has grown with FCF, and many have a policy to return 100% of it to shareholders - shareholders get 100% of the earnings



Source: company data, Jefferies; *MXIM 2005, 2006 estimates based on FactSet

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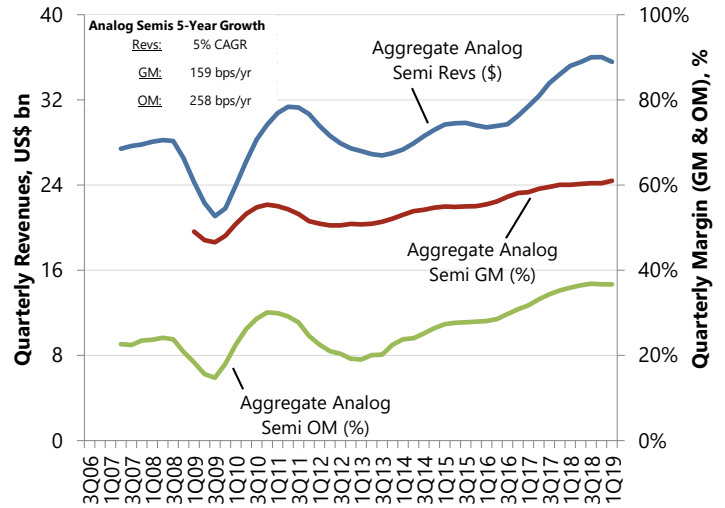
Chart 4 - Analog Stocks vs SPX Since 2015 Inventory Correction



Source: Jefferies, Factset. Composite includes: TXN, ADI, MCHP, MXIM, ON, indexed to 10-Oct-14, beginning of the 2015 inventory correction

Our index of analog companies has outperformed the S&P 500 since the 2015 inventory corrections

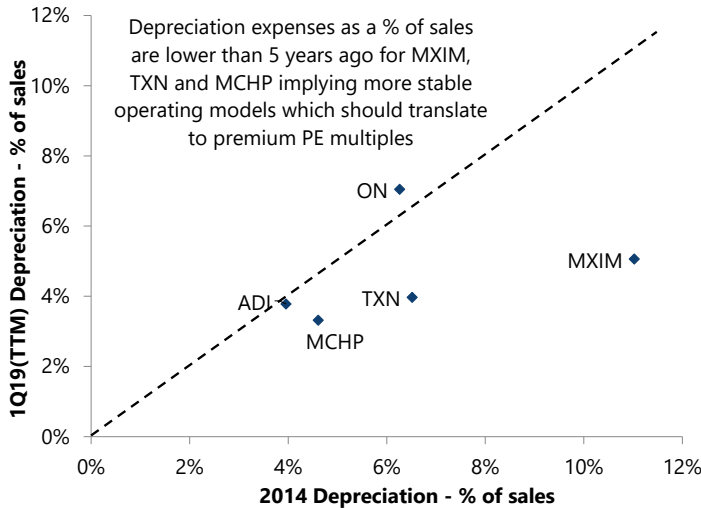
Chart 5 - Analog Semi Gross and Operating Margin (TTM)



Source: Jefferies, company data, FactSet. Analog sample includes TXN +NSM, MXIM, ON+FCS, MCHP+ATML+MSCC, ADI+LLTC.

Over the past 5 years, aggregate gross and operating margins for our sample of companies increased by 8% and 13%, or by 159bps/yr and 258bps/yr. During that period, revenue growth for the group has been 30% or 5% CAGR

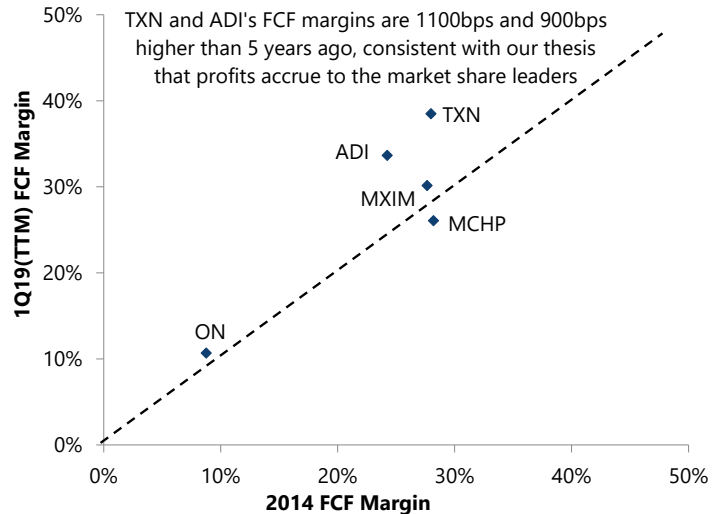
Chart 6 - Depreciation - % of Sales 1Q19(TTM) vs. 2014



Source: Jefferies, FactSet and company data

Compared to 2014, we noted that the current levels (1Q19TTM) of depreciation are lower for most of the analog companies in our sample implying more stable operating model with lower risk of negative operating leverage during downward revisions

Chart 7 - FCF Margin 1Q19(TTM) vs. 2014

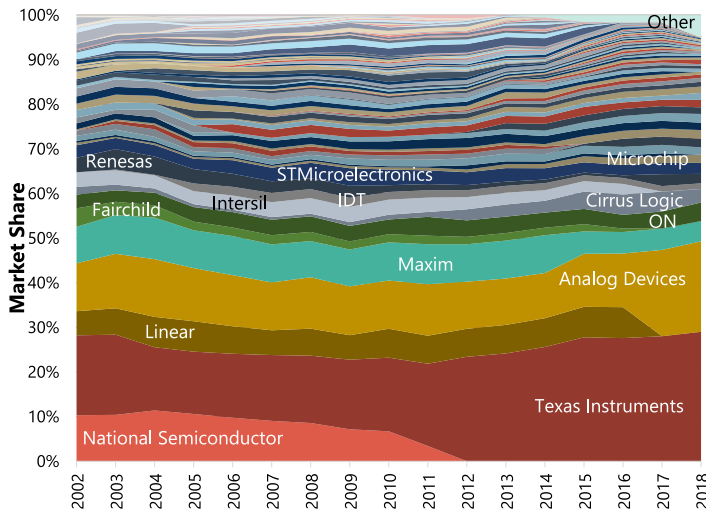


Source: Jefferies, FactSet and company data

All of the analog players in our sample have similar or higher FCF margins in 1Q19 (TTM) as compared to 2014

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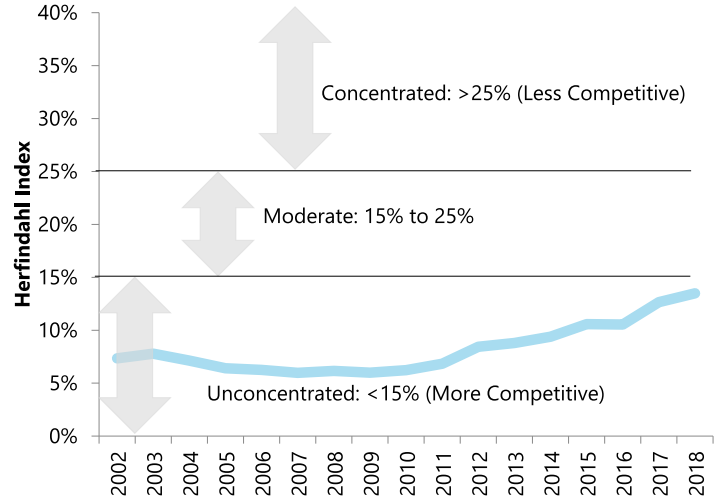
Chart 8 - Total Analog Market Share



Source: Jefferies, Gartner. Analog market share calculated based upon revenue.

The total Analog market has 2 players with dominant market share (TXN, ADI) accounting for 49% of the market, with the 3rd place accounting only for 5% of the market

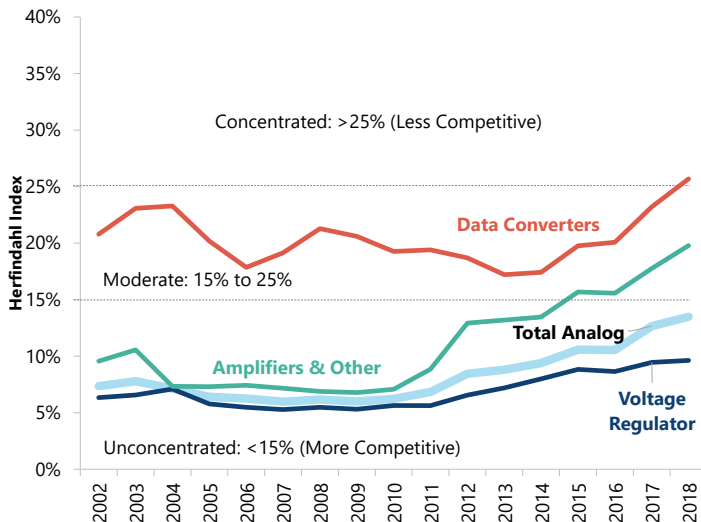
Chart 9 - Total Analog Herfindahl Index



Source: Jefferies, Gartner. The Herfindahl Index is calculated by summing the squares of the market shares of top 50 industry participants

The Total Analog market HHI index has increased steadily with consolidation over the past 10 years, but is still in the "Unconcentrated Zone" suggesting more room for consolidation

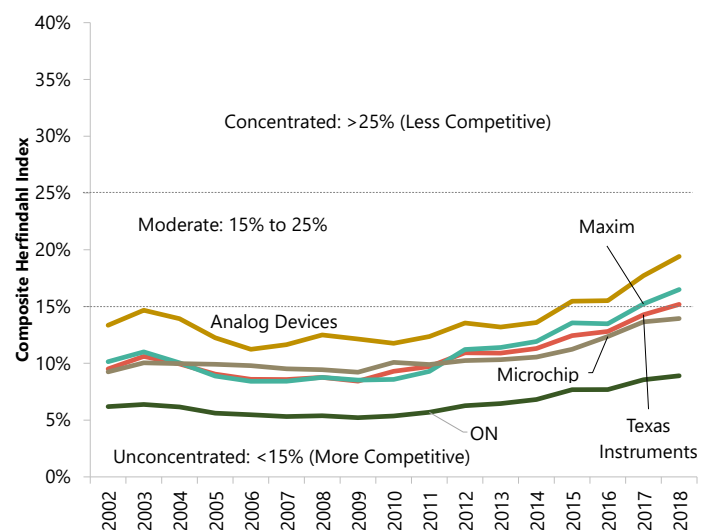
Chart 10 - Analog Segment HHI



Source: Jefferies, Gartner, company data

Looking at the analog market subsegments, the HHI looks more compelling and more easily explains the recent 1,000 bps expansion of operating margins.

Chart 11 - TXN, ADI, MXIM, ON and MCHP Composite HHI



Source: Jefferies, Gartner, company data

Among the 4 largest analog companies in our sample, ADI has the highest composite HHI, compared to MXIM, TXN and MCHP. Importantly, all have increased.

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Chart 12 - Semiconductor Commentary on Pricing Power - 2019

Date	Company	Commentary
11-Jun	MCHP	CFO: But what we've seen in this cycle which is different than others is ASPs or the average selling prices, the pricing pressure that's coming in other cycles, really haven't been there. And we think that's a factor of industry consolidation and a lot of the poor players in terms of pricing model, business model had been taken out through acquisitions. And so, prices have held up quite well and that has obviously helped in where gross margins are...
10-Jun	MCHP	CFO: we're having great success in holding pricing flat. We're being fair with our customers; we're not raising prices on customers, but really holding pricing flat in this environment. And that's a change from where it was just a few years ago where you'd see 1%, 2%, 3% ASP decline per year and essentially give away some of the upside that we were seeing in unit growth in ASP decline.
29-May	MCHP	CFO: And so we've seen pricing be very, very stable in this environment. When we compete against our top tier competitors, we're competing against product specs and technical support and it's not a pricing discussion. Obviously, price is important to the customer, but that's not what ultimately wins you that design.
14-May	MXIM	CFO: It's a favorable pricing environment.
29-Apr	ON	CEO: We're not seeing any pricing declines at all. In fact, it's less than normal right now.
13-Feb	MCHP	CFO: We're in a – we believe a good environment from ASP perspective. We've been holding ASPs relatively flat with customers and having good success with that. And so, as our cost structures improve, we think that we can continue to get gross margin improvement over the course of time as the revenue environment becomes a little bit more constructive.
12-Feb	MXIM	CFO: "But both from a revenue growth point of view from the ability to continue to, kind of, improve utilization and really loading in our one factory left up in Oregon, I think our mix of shifting more to industrial helps us. I think the pricing environment is favorable in semiconductors' given consolidation. I think there's a number of factors."
5-Feb	TXN	Head of IR: "And as our customers go through and decide which product they're going to use, there can be tens, if not hundreds of specs that an engineer is considering. And the average sales price of a product in the market overall is about \$0.35. And out of those hundreds of specifications they're looking at, pricing is always a concern, but it just very rarely is one of the top concerns. So you can't sell a \$0.35 part for \$3.50. But that's just not usually one of the top things that a customer is concerned about. But really looking at the functionality of the device and how it works inside of their design."
4-Feb	ON	CEO: Our annual contracts are usually completed, and they show up in our books in the first quarter here, as you mentioned. Those numbers were better than we've had, quite benign, and should not be declining – or should not provide a decline in ASP for the first quarter.
7-Feb	NXP	CEO: I would say that the general environment on pricing is okay. I don't think that we would say that it's poor for us at all. I think if anything we're trying to whittle down, when you go through the annual price negotiations with the OEMs and the tier ones, it's an arm wrestling that takes place. And we try to get it down slightly and, it's under the contract, and we try to reduce it slightly, and they try to get a little more. But I don't think there's a significant change in environment that we see associated with that. And on most of the Industrial & IoT, you said that price with the design wins and then you have a built in reduction that takes place associated with those that we honor contracts for them... But I wouldn't say that the pricing environment is problematic. It's very healthy right now.
3-Jan	ON	CEO: So other than China construction-related things, everything else actually does look very good. We're seeing the push for the higher efficiency being well received and customers willing to pay additional for that, which is great for a pricing environment.

Source: Jefferies, company data, FactSet

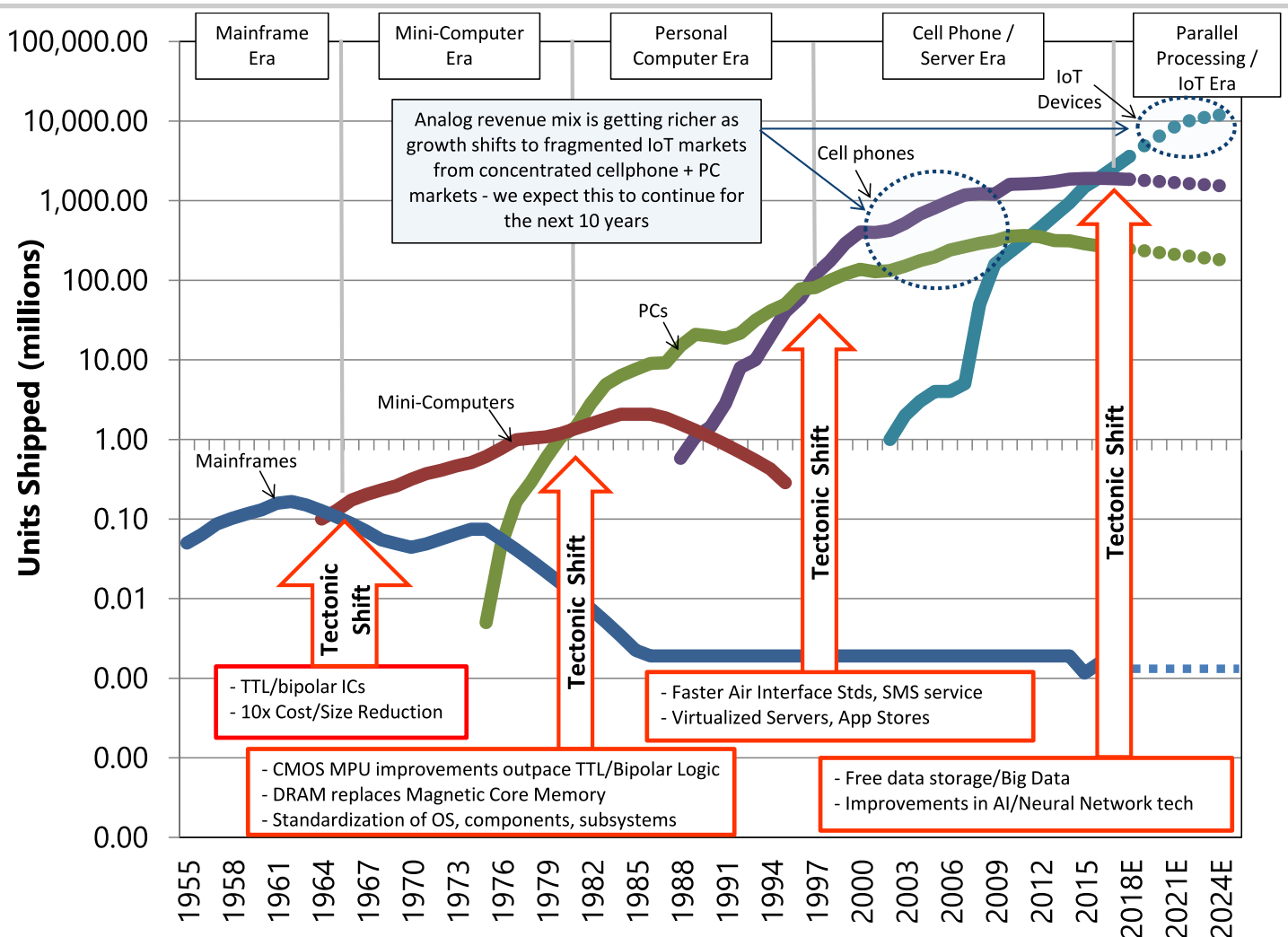
Analog companies continue to report secular improvements in the pricing environment. We think that better pricing is driven more by secular dynamics associated with increased industry concentration

Secular Analog Demand– Tectonic Shift to Parallel Processing and IoT Computing Paradigm

In our July, 2017 note: “4th Tectonic Shift in Computing,” we observed that the computing paradigm shifted every 15 years (10x units, 1/10th cost, 1/10th footprint), and argued that it is currently shifting to a parallel processing / IoT model. We believe the current shift is being driven by both the low cost of storing the data that the IoT devices are generating, as well as improvements in parallel processing technologies like neural networking. As the data from the IoT devices is being processed in an AI framework, higher utility is being driven into those devices, increasing demand for them. The higher utility / increased demand feedback loop is becoming a virtuous circle.

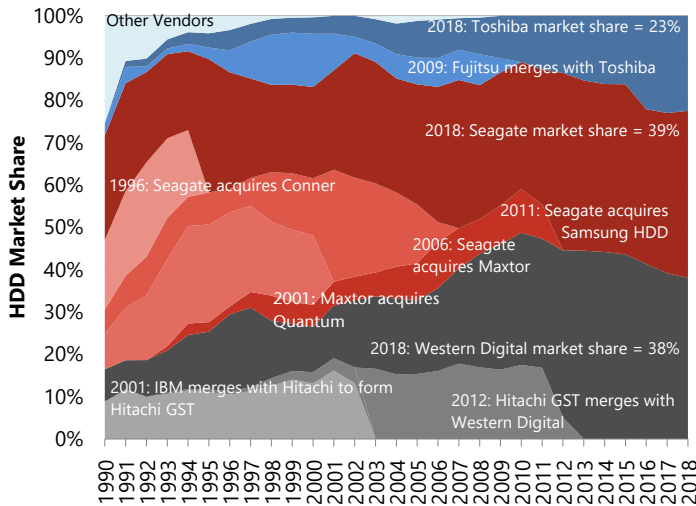
We argued that analog companies, TXN, ADI, MCHP, ON and MXIM were plays on this Tectonic Shift theme as companies that supply components that enable the IoT devices.

Chart 13 - Tectonic Shifts in the Computing Paradigm over the Past 60 years



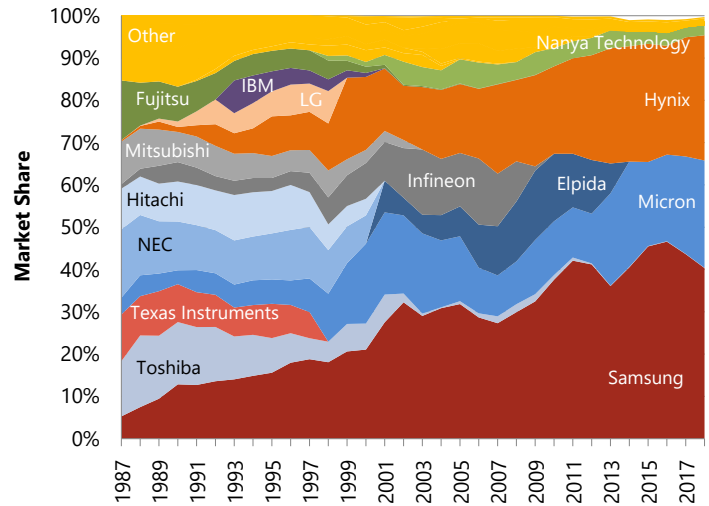
Source: Jefferies, Mainframe computer data from IBM filings, “The Early Computer Industry: Limitations of Scale and Scope”, A. Gandy; Minicomputer “History of Computer Communications” J. Pelkey; Personal Computer data from “Total Share: Personal Computer Market Share 1975-2010”, J. Reimer, Gartner; Mobile devices from Counterpoint Research, Canalis Research, “Smartphones” Research Report, M. Ilyas, S. Ahson; IoT devices from Gartner.

Chart 14 - HDD Market Share Over Time



Source: Jefferies, Gartner. HDD market share calculated based on units shipped.

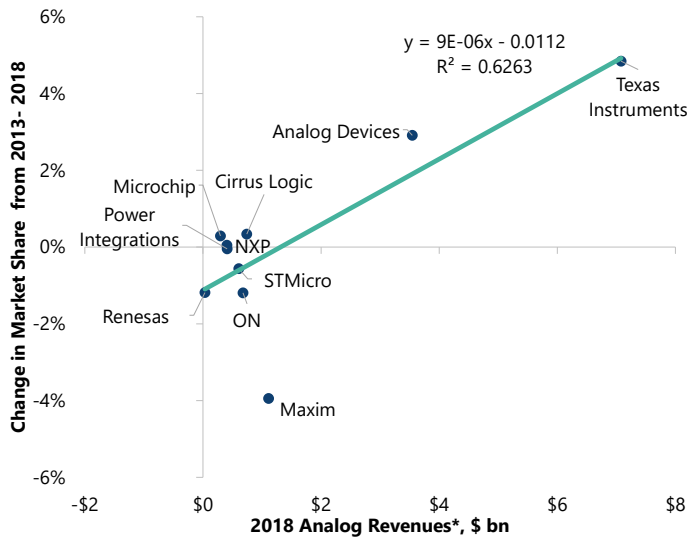
Chart 15 - DRAM Market Share



Source: Jefferies, Gartner. * DRAM market share calculated based upon revenue.

Consolidation case studies of DRAM and HDD industries (See Appendix 3) suggest that the natural order of tech industries is to have 2-to-3 players dominate the market. For example, In DRAM the top 3 players combined represent 95% of the market while in HDD top 3 players represent 100% of the market.

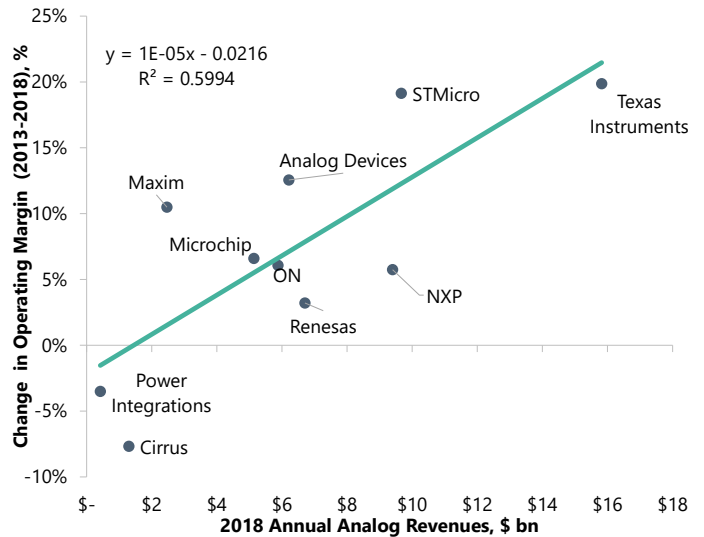
Chart 16 - Change in Market Share vs. 2018 Revenue



Source: Jefferies, Gartner, company data; ADI revenue and market share excl. LLTC; ON excl. FCS and Renesas excl. Intersil; *Gartner estimates for General Purpose Analog Revs

We plotted analog companies' revenues and change of market share over the past 5 years and saw a strong correlation within the data set (R-sq of 62%). We see this as a confirmation of our thesis that scale is competitive advantage in analog space and over time "the big get bigger".

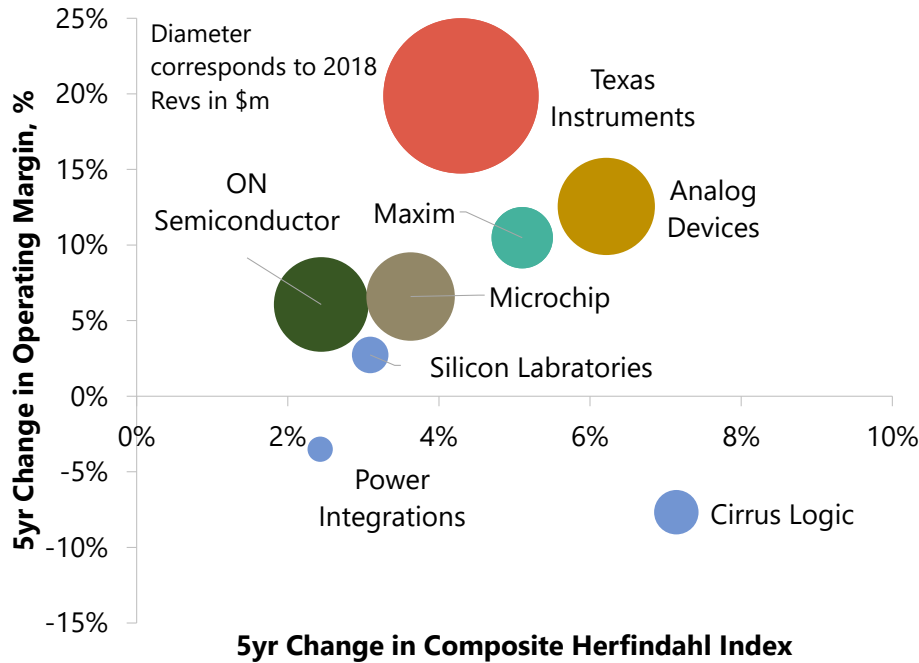
Chart 17 - Delta in Op Margins from 2013-18 vs. 2018 Revs



Source: Jefferies, FactSet, company data

We looked at the increase in profitability and the relationship between the Composite Herfindahl index and the size of the company. We observe that the industry leaders (TXN, ADI) have seen the most improvement in operating margin over the last 5 years, leading us to conclude that "the rich are get richer".

Chart 18 - 5yr Changes in Profitability and Composite HHI

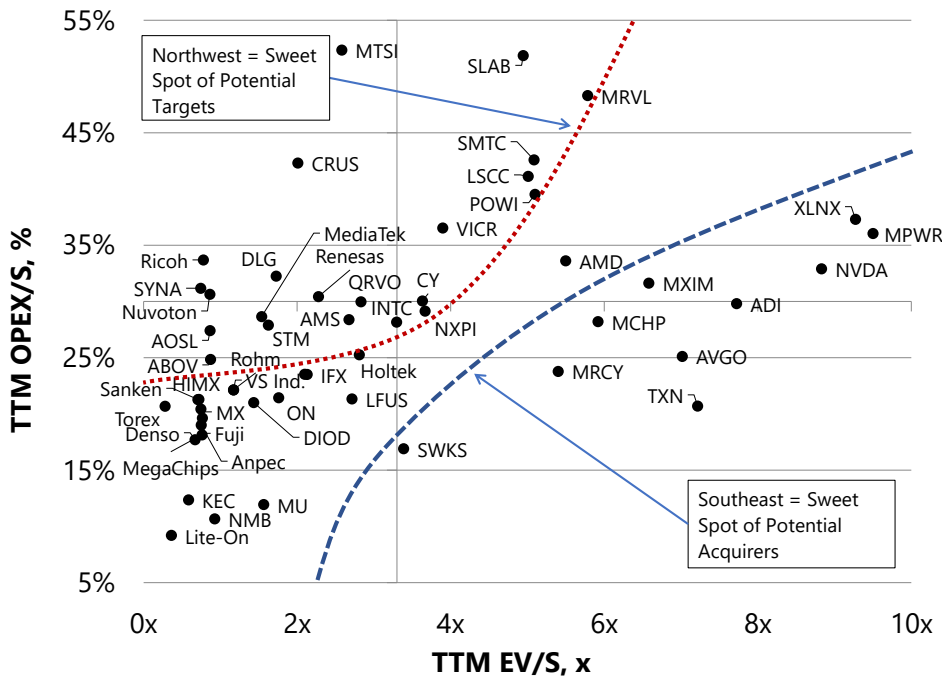


We plotted annual revenues and change in operating margins over the last 5 years for the largest analog companies. We show that over the past 5 years, the companies with the largest revenues, market share and composite HHI also had the highest share gain and largest positive change in operating margin.

Conclusion: the big are getting bigger and the rich are getting richer.

Source: Jefferies, FactSet, company data

Chart 19 - Framework for Identifying Potential M&A Targets and Acquirers - Total Analog Market



According to our semi M&A framework (See note Semis M&A Handbook: More to Come), semiconductor M&A often succeeds when companies with a low cost structure and higher valuation (Southeast on chart) acquired companies with high cost structures and low valuations (Northwest on chart). By acquiring Northwest companies can win twice: 1) lower costs and increase earnings, and 2) get a better multiple on the higher earnings stream.

We estimate that there are still over 100 analog companies so we expect more consolidation. This framework suggests that those companies to the Northwest of the dotted red line could potentially be attractive targets.

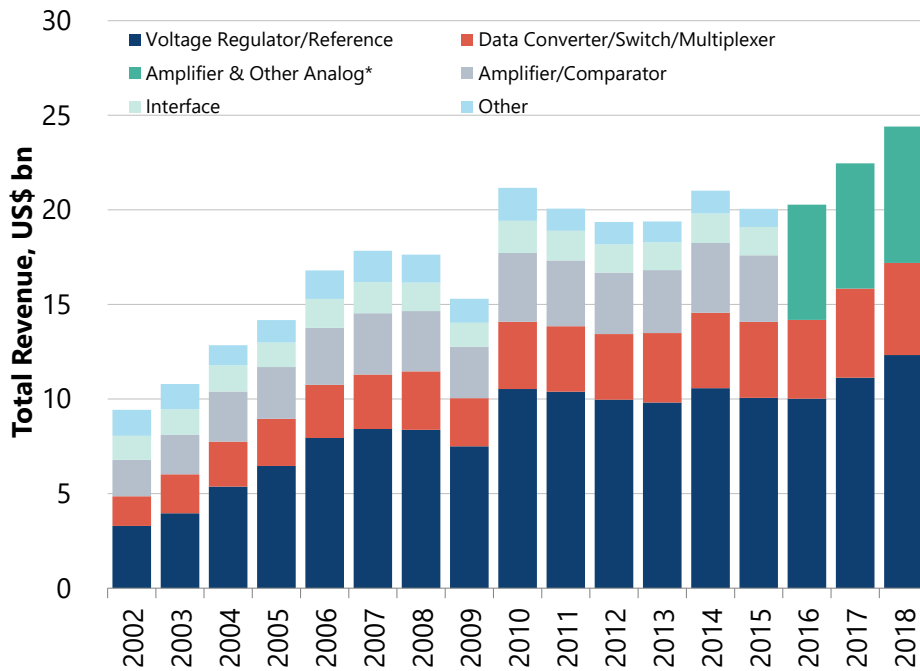
Source: Jefferies, FactSet

Section 2. Analog HHI Analysis

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2.1. Total Analog Industry Concentration Analysis

Chart 20 - Analog Segments Revenue



The total Analog market has grown at 5%/3% CAGR for the 5/10 years

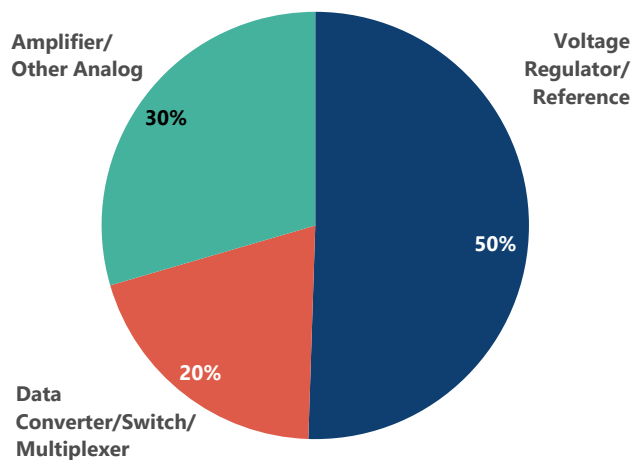
The Voltage Regulator / Reference segment has grown at a CAGR of 5%/4% for the past 5/10 years

Data Converter / Switch / Multiplexer has grown at 6%/5% CAGR for the same periods

Amplifier & Other Analog has grown at 4%/2% CAGR for the 5/10 years

Source: Gartner, *Amplifier & Other includes Amplifier/Comparator, Interface and Other after Gartner switched to aggregate presentation in 2015.

Chart 21 - Total Analog Market Segments Proportions



The largest segment of the Total Analog market is Voltage Regulator/Reference, representing 50% of Analog revenues

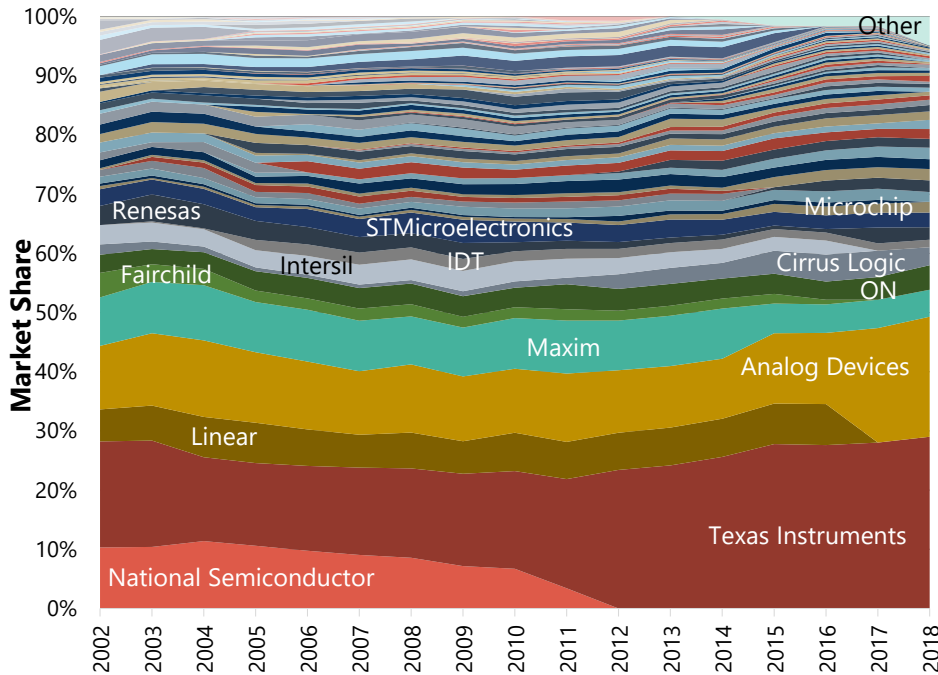
Data Converters, Switches and Multiplexes segment account for 20% of the Analog market

Amplifiers and Other Analog represent 30%. Within Amplifiers and Other Analog, Amplifiers comprise 60%+ of the Amplifiers & Other segment (based on market data from 2015)

Source: Jefferies, Gartner. Analog segments proportions calculated based upon revenue in 2017, latest actual full year data.

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Chart 22 - Total Analog Market Share



Source: Jefferies, Gartner. Analog market share calculated based upon revenue.

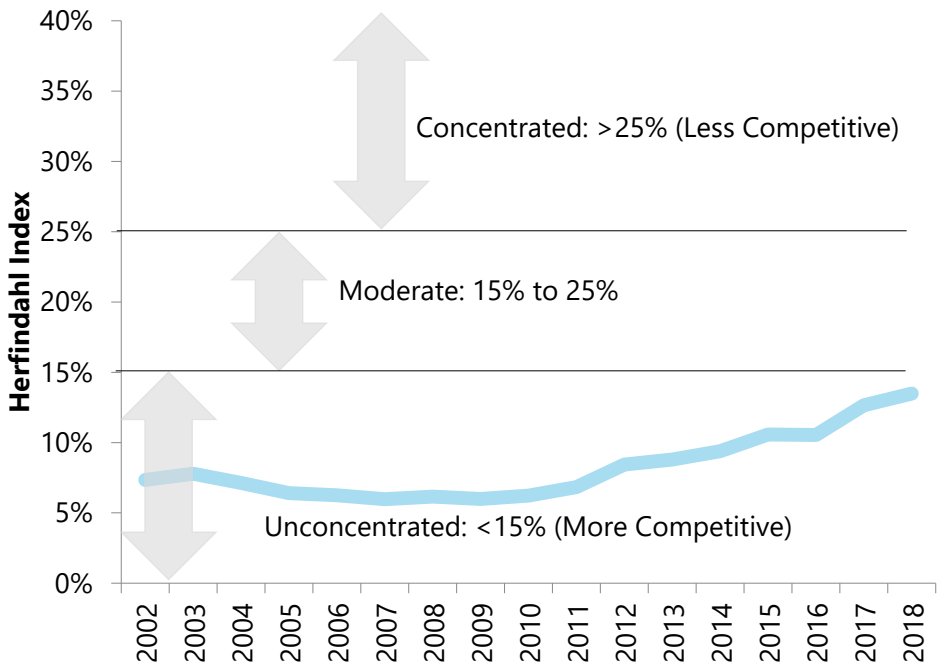
The Total Analog market has consolidated over the last 10 years. Notable acquisitions that have changed the competitive landscape:

- Texas Instruments + National Semi
- ON + Fairchild
- Linear + Analog Devices
- Richtech + MediaTek
- Renesas + Intersil + Integrated Devices

We expect the analog industry to become even more concentrated over the next 5-to-10 years

Companies with 1.0-2.5% market share in declining order are MediaTek, Monolithic Power Systems, Infineon, Power Integrations, NXP, Nisshinbo, Sanken, Qualcomm, Diodes and Minebea Mitsumi.

Chart 23 - Total Analog Herfindahl Index



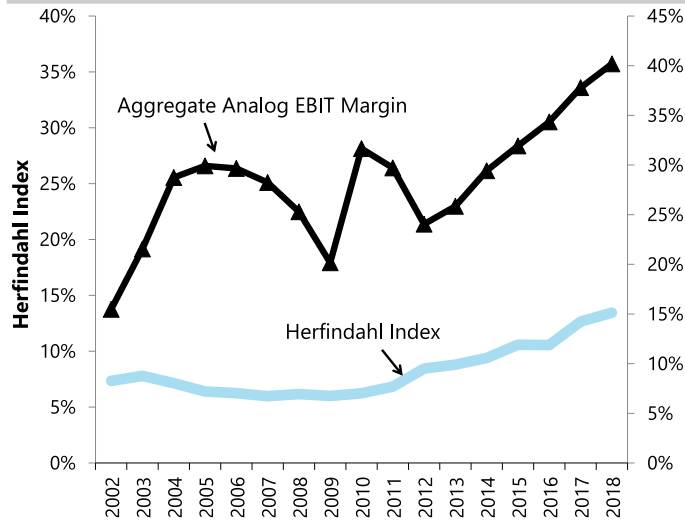
Source: Jefferies, Gartner. The Herfindahl Index is calculated by summing the squares of the market shares of top 50 industry participants

Total Analog segment HHI has increased to 13.5% from 6.0% over the last 10 years, which we think explains a lot of the positive pricing commentary from and margin expansion at the analog companies.

On an aggregate basis, the HHI is still low, which suggests there is a lot more consolidation to go.

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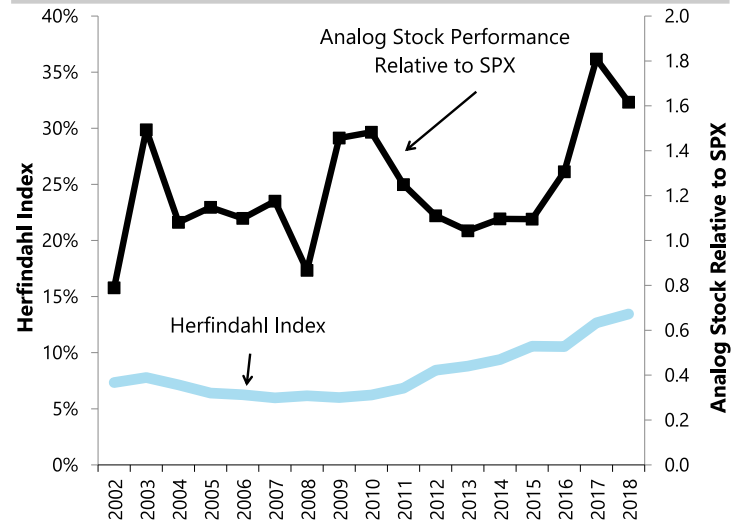
Chart 24 - Analog Herfindahl Index vs. Analog EBIT Margin



Source: Jefferies, Gartner, FactSet. Average Analog EBIT margin calculation includes ADI+LLTC, MXIM, ON+FCS and TXN.

Consistent with previous case studies we have published on industry concentration (See Appendix 3 for HDD and DRAM case studies), analog EBIT margins have increased as the industry consolidated

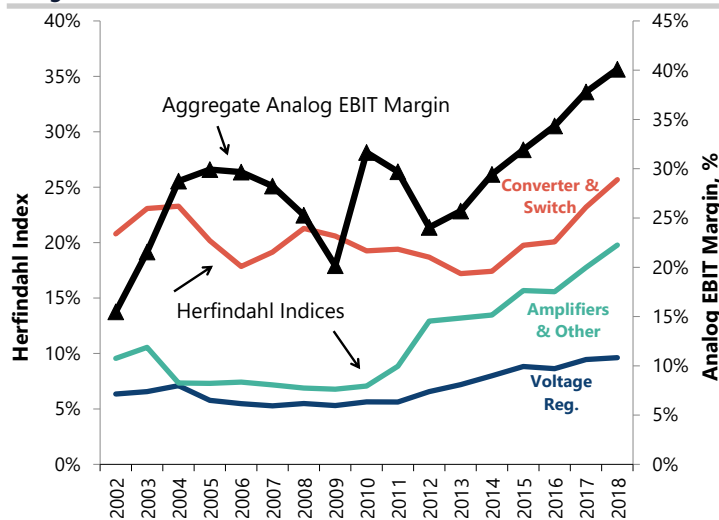
Chart 25 - Analog Herfindahl Index vs Relative Stock Performance



Source: Jefferies, Gartner, FactSet. Average Analog stock performance calculation includes ADI+LLTC, MXIM, ON+FCS and TXN. Relative performance is indexed to December 31, 2001.

Also consistent with our HDD and DRAM case studies (see Appendix 3), analog stock performance has outperformed the S&P500 as it has become more concentrated

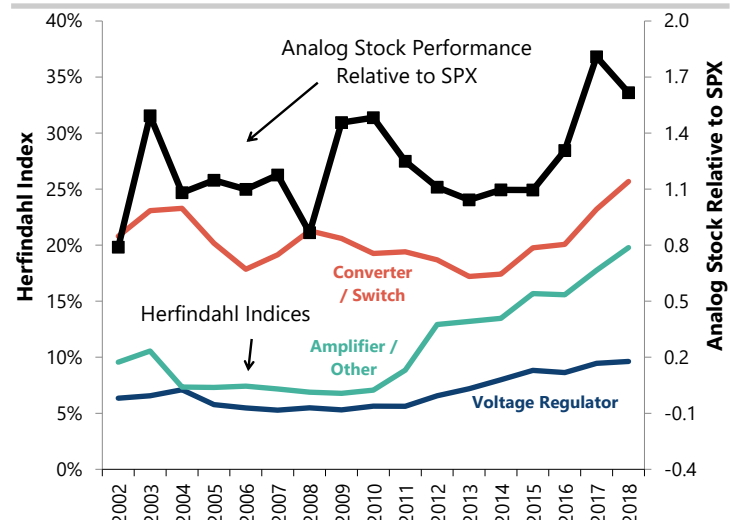
Chart 26 - Analog Segments Herfindahl Indices vs. Analog EBIT Margin



Source: Jefferies, Gartner, FactSet. Average Analog EBIT margin calculation includes ADI+LLTC, MXIM, ON+FCS and TXN.

On a segment level within the analog industry, Converter & Switch and Amplifier & Other have seen the most consolidation over the past 5-to-10 years, which we think will particularly benefit TXN and ADI over the next 5-10 years, given their 5-10 year product cycles

Chart 27 - Analog Segments Herfindahl Index vs Relative Stock Performance



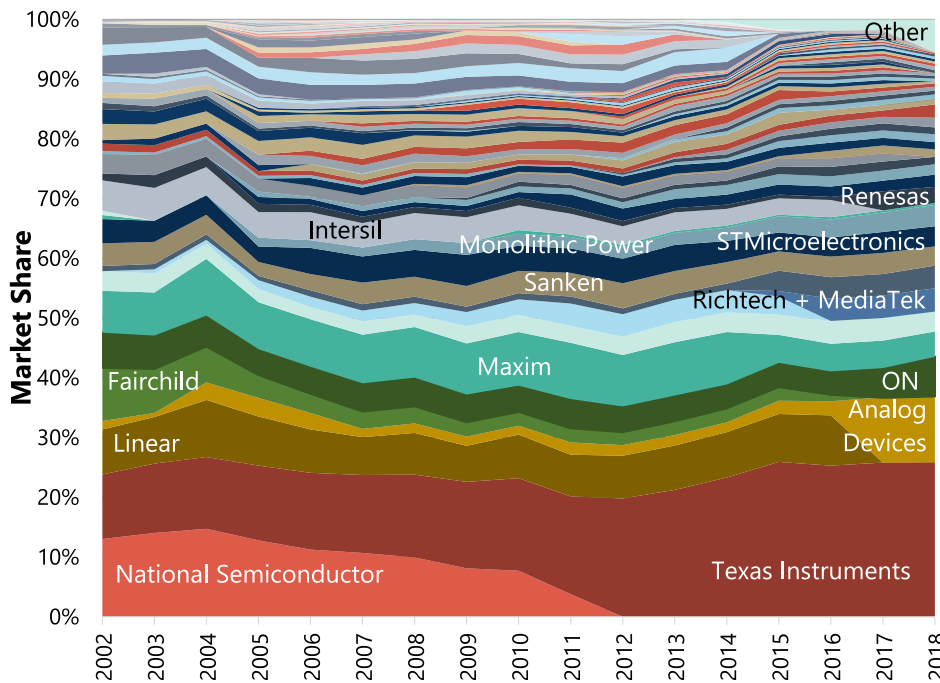
Source: Jefferies, Gartner, FactSet. Average Analog stock performance calculation includes ADI+LLTC, MXIM, ON+FCS and TXN. Relative performance is indexed to December 31, 2001.

Analog stocks have outperformed the industry as the HHI has increased

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2.2. Voltage Regulator / Reference Concentration Analysis

Chart 28 - Voltage Regulator / Reference Market Share



The Voltage Regulator market is the largest and the most fragmented analog segment but it is still consolidating. Notable acquisitions that have changed the competitive landscape:

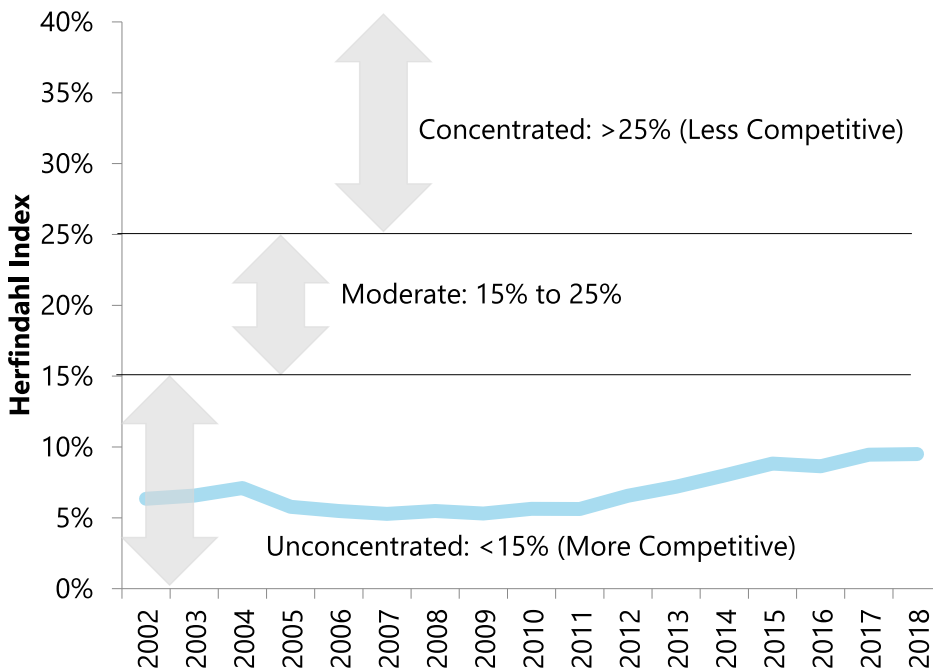
- Texas Instruments + National Semi
- ON + Fairchild
- Linear + Analog Devices
- Richtech + MediaTek
- Renesas + Intersil

TXN and ADI are the market leaders with 26% and 11% share

Others with 1.0-2.0% market share in declining order are Nisshinbo, Minebea Mitsumi, Diodes, Dialog Semiconductor, Lite-On Semiconductor, MCHP, Ablic, Cirrus Logic, Qualcomm

Source: Jefferies, Gartner. Analog market share calculated based upon revenue.

Chart 29 - Voltage Regulator / Reference Herfindahl Index



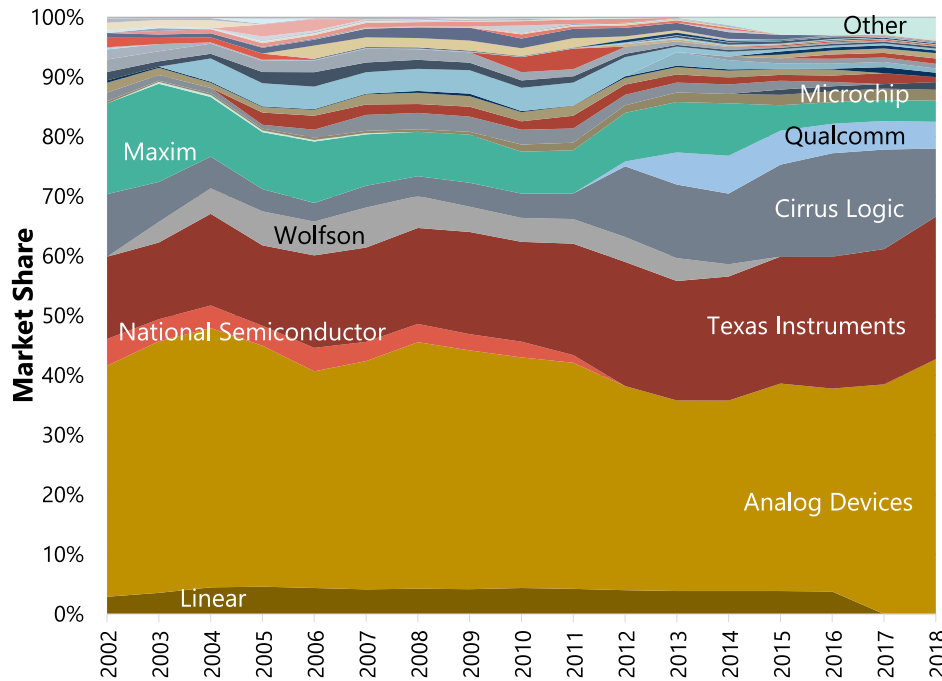
The HHI index for Voltage Regulator / Reference segment of Analog Market was 9.6% in 2018, up from 5.3% in 2009

Source: Jefferies, Gartner. The Herfindahl Index is calculated by summing the squares of the market shares of top 50 industry participants.

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2.3. Data Converter / Switch / Multiplexer Concentration Analysis

Chart 30 - Data Converter / Switch / Multiplexer Market Share



Data Converter/Switch is the most concentrated analog segment. Notable acquisitions that have changed the competitive landscape:

- Analog Devices + Linear
- Texas Instruments + National Semi
- Cirrus Logic + Wolfson
- On + Fairchild

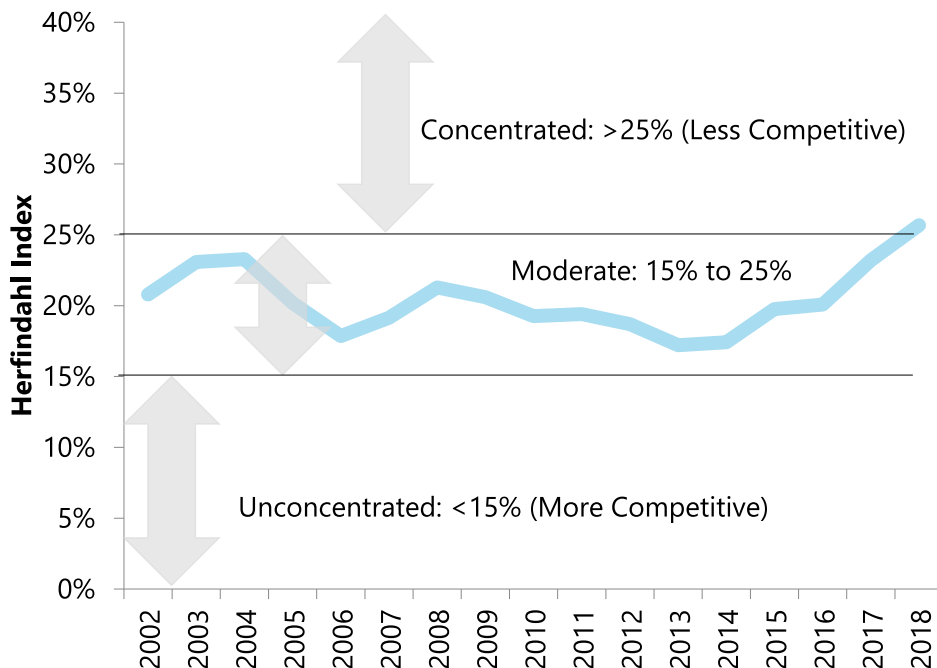
Analog Devices has 43% share of the market, while Texas Instruments controls 24% of the market. Notably, for the period 2002-2018, TXN increased market share by 10%, while ADI gained 4%

ADI and TXN are the market leaders with 43% and 24% share.

Others with 0.5%-1.0% market share in declining order are CEC Huada Semiconductor, Mercury Systems, Diodes, ON Semiconductor, Cobham, Renesas, Toshiba and Nuvoton Technology.

Source: Jefferies, Gartner. Analog market share calculated based upon revenue.

Chart 31 - Data Converter / Switch / Multiplexer Herfindahl Index



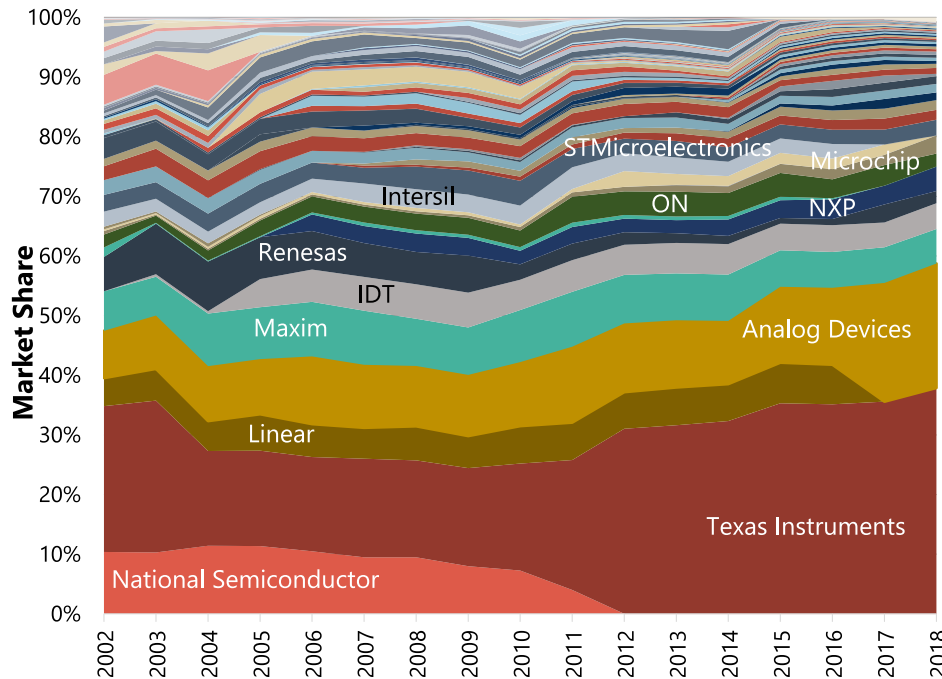
The Data Converter / Switch / Multiplex HHI is at 26%, up from 17% in 2013, crossing into "Concentrated" HHI level

Source: Jefferies, Gartner. The Herfindahl Index is calculated by summing the squares of the market shares of top 50 industry participants.

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2.4. Amplifiers and Other Analog Concentration Analysis

Chart 32 - Amplifiers and Other Analog Market Share



The other Analog segment includes Amplifiers, Comparators, Interface, Clock, Timing and Other Analog.

Notable acquisitions that have changed the competitive landscape:

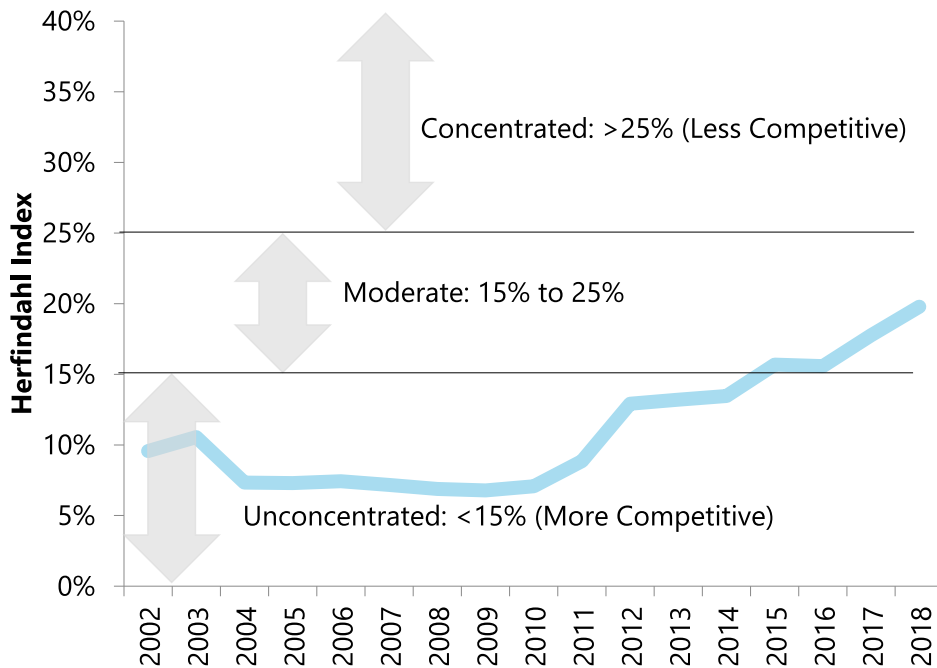
- Analog Devices + Linear Technology
- Texas Instruments + National Semi.
- Renesas + Intersil
- NXP + Freescale
- On + Fairchild
- Rohm + Poweration

TXN and ADI have the leading market shares with 38% and 21%, respectively

Others with 1.0% - 1.7% market share in declining order are Silicon Laboratories, Skyworks Solutions, Nisshinbo, Diodes, MegaChips, Toshiba, Rohm, Mercury Systems and Cobham

Source: Jefferies, Gartner. Analog market share calculated based upon revenue.

Chart 33 - Amplifiers and Other Analog Herfindahl Index



This segment has seen the greatest consolidation over the past 8 years with 1270bps increase in its HHI since 2010

Source: Jefferies, Gartner. The Herfindahl Index is calculated by summing the squares of the market shares of top 50 industry participants.

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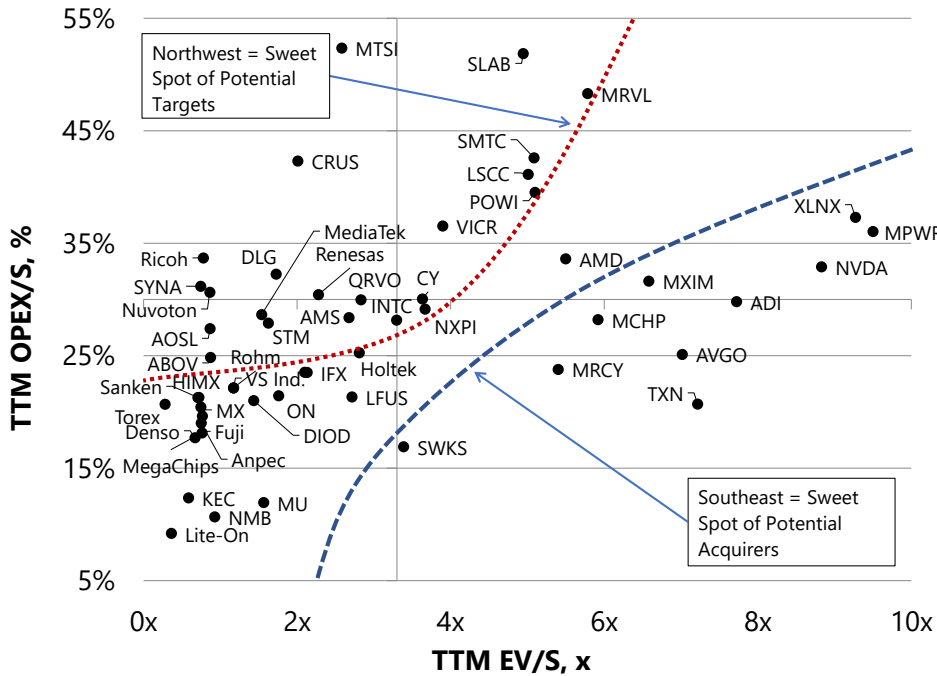
Section 3. M&A Analysis

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Section 3. M&A Analysis

Chart 34 - Framework for Identifying Potential M&A Targets and Acquirers - Total Analog Market

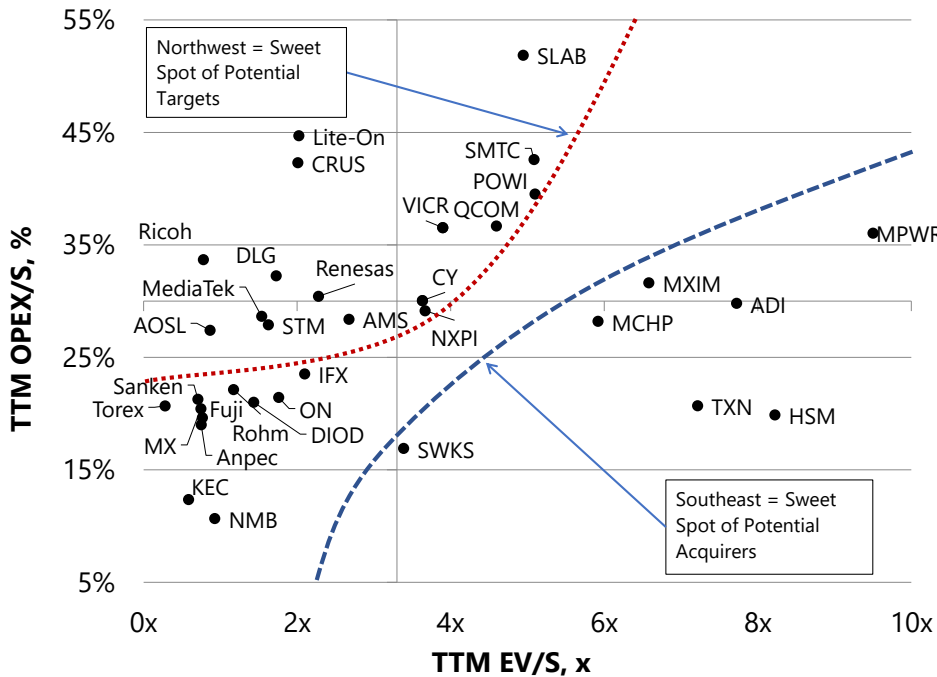
According to our semi M&A framework (See note Semis M&A Handbook: More to Come), semiconductor M&A often succeeded when companies with low cost structure and higher valuation (Southeast on chart) acquired companies with high cost structure and low valuations (Northwest on chart). By acquiring Northwest, acquirers can win twice: 1) lower costs and increase earnings, and 2) get a better multiple on the higher earnings stream.



Source: Jefferies, FactSet

Chart 35 - Framework for Identifying Potential M&A Targets and Acquirers - Voltage Reg/Ref Segment

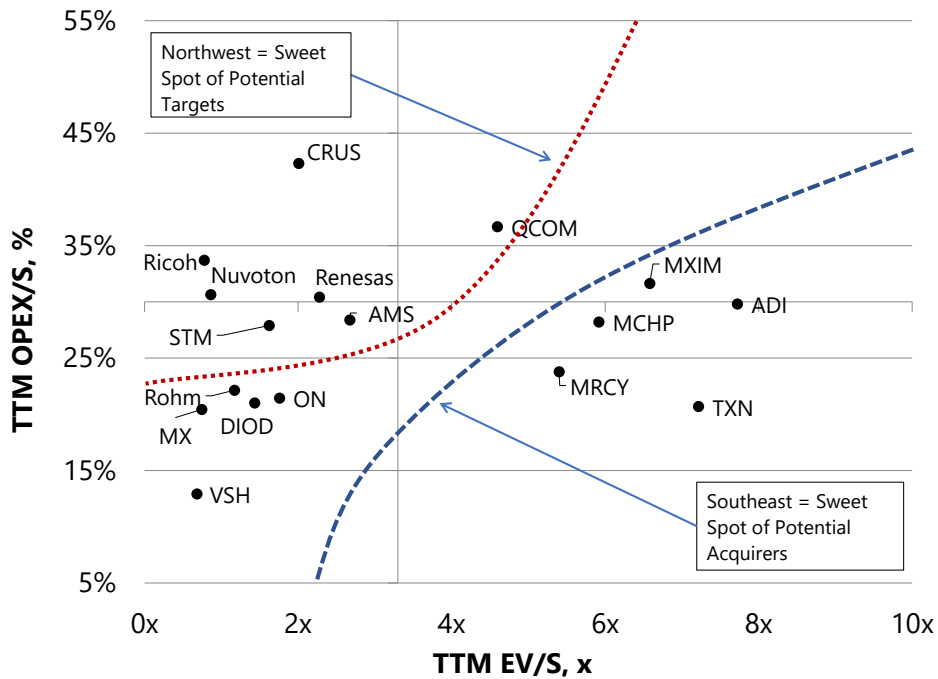
Within Voltage Regulator / Reference space our framework suggests that SLAB, SMTC, POWI, VICR, Lite-on, CRUS, AMS, DLG, Ricoh, MediaTek and AOSL might be attractive targets.



Source: Jefferies, FactSet

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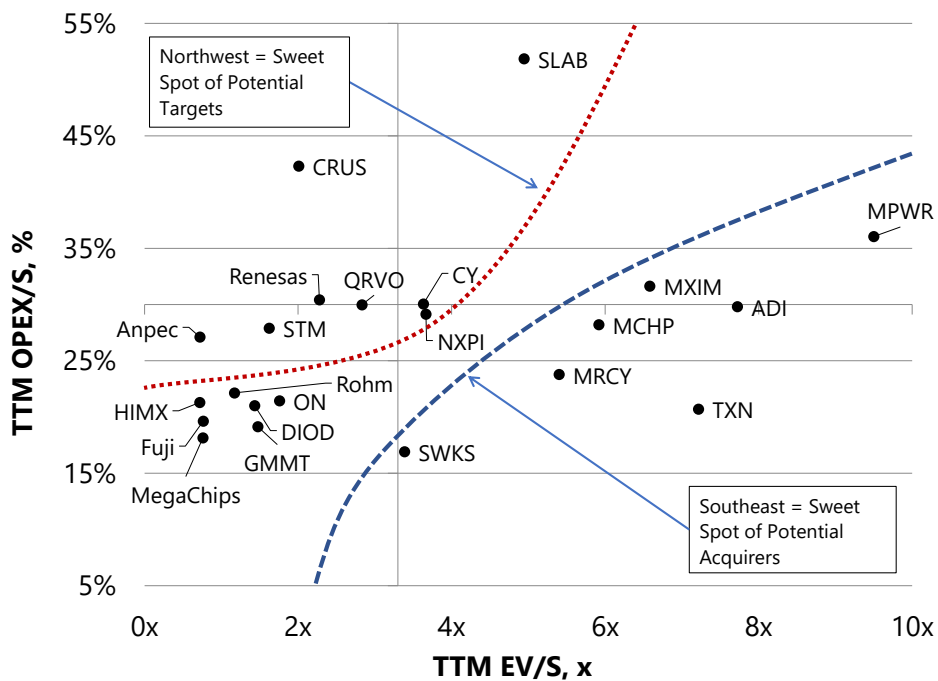
Chart 36 - Framework for Identifying Potential M&A Targets and Acquirers - Data Converter/Switch/Multiplexer Segment



Data Converter / Switch / Multiplexer is moderately concentrated according to our HHI analysis, but also has fewer public players. Our M&A framework suggests that CRUS, AMS, Ricoh and Nuvoton might be attractive candidates in this segment.

Source: Jefferies, FactSet

Chart 37 - Framework for Identifying Potential M&A Targets and Acquirers - Amplifier and Other Analog Segment



The Amplifier and Other Analog segment has recently reached moderate concentration levels according to our HHI analysis and similarly to Data Converter / Switch / Multiplexer has fewer potential public targets. Our framework agrees CY could be a good target (recently announced to be acquired by IFX), and SLAB, CRUS and Anpec might be attractive targets.

Source: Jefferies, FactSet

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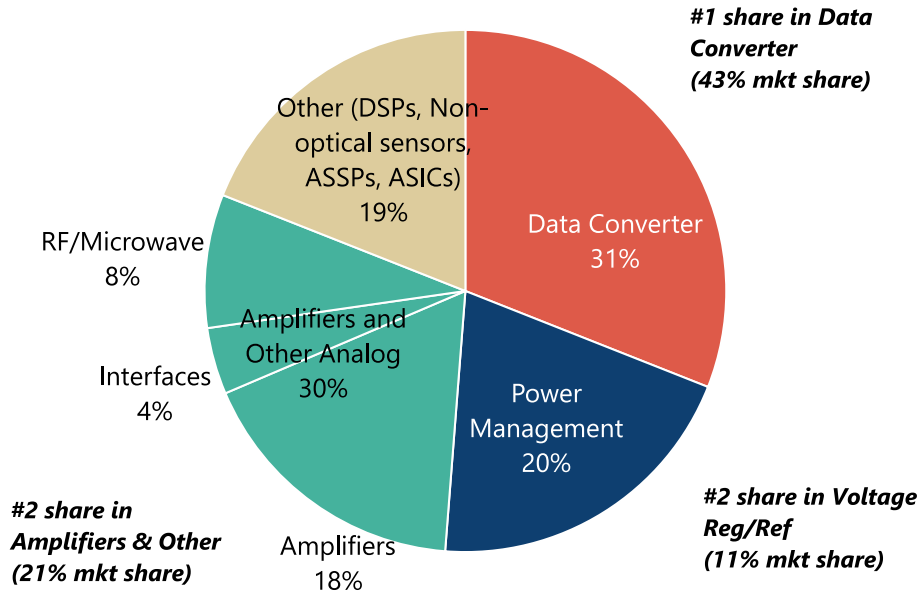
Section 4. Analog Players' EPS Sensitivity Analysis

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Section 4. Analog Players' EPS Sensitivity Analysis

4.1. ADI Sensitivity Analysis

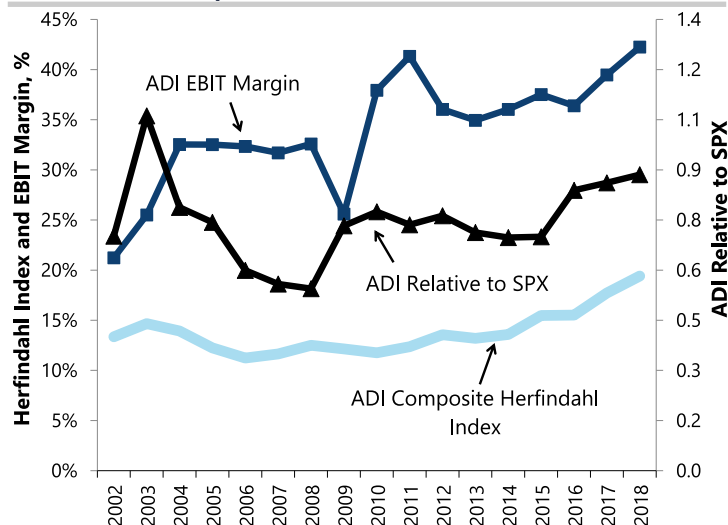
Chart 38 - ADI Revenue Split



Based on data provided by ADI, we estimate that Data Converter is the largest analog segment for the company, followed by Amplifiers and Other Analog and then by Power Management (Voltage Reg/Ref). We note that "Other" category includes some analog devices that fall outside of the general purpose analog devices categories.

Source: Jefferies, ADI, Gartner. Revenue split provided based on ADI segment data split provided in 2017 overlaid with Gartner revenue estimates for 2017.

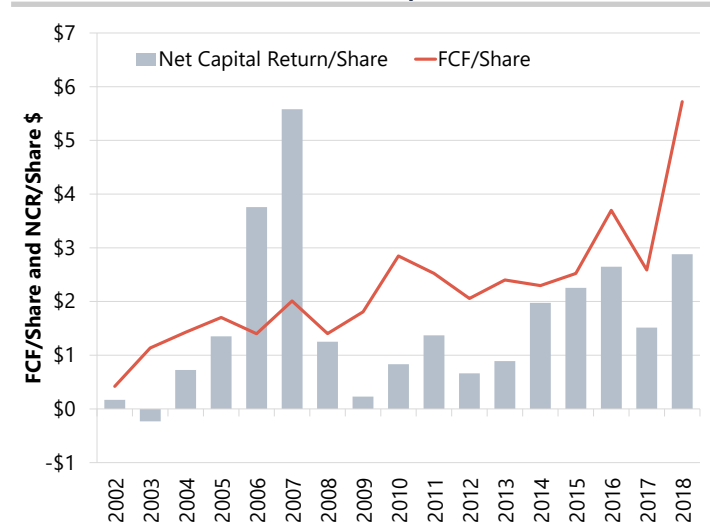
Chart 39 - ADI Composite HHI, EBIT and Stock



Source: Jefferies, Gartner, FactSet; Composite HHI calculated from Analog. Performance Relative to SPX is calculated from 31-Dec-01.

Over the past 10 years, ADI's Composite HHI increased by 690bps, its EBIT increased by 1,000bps and its stock outperformed SPX by 174%.

Chart 40 - ADI FCF/Share and Net Capital Return/Share

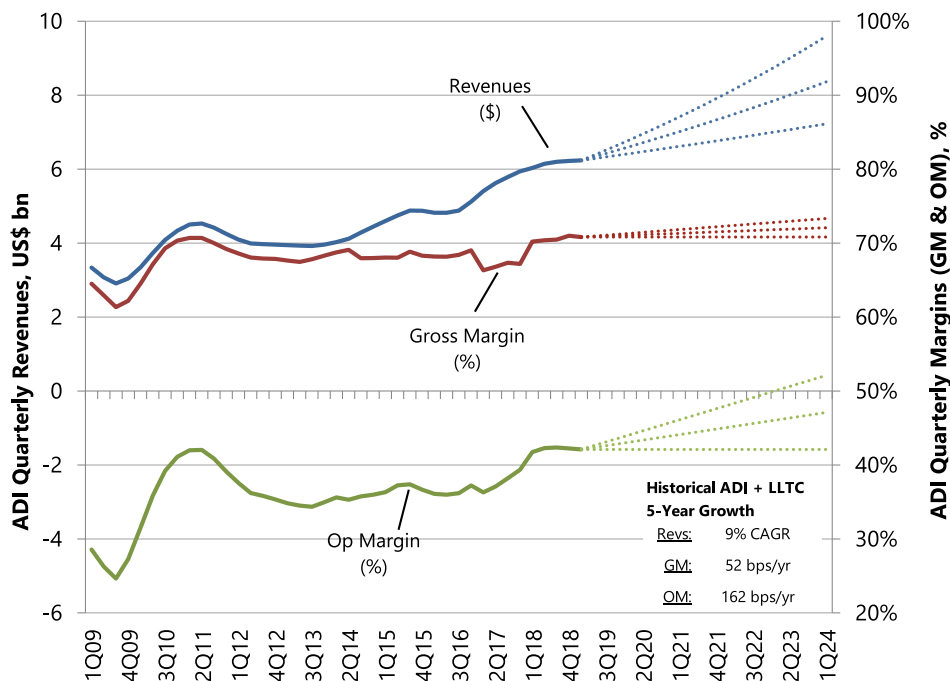


Source: Jefferies, company data

ADI FCF/share doubled over the past 3 years and increased steadily over the past 16 years, through the great recession and six inventory corrections. ADI's capital return fell below FCF/share as it delevered from its LLTC acquisition.

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Chart 41 - ADI Revenue and Margins, Historical and Forecast (TTM)



Source: Jefferies, company data, FactSet

Chart 42 - ADI EPS 3-yr and 5-yr Sensitivity Analysis

3 year

ADI Op Margin Expansion:	Revenue Growth		
	3%	6%	9%
0bps	\$ 6.10	\$ 6.70	\$ 7.33
100bps	\$ 6.59	\$ 7.23	\$ 7.90
200bps	\$ 7.07	\$ 7.75	\$ 8.47

5 year

ADI Op Margin Expansion:	Revenue Growth		
	3%	6%	9%
0bps	\$ 6.68	\$ 7.79	\$ 9.04
100bps	\$ 7.55	\$ 8.80	\$ 10.20
200bps	\$ 8.43	\$ 9.81	\$ 11.36

Source: Jefferies, company data, FactSet

Over the past five years, ADI and LLTC pro-forma revenues have increased at 9% CAGR, while gross and operating margins have expanded by 52 bps/yr and 162 bps/yr, respectively.

In the chart to the left, we show actual pro-forma TTM revenue, gross and operating margins through C1Q19, and forecasted bear, base and bull case projections for each for the next 5 years.

ADI's target model of 70%-plus GM and OM of 39%-45% is in-line with our 5yr base case GM and slightly more conservative than our OM base case.

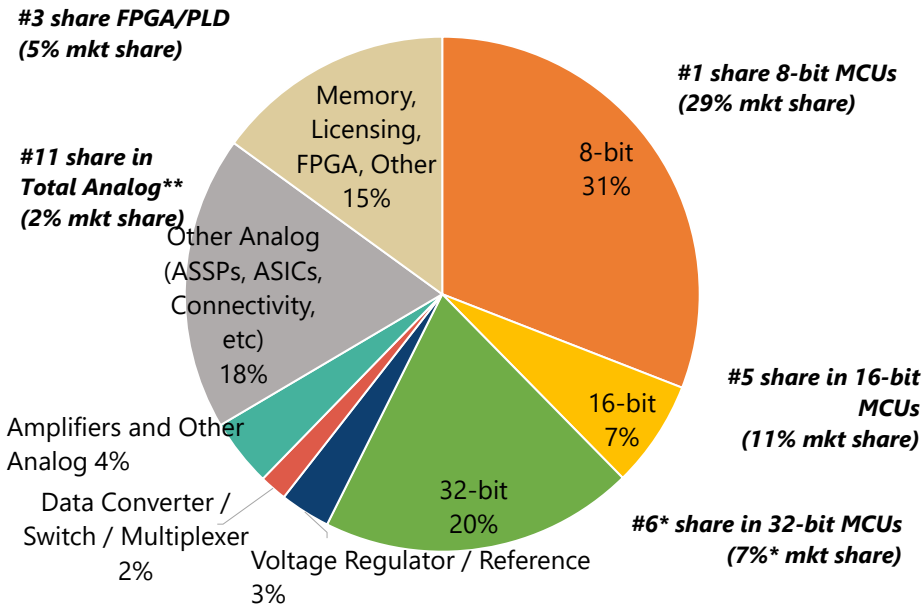
Our 3-yr and 5-yr base case for EPS assumes 6% revenue CAGR and a 100 bps/yr improvement in operating margins. Our 3-yr and 5-yr bull case assumes 9% revenue CAGR and a 200 bps/yr improvement in operating margins.

Our 5-yr base and bull case targets translate to EPS that is 67% and 116% higher than CY19 consensus estimates of \$5.27.

4.2. MCHP Sensitivity Analysis

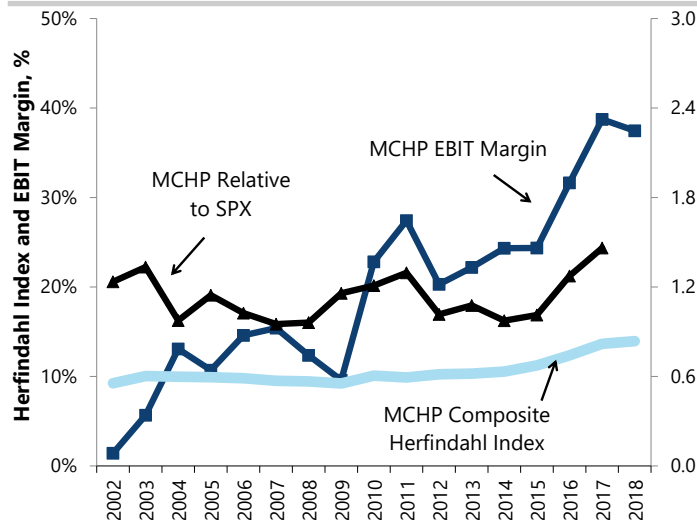
Chart 43 - MCHP Revenue Split (2018)

We estimate analog revenues at 25-30% of MCHP sales and MCUs at 55-60% of its sales.



Source: Jefferies, company data, Gartner. Revenue split provided based on MCHP data and Gartner estimates; MCHP 2018 reported revenue is significantly above Gartner estimates

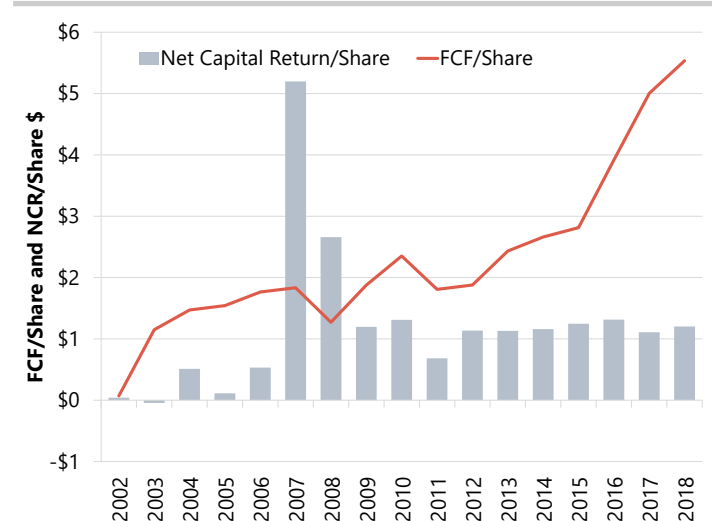
Chart 44 - MCHP Composite HHI, EBIT and Stock



Source: Jefferies, Gartner, FactSet. Performance Relative to SPX is calculated from 31-Dec-01. Composite HHI calculated from Analog and subsegment MCU

Over the past 10 years MCHP's Composite HHI has increased by 450bps, its EBIT margin increased by 2,510bps and its stock outperformed the SPX by 143%

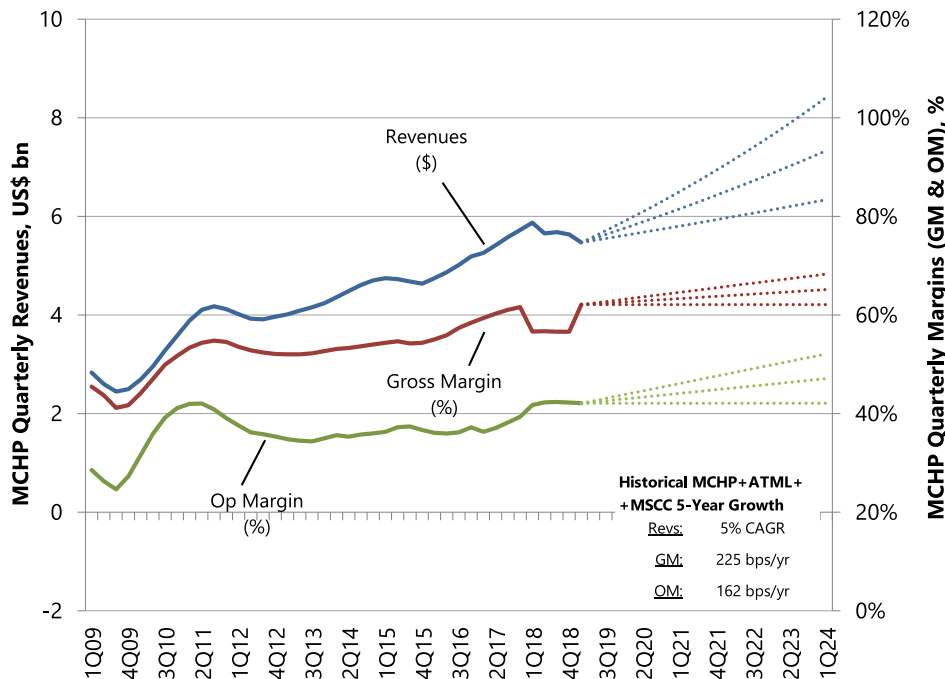
Chart 45 - MCHP FCF/Share and Net Capital Return/Share



Source: Jefferies, company data

MCHP's FCF/share doubled over the past 4 years and increased steadily over the past 16 years through the great recession and six inventory corrections. MCHP's main capital return vehicle is its dividend, as its main use of cash recently is to pay down debt from its MSCC acquisition

Chart 46 - MCHP Revenue and Margins, Historical and Forecast (TTM)



Source: Jefferies, company data, FactSet

Chart 47 - MCHP EPS 3-yr and 5-yr Sensitivity Analysis

3 year

MCHP		Revenue Growth		
Op Margin Expansion:		3%	6%	9%
0bps	\$ 6.76	\$ 7.44	\$ 8.16	
100bps	\$ 7.37	\$ 8.10	\$ 8.88	
200bps	\$ 7.98	\$ 8.77	\$ 9.60	

5 year

MCHP		Revenue Growth		
Op Margin Expansion:		3%	6%	9%
0bps	\$ 6.99	\$ 8.19	\$ 9.53	
100bps	\$ 8.03	\$ 9.39	\$ 10.91	
200bps	\$ 9.07	\$ 10.59	\$ 12.29	

Source: Jefferies, company data, FactSet

Over the past five years, MCHP and ATML, MSCC pro-forma revenues have increased at a 5% CAGR, while gross and operating margins have expanded by 225 bps/yr and 162 bps/yr, respectively

In the chart to the left, we show actual TTM revenue, gross and operating margins through C1Q19, and forecasted bear, base and bull case projections for each for the next 5 years

MCHP's long term model is 63% non-GAAP GM and 40.5% OM, which we view as conservative

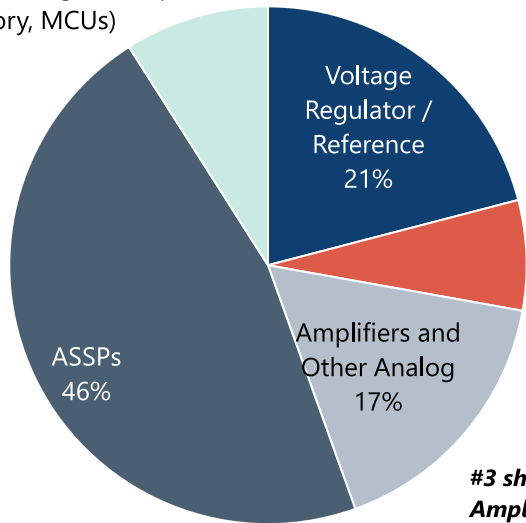
Our 3-yr and 5-yr base case for EPS assumes 6% revenue CAGR and a 100 bps/yr improvement in operating margins. Our 3-yr and 5-yr bull case assumes 9% revenue CAGR and a 200 bps/yr improvement in operating margins

Our 5-yr base and bull case targets translate to EPS that is 52% and 99% higher than CY19 consensus estimates of \$6.18

4.3. MXIM Sensitivity Analysis

Chart 48 - MXIM: Revenue Split

Non-Analog (non-optical sensors, memory, MCUs) 9%



#4 share in Voltage Reg/Ref (4% mkt share)

Data Converter / Switch / Multiplexer 7%

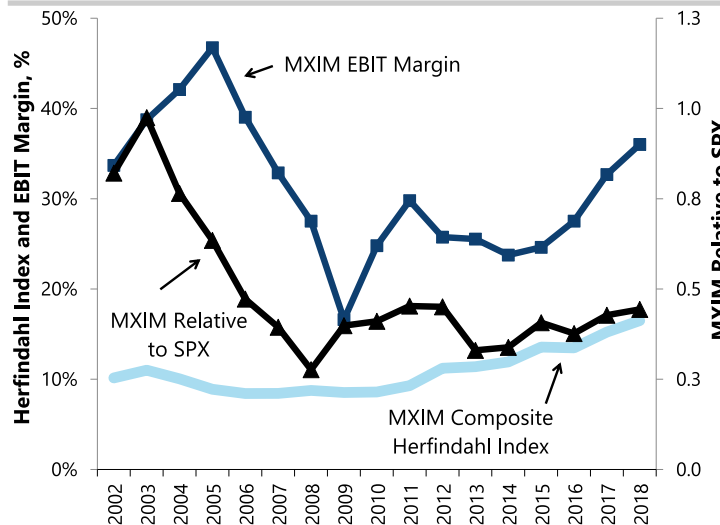
#5 share in Data Converter (4% mkt share)

#3 share in Amplifiers & Other (6% mkt share)

Analog represents ~90% of the MXIM's revenues. According to Gartner, MXIM holds the #3 market share position in Total Analog and the #3-5 positions in all analog segments. In Amplifiers & Other, it holds the #3 position with 6% market share. ASSPs reflect mostly analog devices that do not fall into the general purpose device category

Source: Jefferies, Gartner, company data

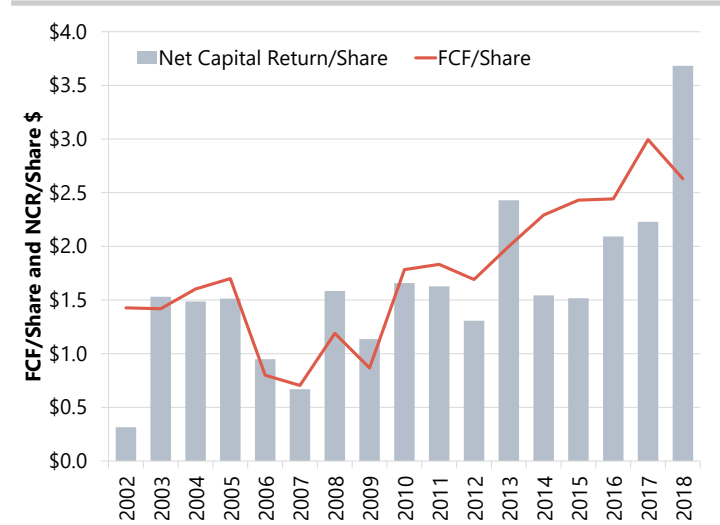
Chart 49 - MXIM Composite HHI, EBIT and Stock



Source: Jefferies, Gartner, FactSet, Composite HHI calculated from Analog. Performance Relative to SPX is calculated from 31-Dec-01.

Over the past 10 years MXIM's Composite HHI has increased by 775bps, its EBIT margin increased by 849bps and its stock outperformed the SPX by 168%

Chart 50 - MXIM FCF/Share and Net Capital Return/Share

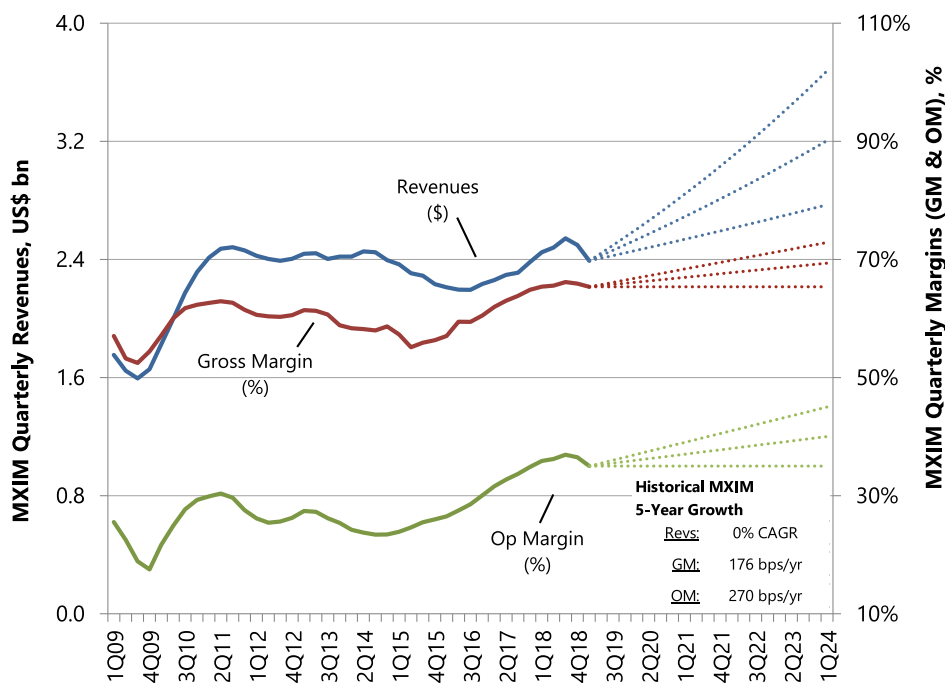


Source: Jefferies, company data

Over the past 10 years MXIM's FCF/share more than doubled during multiple inventory corrections. MXIM's capital return exceeded its FCF/share due to its excess cash

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Chart 51 - MXIM Revenue and Margins, Historical and Forecast (TTM)



Source: Jefferies, company data, FactSet

Chart 52 - MXIM EPS 3-yr and 5-yr Sensitivity Analysis

3 year

MXIM Op Margin Expansion:	Revenue Growth		
	3%	6%	9%
0bps	\$ 2.66	\$ 2.90	\$ 3.15
100bps	\$ 2.90	\$ 3.16	\$ 3.43
200bps	\$ 3.14	\$ 3.41	\$ 3.71

5 year

MXIM Op Margin Expansion:	Revenue Growth		
	3%	6%	9%
0bps	\$ 2.86	\$ 3.30	\$ 3.79
100bps	\$ 3.29	\$ 3.79	\$ 4.35
200bps	\$ 3.71	\$ 4.28	\$ 4.91

Source: Jefferies, company data, FactSet

Over the past five years, MXIM revenues remained flat, while gross and operating margins have expanded by 176 bps/yr and 270 bps/yr, respectively

In the chart to the left, we show actual TTM revenue, gross and operating margins through 4Q18, and forecasted bear, base and bull case projections for each for the next 5 years

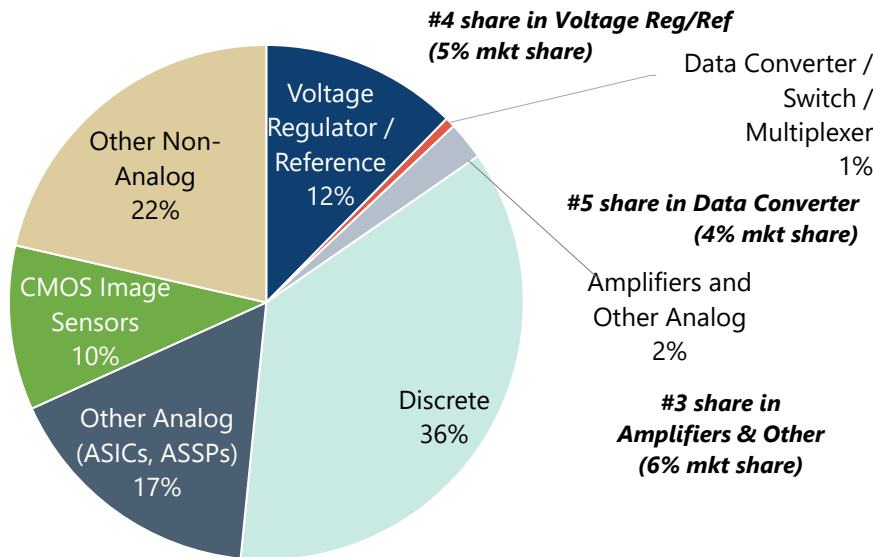
MXIM's target model is 70% GM and 40% OM is in-line with our base case scenario

Our 3-yr and 5-yr base case for EPS assumes 6% revenue CAGR and a 100 bps/yr improvement in operating margins. Our 3-yr and 5-yr bull case assumes 9% revenue CAGR and a 200 bps/yr improvement in operating margins

Our 5-yr base and bull case targets translate to EPS that is 50% and 94% higher than CY19 consensus estimates of \$2.53

4.4. ON Sensitivity Analysis

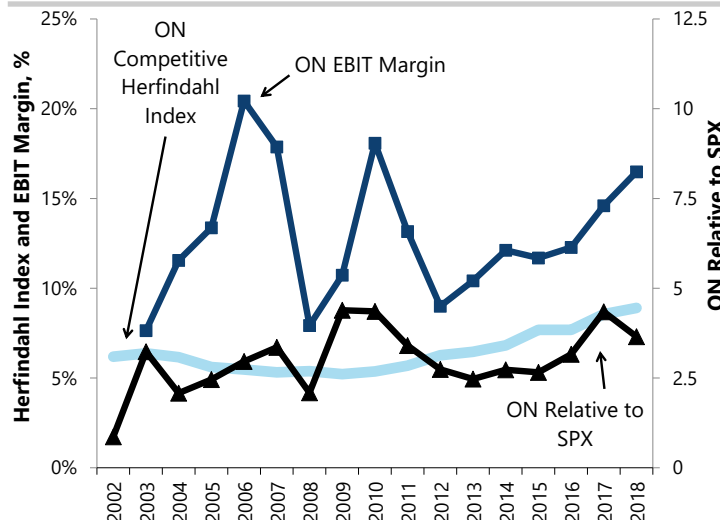
Chart 53 - ON: Revenue Split



ON has about 30-35% exposure to the analog market, along with high relative share in auto image sensors and #2 share in discretes, behind only IFX

Source: Jefferies, Gartner, company data

Chart 54 - ON Composite HHI, EBIT and Stock

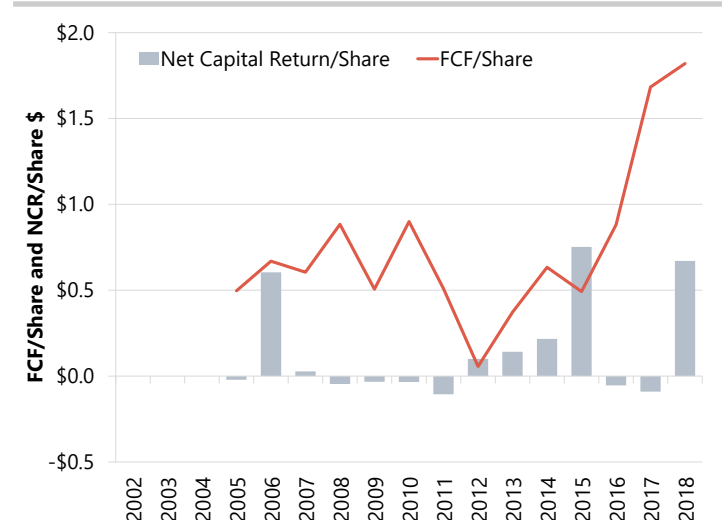


Source: Jefferies, Gartner, FactSet. Composite HHI calculated from Analog and Discrete. Performance Relative to SPX is calculated from 31-Dec-01.

Over the past 10 years ON's composite HHI has increased by 350bps, its EBIT margin increased by 856bps; meanwhile the stock has outperformed the SPX by 208%

After Sanyo in 2011 and managing the impact of a tsunami, nuclear disaster and floods, ON's EBIT margins bottomed in 2012 and have improved by 750bps. We expect OMs to expand another 600bps

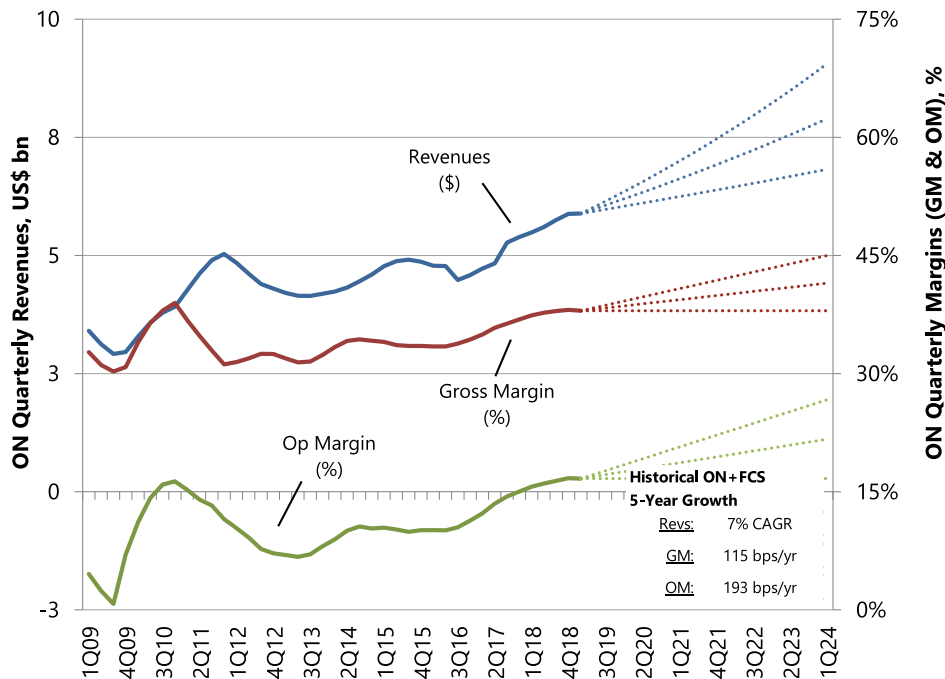
Chart 55 - ON FCF/Share and Net Capital Return/Share



Source: Jefferies, company data

ON's FCF/share has doubled over its baseline 10 years ago as it successfully integrated FCS. The company started returning cash to shareholders again in 2019 as it approached its target leverage ratio

Chart 56 - ON Revenue and Margins, Historical and Forecast (TTM)



Source: Jefferies, company data, FactSet

Over the past five years, ON and FCS performance revenues have increased at a 7% CAGR, while gross and operating margins have expanded by 115 bps/yr and 193 bps/yr, respectively

In the chart to the left, we show actual TTM revenue, gross and operating margins through C1Q19, and forecasted bear, base and bull case projections for each for the next 5 years

ON's 2022 target model of 43% GM and 22% OM is in-line with our base case on the OM, and falls in-between our base and bull cases on GM

Chart 57 - ON EPS 3-yr and 5-yr Sensitivity Analysis

3 year

ON Op Margin Expansion:	Revenue Growth		
	3%	6%	9%
0bps	\$ 1.81	\$ 1.99	\$ 2.18
100bps	\$ 2.18	\$ 2.39	\$ 2.62
200bps	\$ 2.55	\$ 2.80	\$ 3.06

Our 3-yr and 5-yr base case for EPS assumes 6% revenue CAGR and a 100 bps/yr improvement in operating margins. Our 3-yr and 5-yr bull case assumes 9% revenue CAGR and a 200 bps/yr improvement in operating margins

Our 5-yr base and bull case targets translate to EPS that is 70% and 146% higher than CY19 consensus estimates of \$1.78

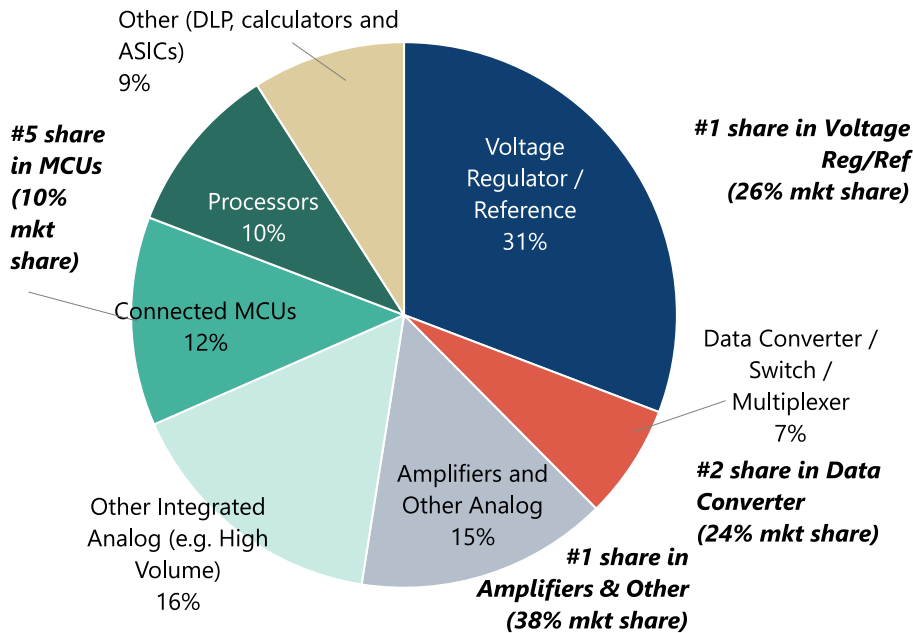
5 year

ON Op Margin Expansion:	Revenue Growth		
	3%	6%	9%
0bps	\$ 1.93	\$ 2.26	\$ 2.62
100bps	\$ 2.59	\$ 3.02	\$ 3.50
200bps	\$ 3.25	\$ 3.78	\$ 4.38

Source: Jefferies, company data, FactSet

4.5. TXN Sensitivity Analysis

Chart 58 - TXN Revenue Split (2018)



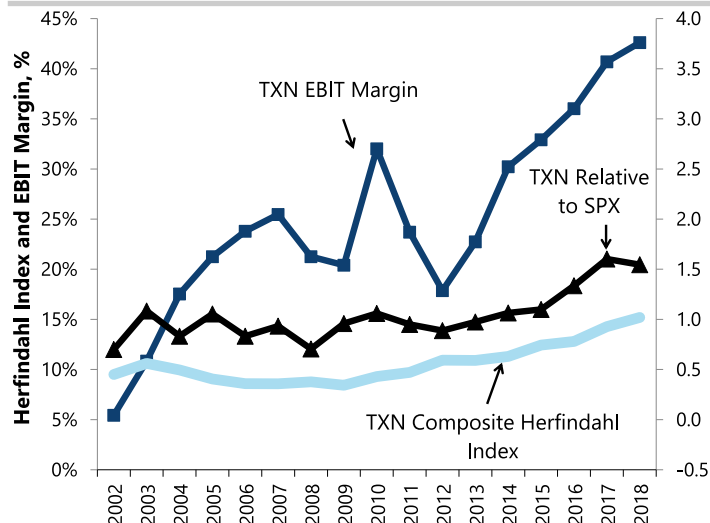
TXN reports Analog to represent 66% of the total revenues. Voltage Reg/Ref segment is the largest for TXN and represents ~30% of TXN's revenues, followed by Amplifiers & Other Analog. In both of these segments TXN holds the leading market share, while in Data Converter segment TXN is in second place after ADI

Notably TXN's market share in Amplifiers & Other Analog has increased by 2% from 2017 to 2018

Source: Jefferies, TXN, Gartner. Revenue split provided based on TXN 2018 segment and product line data.

Note: TXN reported the following revenues split for 2018: Analog - 66%, Embedded Processing - 23% and Other - 9%.

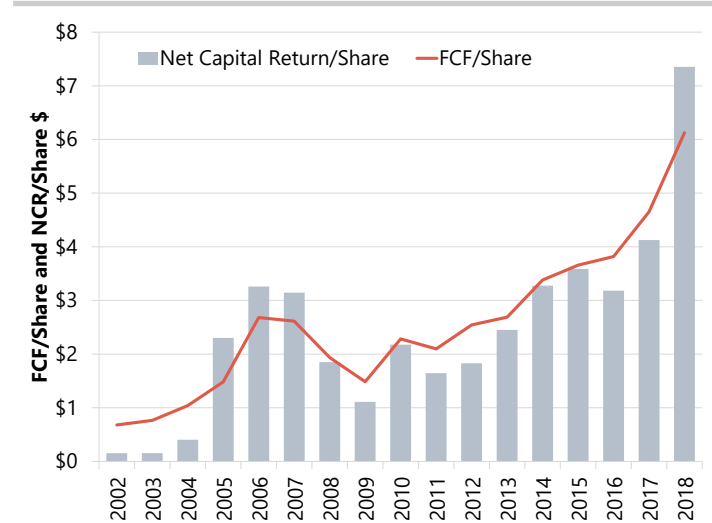
Chart 59 - TXN Composite HHI, EBIT and Stock



Source: Jefferies, Gartner, FactSet. Composite is calculated from Analog and MCU. Performance Relative to SPX is calculated from 31-Dec-01.

Over the past 10 years, TXN's Composite HHI increased by 643bps, its EBIT increased by 2,140bps and its stock outperformed SPX by 331%

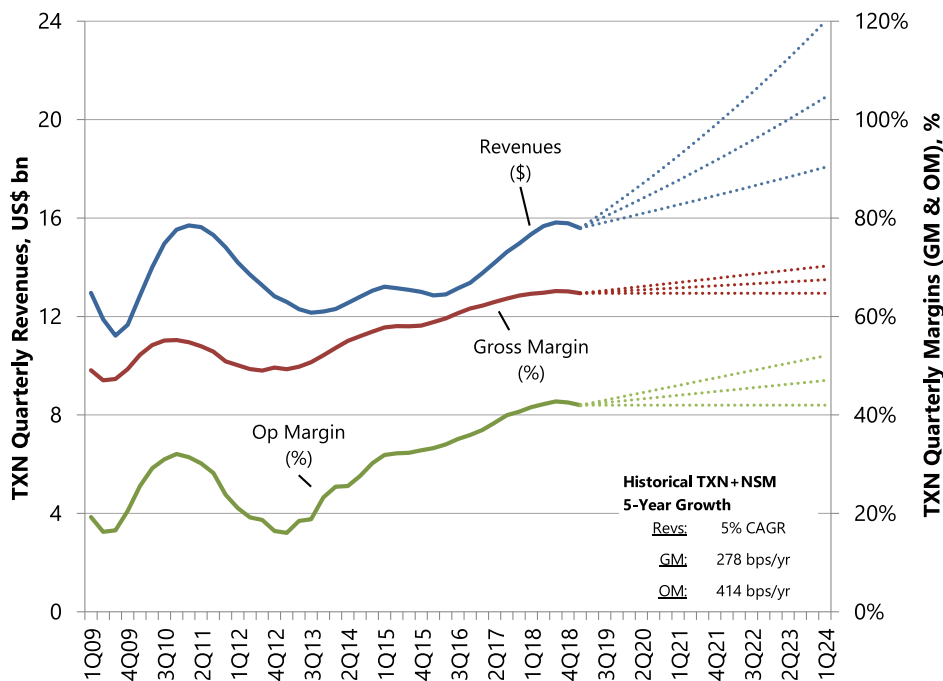
Chart 60 - TXN FCF/Share and Net Capital Return/Share



Source: Jefferies, company data

TXN's FCF/share doubled over the past 5 years and increased steadily over the past 16 years, through the great recession and six inventory corrections. TXN's capital return exceeded its FCF/share due to its excess cash

Chart 61 - TXN Revenue and Margins, Historical and Forecast (TTM)



Over the past five years, TXN revenues have increased at a 5% CAGR, while gross and operating margins have expanded by 278 bps/yr and 414 bps/yr, respectively

In the chart to the left, we show actual TTM revenue, gross and operating margins through 1Q19, and forecasted bear, base and bull case projections for each for the next 5 years

TXN does not provide the details on target margins

Source: Jefferies, company data, FactSet

Chart 62 - TXN EPS 3-yr and 5-yr Sensitivity Analysis

3 year

TXN Op Margin Expansion:	Revenue Growth		
	3%	6%	9%
0bps	\$ 5.94	\$ 6.47	\$ 7.04
100bps	\$ 6.38	\$ 6.96	\$ 7.56
200bps	\$ 6.83	\$ 7.44	\$ 8.09

Our 3-yr and 5-yr base case for EPS assumes 6% revenue CAGR and a 100bps/yr improvement in operating margins. Our 3-yr and 5-yr bull case assumes 9% revenue CAGR and a 200 bps/yr improvement in operating margins

Our 5-yr base and bull case targets translate to EPS that is 60% and 104% higher than CY19 consensus estimates of \$5.16

5 year

TXN Op Margin Expansion:	Revenue Growth		
	3%	6%	9%
0bps	\$ 6.36	\$ 7.34	\$ 8.43
100bps	\$ 7.15	\$ 8.25	\$ 9.48
200bps	\$ 7.94	\$ 9.16	\$ 10.53

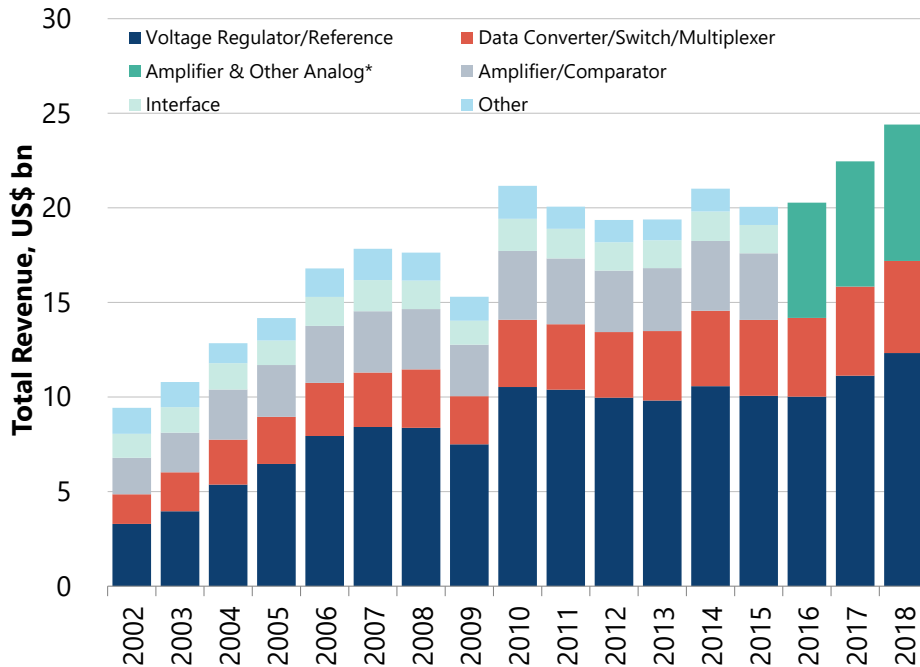
Source: Jefferies, company data, FactSet

Appendices

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Appendix 1. Analog Primer

Chart 63 - Analog Segments Revenue



Total Analog market has grown at 5%/3% CAGR for the 5/10 years

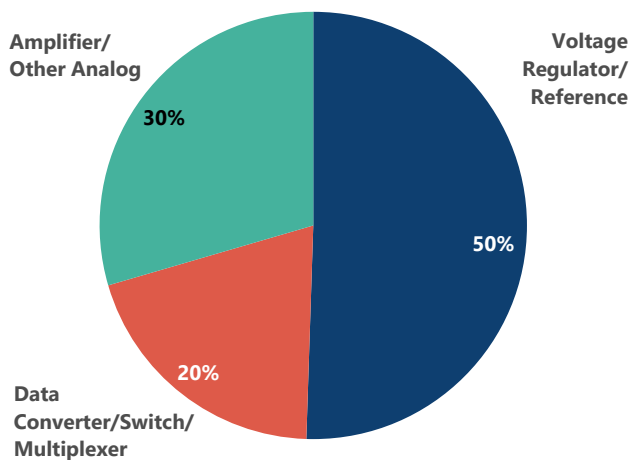
The Voltage Regulator / Reference segment has grown at a CAGR of 5%/4% for the past 5/10 years

Data Converter / Switch / Multiplexer has grown at 6%/5% CAGR for the same periods

Amplifier & Other Analog has grown at 4%/2% CAGR for the 5/10 years

Source: Gartner, *Amplifier & Other includes Amplifier/Comparator, Interface and Other after Gartner switched to aggregate presentation in 2015.

Chart 64 - Total Analog Market Segments Proportions



The largest segment of the Total Analog space is the Voltage Regulator/Reference segment, representing 50% of Analog revenues

Data Converters, Switches and Multiplexes account for 20% of the Analog market

Amplifiers and Other Analog represent 30%. Within Amplifiers and Other Analog, Amplifiers comprise 60%+ of the Amplifiers & Other segment (based on market data from 2015)

Source: Jefferies, Gartner. Analog segments proportions calculated based upon revenue in 2017, latest actual full year data.

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Chart 65 - Main Types of Analog Devices

Category	Analog Type of Device	Description
Voltage Regulator / Reference	Voltage Regulator	A circuit which is connected between the power source and a load, which provides a constant voltage despite variations in input voltage or output load.
	Voltage Reference	An electronic device which produces a constant voltage regardless of the loading on the device, temperature changes, passage of time and power supply variations.
Data Converter / Switch / Multiplexer	Data Converter	A/D or D/A converter: An electronic circuit that converts analog signals to digital, or vice-versa. An analog signal is a continuously varying voltage or current. Its digital counterpart is a stream of digital numbers, each representing the amplitude of the analog signal at a moment in time.
	Switch	A switching device capable of switching or routing analog signals based on the level of a digital control signal. Commonly implemented using a "transmission gate," an analog switch performs a function similar to that of a relay. For example, an analog switch can turn an audio signal on or off based on a MUTE signal; or analog switches could send one of two signals to a headphone amplifier. Most commonly implemented using CMOS technology integrated circuits.
	Multiplexer	An array of analog switches, usually on a single CMOS chip, that allows one input signal to be routed to any of several output lines, depending on the value of a set of digital control lines. A multiplexer can also be used in the opposite direction, allowing the array to connect one of several input lines to the output, depending on the control lines. Several of these can be implemented on one chip to make a multi-channel version.
Amplifier and Other Analog	Amplifier	An electrical circuit that produces an output that is a replica of the input. The output may be scaled or have increased drive, or it may provide isolation (so changes in output conditions do not affect the input or other outputs). It may perform other transformations (e.g., filtering or logarithmic drive).
	Comparator	A comparator is a device that accepts two analog inputs, compares the inputs, and produces a binary output that is a function of which input is higher. If the non-inverting (+) input is greater than the inverting (-) input, then the output goes high. If the inverting (-) input is greater than the non-inverting (+) input, then the output goes low.
	Interface	An IC that is used to connect sensors and other devices. It collects input at the interface collects data from the sensor and the output of the interface sends the data to a computer or other suitable device. Sensor interface chips may be used in many types of sensors and sensing devices, including accelerometers, strain gauges, piezoresistive pressure sensors, load cells, thermistors, and other bridge-type sensors. Sensor interface and excitation IC chips are often self-calibrating, which enables them to get high accuracy data from sensors that may not be ideal. Basic sensor interface chips typically include sensor-excitation circuitry, a programmable gain amplifier, and an analog output. Other types of sensor interface chips include other components, such as digital-to-analog converters (DAC), analog-to digital converters (ADC), electrically-erasable programmable read-only memory chips (EEPROMs), and other components to manage temperature drift. A sensor IC chip also can perform signal conditioning such as gain and offset adjustment and linearity correction.
	Other Analog	Including but not limited to clocks, timing controllers, oscillators and other devices.

Source: Jefferies, Analog companies websites

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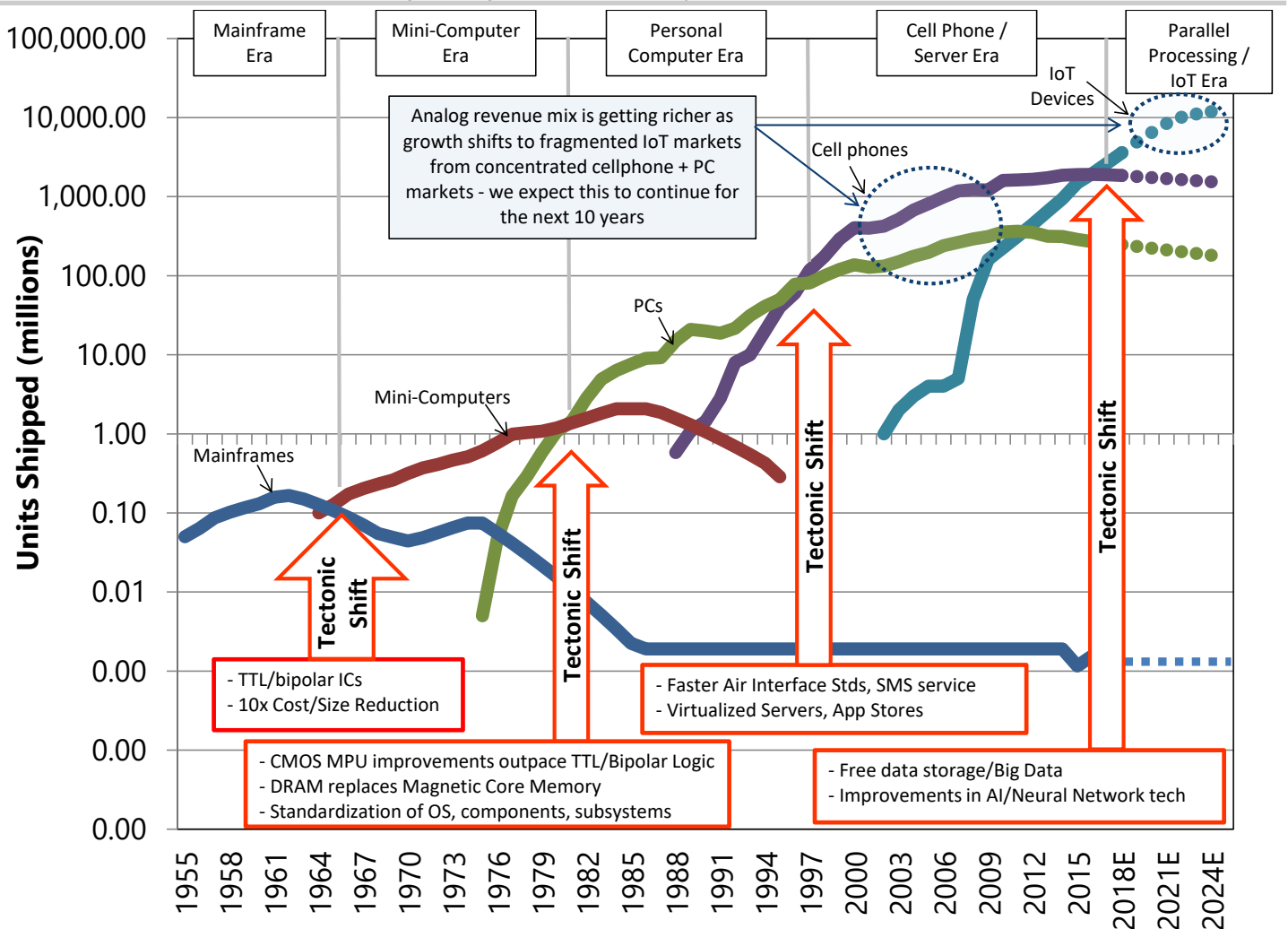
Appendix 2. Tectonic Shifts in Computing - PC and Cellphone Case Studies

Secular Analog Demand – Tectonic Shift to Parallel Processing and IoT Computing Paradigm

In our July, 2017 note: “4th Tectonic Shift in Computing,” we observed that the computing paradigm shifted every 15 years (10x units, 1/10th cost, 1/10th footprint), and argued that it is currently shifting to a parallel processing / IoT model. We believe the current shift is being driven by both the low cost of storing the data that the IoT devices are generating, as well as improvements in parallel processing technologies like neural networking. As the data from the IoT devices is being processed in an AI framework, higher utility is being driven into those devices, increasing demand for them. The higher utility / increased demand feedback loop is becoming a virtuous circle.

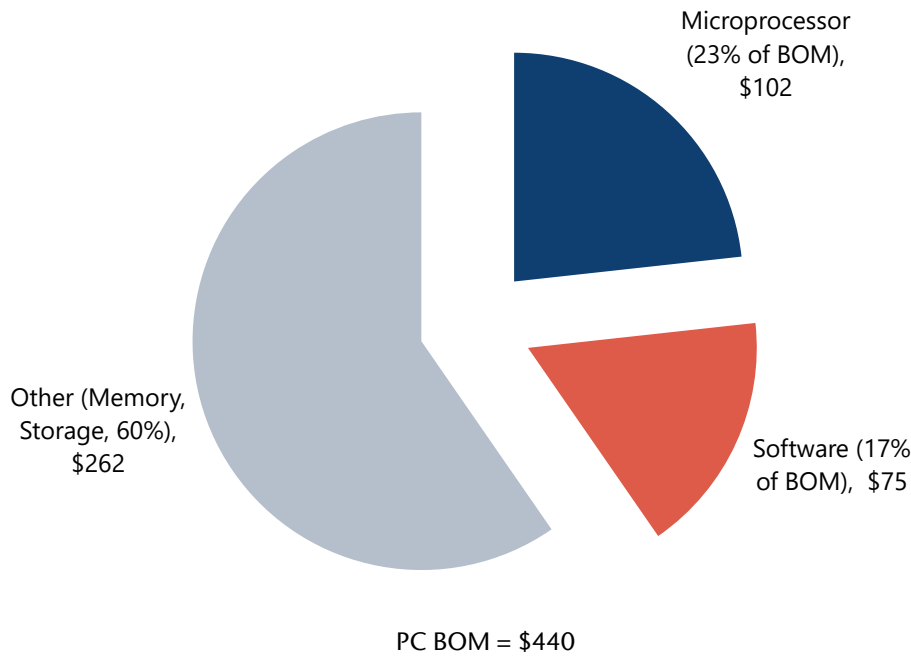
We argued that the analog companies, TXN, ADI, MCHP, MXIM and ON are plays on this Tectonic Shift theme as companies that supply critical components that enable the IoT devices.

Chart 66 - Tectonic Shifts in the Computing Paradigm over the Past 60 years



Source: See page 10 for the detailed list

Chart 67 - Critical Components of PC BOM



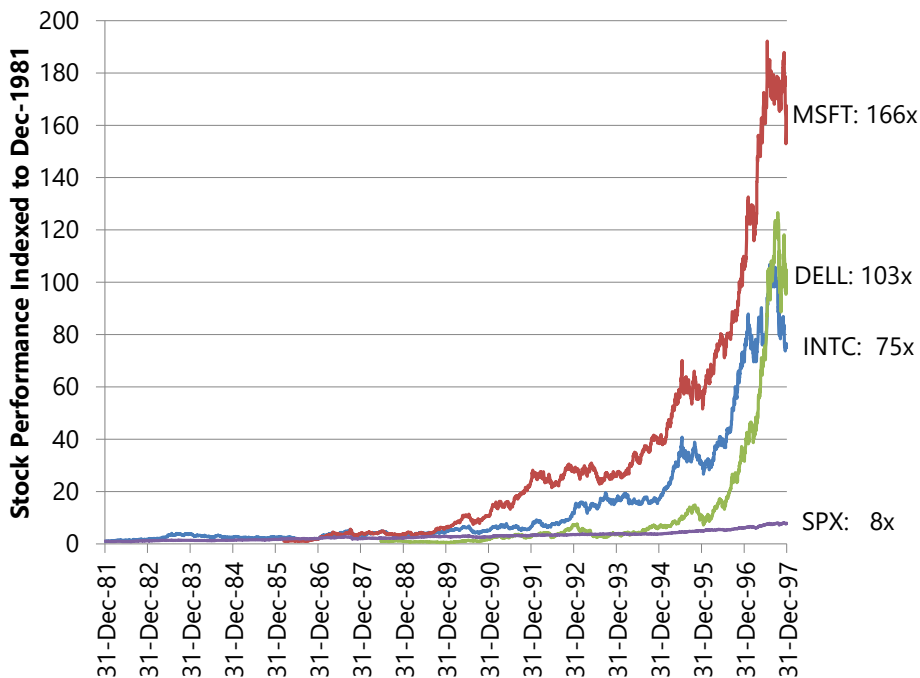
INTC and MSFT have been critical suppliers of components into the PC “Bill of Materials” or BOM, during the PC Era. INTC’s IPO was in 1971, MSFT’s was in 1986

INTC supplies MPUs into PC, which can account for 20-25% of the total BOM of the PC

MSFT supplies software into the PC that can account for 15-20% of the PC BOM

Source: Jefferies, ZDNet

Chart 68 - Stock Performance of PC BOM Plays During PC Era (1981-1997)

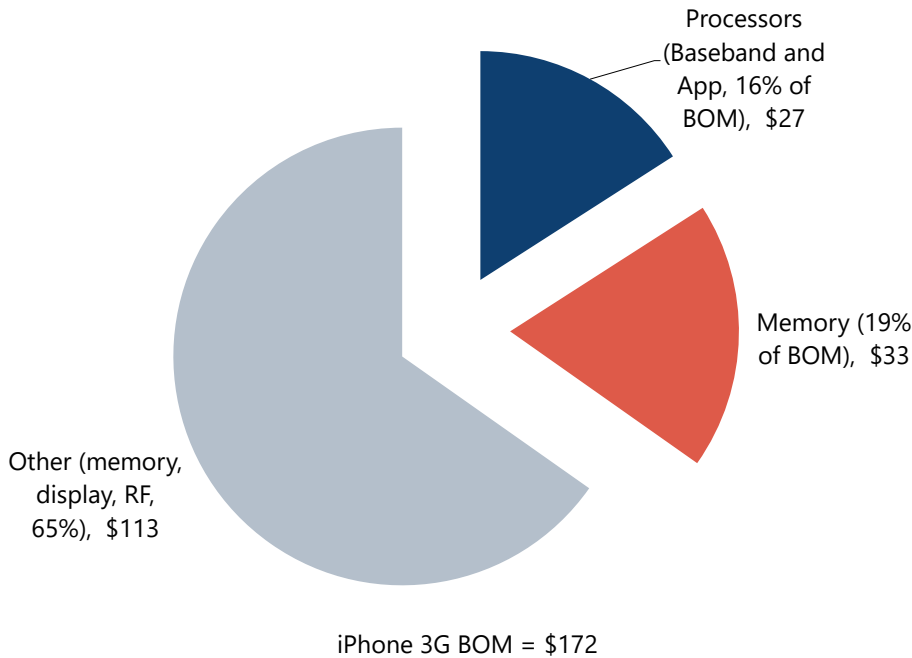


During the PC Era, as defined by unit shipments from the left chart, we estimate that MSFT stock appreciated by 166x, and INTC appreciated by 75x, both of which compare favorably to the SPX which appreciated by 8x

Source: Jefferies, FactSet

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Chart 69 - Critical Components of Cellphone BOM



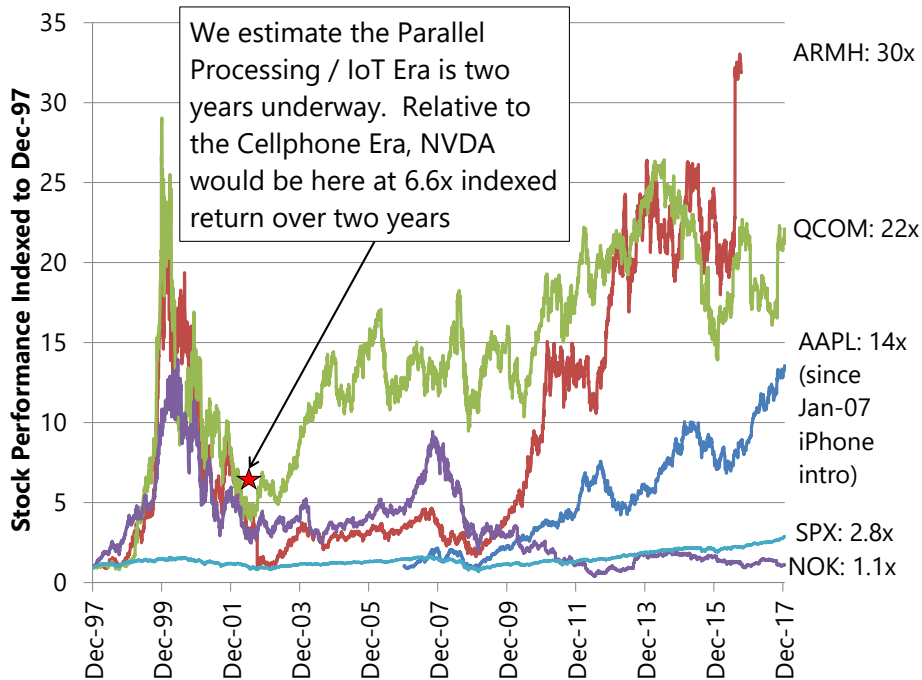
QCOM and ARMH have been critical suppliers of components into the cell phone. QCOM and ARMH went public in 1991 and 1998, respectively

QCOM supplies application and baseband processors into the cellphone, and both ARMH and QCOM have supplied critical IP that go into those cell phone processors

We estimate that their combined content can account for 15-20% of the BOM of a cell phone

Source: Jefferies, IHS

Chart 70 - Stock Performance of PC BOM Plays During PC Era (1981-1997)

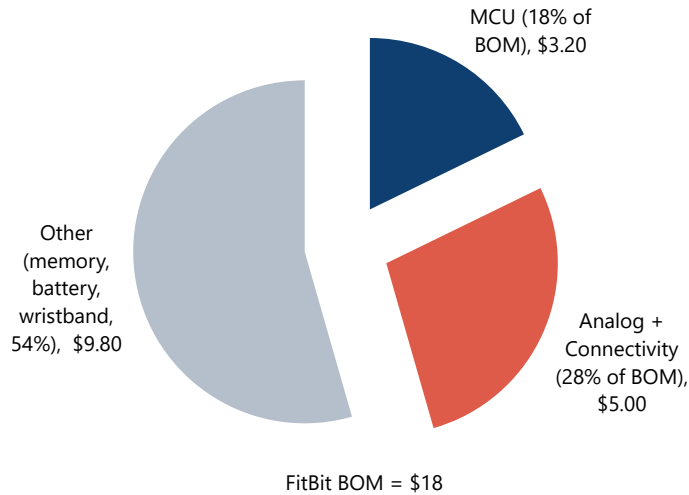


During the Cell Phone / Datacenter Era, we estimate that ARMH stock appreciated by 30x, and QCOM appreciated by 22, both of which compare favorably to the SPX which appreciated by 2.8x

Source: Jefferies, FactSet

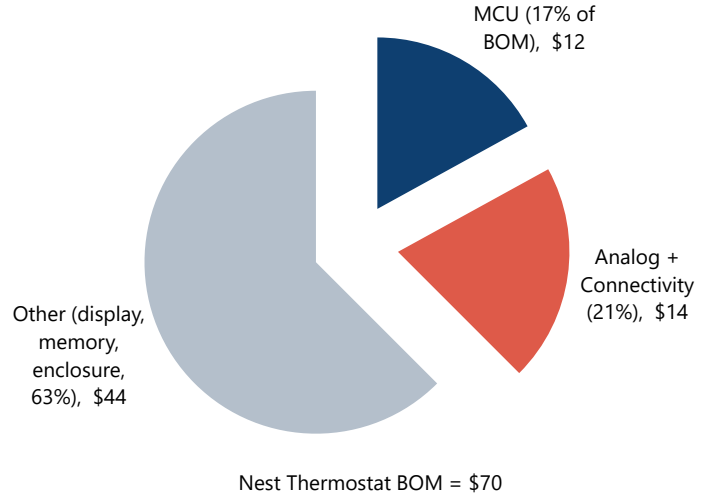
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Chart 71 - Critical Components of FitBit BOM



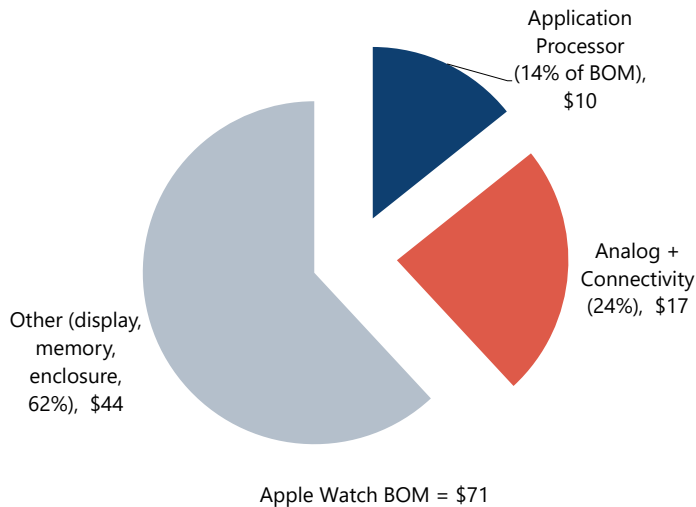
Source: Jefferies, Electronics360

Chart 72 - Critical Components of Nest Thermostat BOM



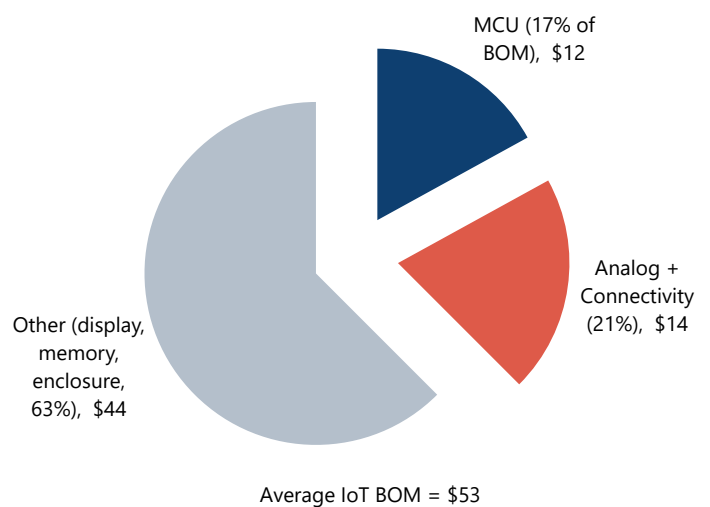
Source: Jefferies, Electronics360

Chart 73 - Critical Components of Apple Watch BOM



Source: Jefferies, MacRumors.com

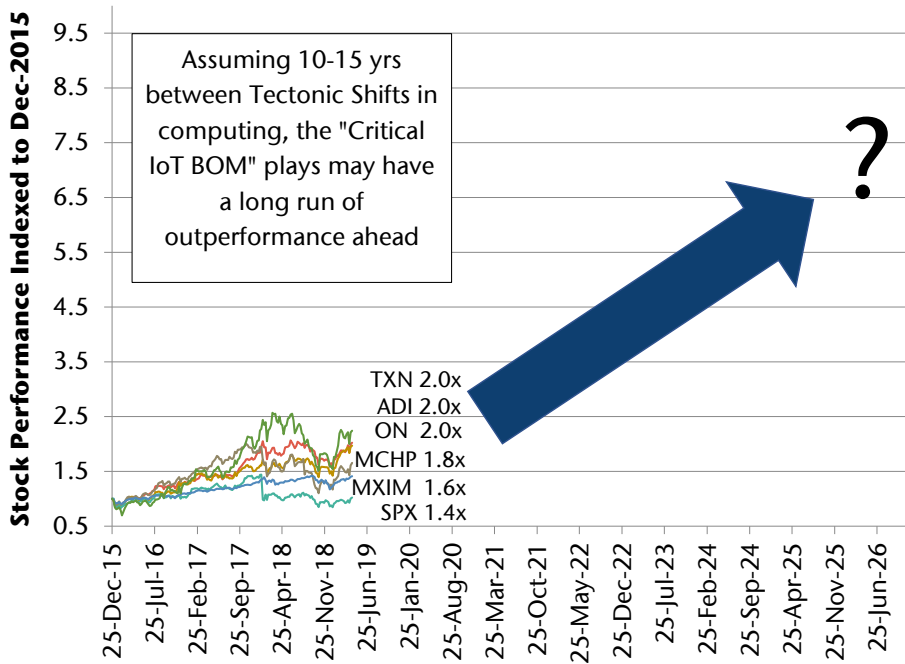
Chart 74 - Critical Components of Average IoT BOM



Source: Jefferies, Electronics360, MacRumors.com

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Chart 75 - Stock Performance of IoT BOM Plays During IoT Era



Source: Jefferies, FactSet

Critical components plays like TXN appear to be off to a good start during the IoT / Parallel Processing Era, having outperformed the SPX since the end of 2015

Assuming 10-15 years between Tectonic Shifts in computing, we think that they are well positioned to benefit from a long run of sustainable growth in secular demand and outperformance during the IoT/Parallel Processing Era

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Appendix 3. HHI Primer and Case Studies (HDD+DRAM)

The Herfindahl-Hirschman Index (aka “Herfindahl Index” or “HHI”) is a quantitative measure of the competitiveness of an industry. It is calculated by summing the squares of the market share of the top 50 companies in an industry. The higher the index, the higher the industry concentration, and lower the competitiveness of the industry. For example, one company with 100% share would return an HHI of 100% (a monopoly). By contrast, 100 companies with 1% share each would return an HHI of 1% (highly competitive industry).

HHI Implementation by FTC and DoJ

The HHI is used by the FTC and DoJ for the purposes of assessing the impact of a merger on an industry’s competitiveness. These Agencies have defined three buckets for the index, and apply the following general standards:

1. HHI < 15% = Unconcentrated Market, which we would describe as highly competitive. Mergers that result in a 1% or less increase in the HHI are unlikely to have adverse competitive effects and normally require no further analysis.
2. HHI between 15% and 25% = Moderately Concentrated. Mergers that result in a 1% or more increase in the HHI raise significant competitive concerns and often warrant scrutiny.
3. HHI > 25% = Highly Concentrated or a less competitive industry. Mergers that result in an increase of the HHI of between 100 and 200 points potentially raise significant competitive concerns and often warrant scrutiny. Mergers that result in a 2% or higher increase in the HHI are viewed as enhancing market power.

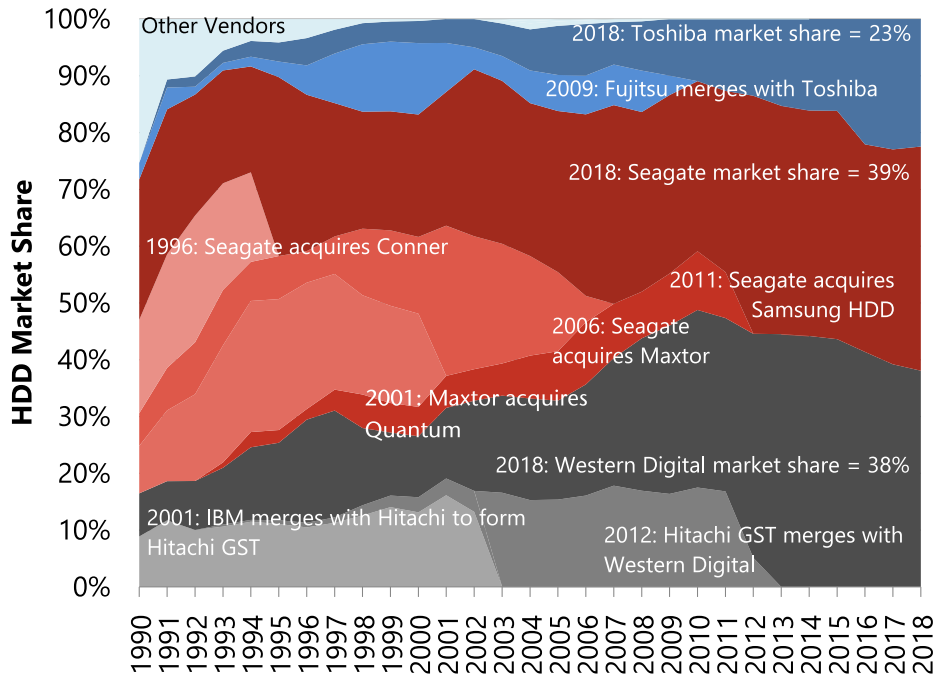
The HHI is named after two economists, Orris Herfindahl and Albert Hirschman

The index was derived to measure the concentration of an industry was first published in 1945 by Hirschman (National Power and the Structure of Foreign Trade, Berkeley)

A variation of that metric used today was published by Herfindahl in 1950 (Concentration in the US Steel Industry, Doctoral Dissertation, Columbia University)

HDD Herfindahl Analysis Case Study

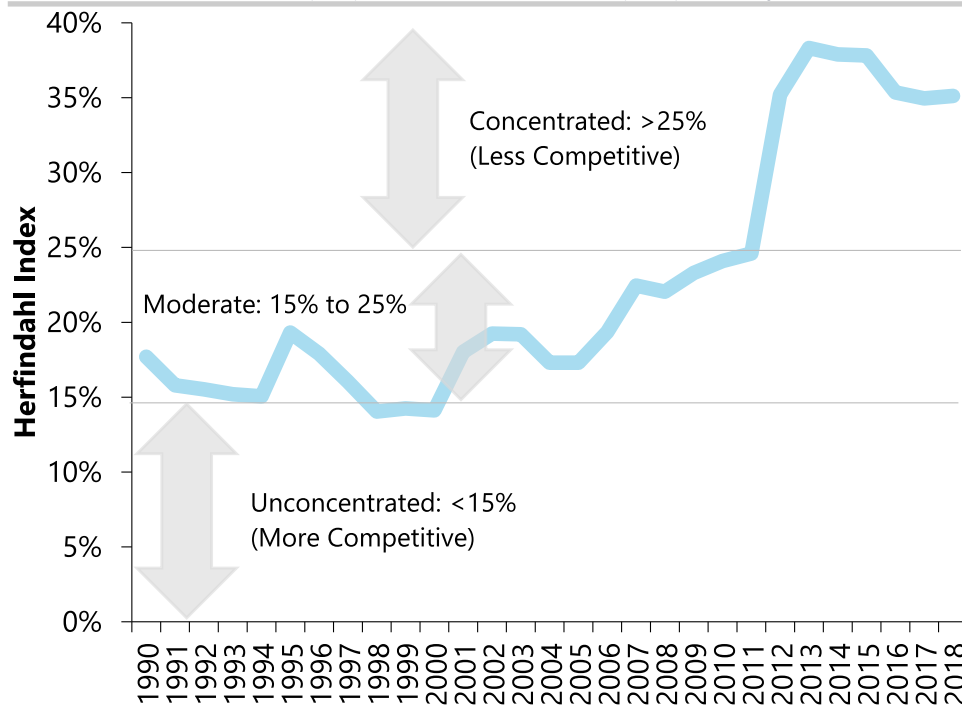
Chart 76 - HDD Market Share Over Time



The HDD industry has consolidated from over a dozen companies 25 years ago, to three main competitors

Source: Jefferies, Gartner. HDD market share calculated based on units shipped.

Chart 77 - Herfindahl Index (HHI) for the Hard Disk Drive (HDD) Industry



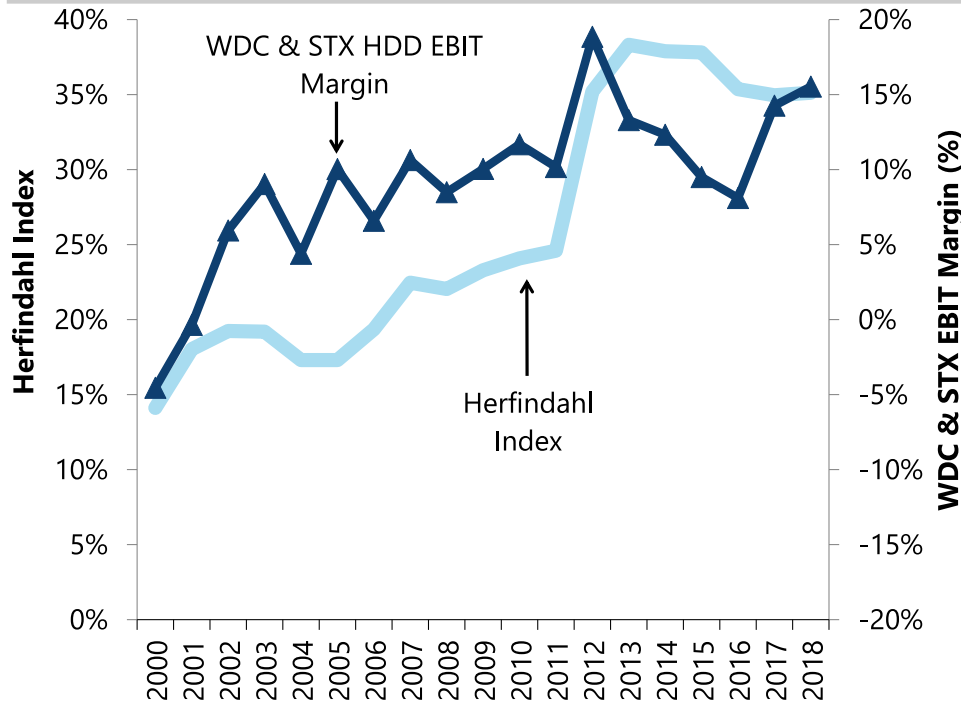
The Herfindahl Index inflected into the Concentrated tier in 2013 and has remained above 35% since

More recently, the HHI declined as Toshiba regained share

Source: Jefferies, Gartner

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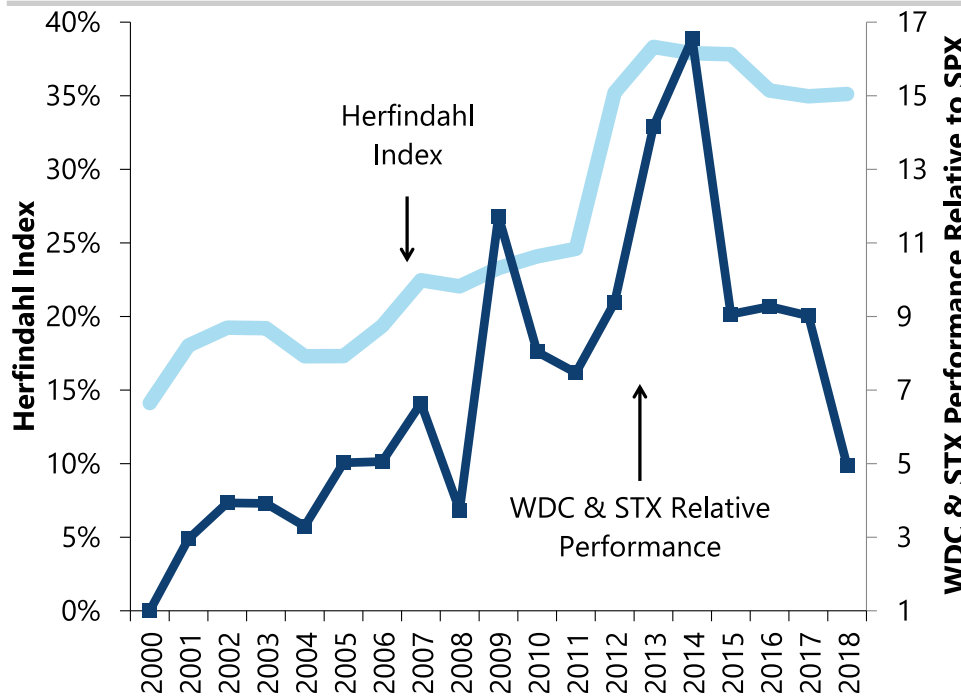
Chart 78 - Herfindahl Index vs. HDD EBIT Margin



Profitability of WDC and STX improved as the industry consolidated, and then declined as Toshiba regained share

Source: Jefferies, Gartner, FactSet, company data. HDD EBIT % is the average EBIT margin of STX and WDC.

Chart 79 - Herfindahl Index vs. Relative Stock Performance



WDC and STX stock prices also improved with the increasing HDD Herfindahl Index, and then declined as Toshiba regained share

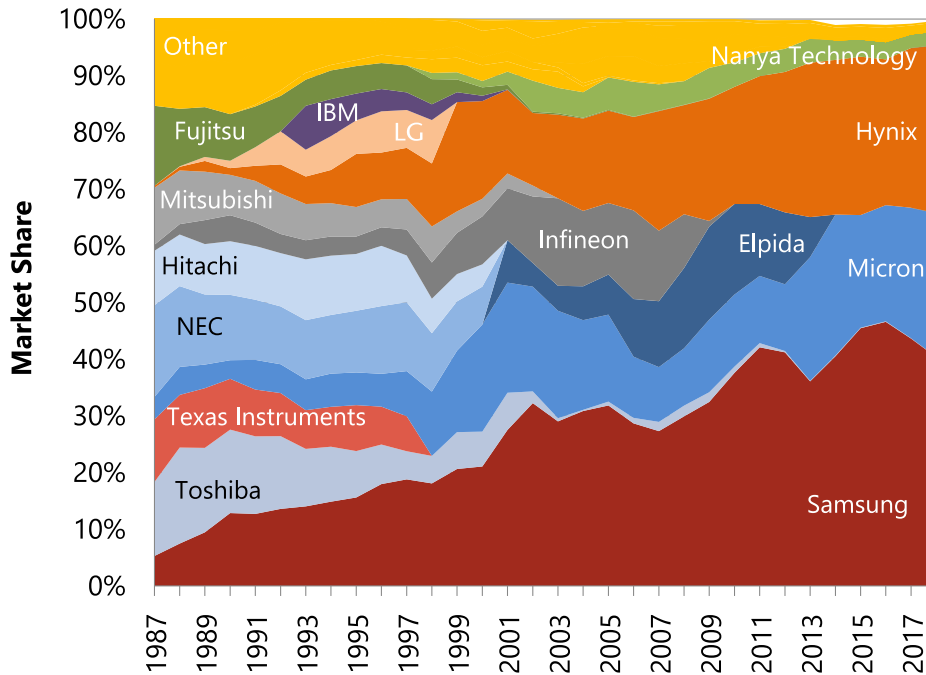
Source: Jefferies, Gartner, FactSet. HDD Relative Stock Performance is a composite of WDC and STX relative SPX.

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DRAM Herfindahl Analysis Case Study

Chart 80 - DRAM Market Share

The DRAM industry has consolidated from 24 companies in 1987 to 3 major competitors with 95% of the market in 2018

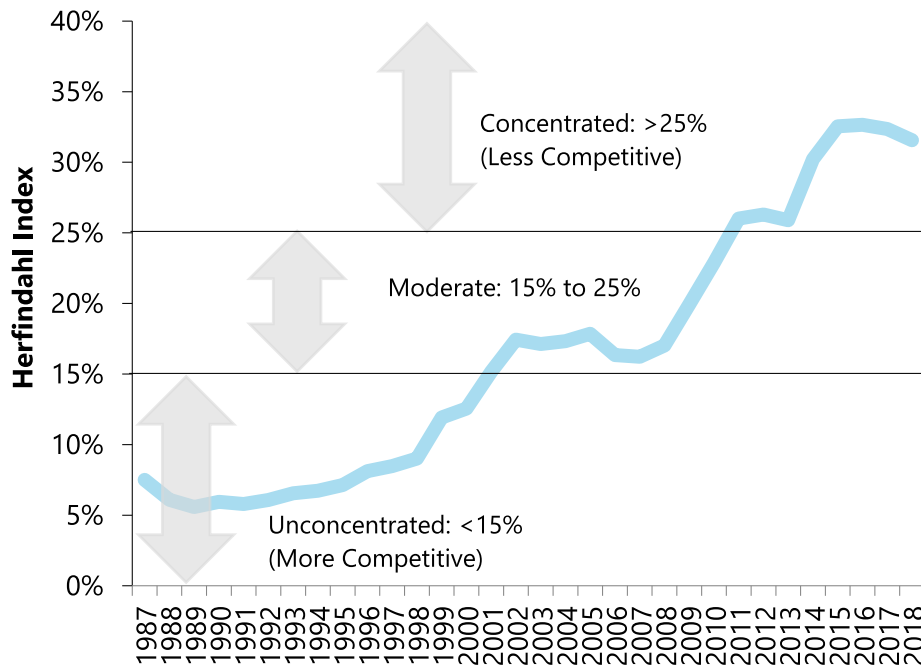


Source: Jefferies, Gartner. * DRAM market share calculated based upon revenue.

Chart 81 - DRAM Herfindahl Index

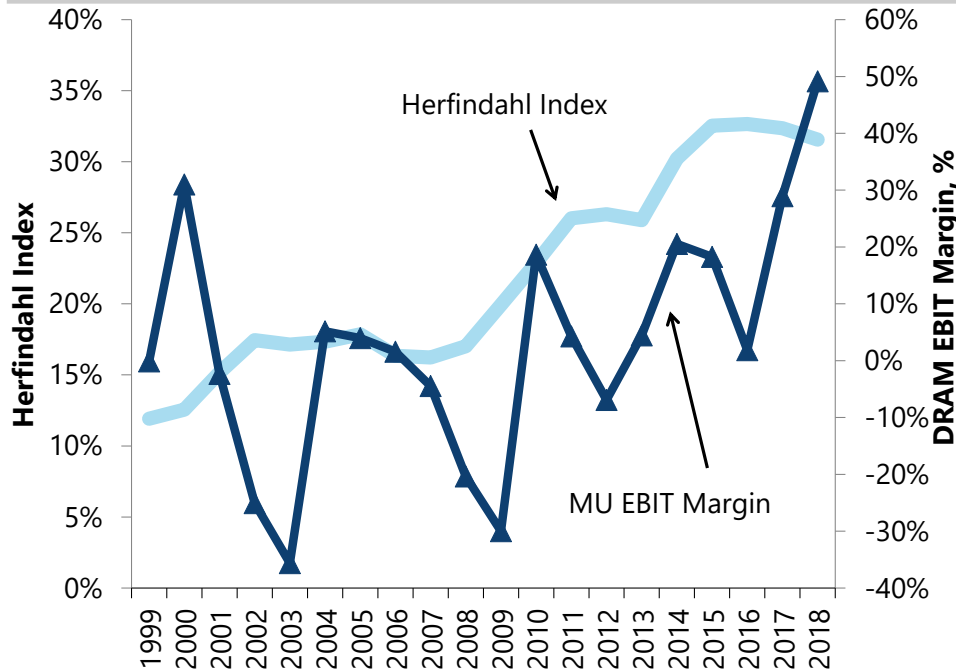
The DRAM HHI has increased dramatically between 2008 and 2017 and remained above 30% since 2014, well into the "Concentrated" industry category

This suggests to us that the recent positive inflection in MU fundamentals are much more secular, rather than cyclical in nature



Source: Jefferies, Gartner. DRAM market shares calculated based on revenues.

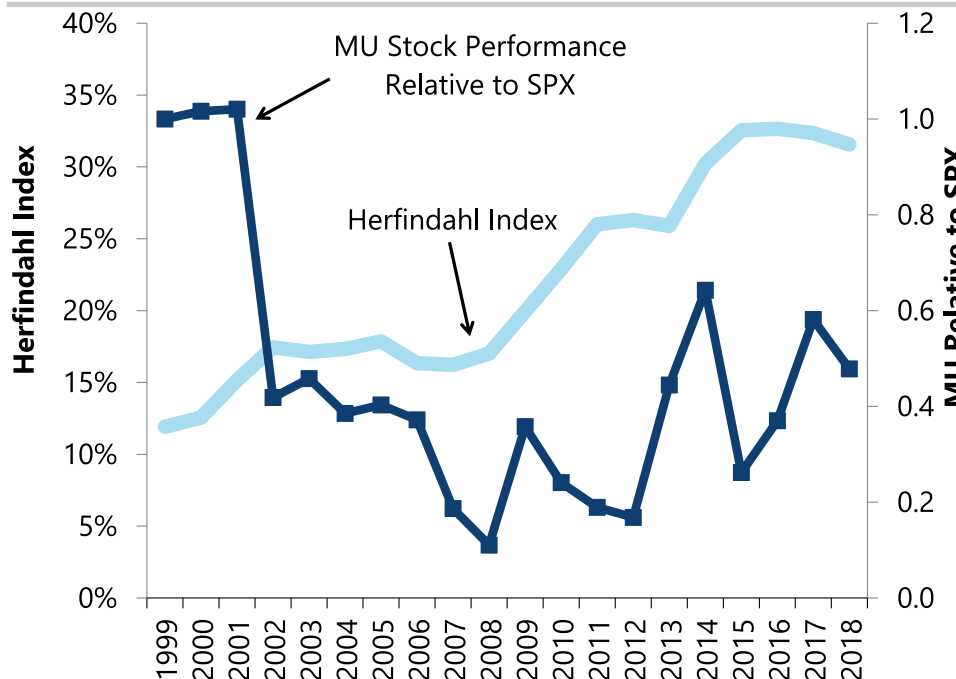
Chart 82 - Herfindahl Index vs. EBIT Margin



We look at MU EBIT margin as a proxy for the DRAM space given it is the only pure play DRAM company. The EBIT margin has increased with the Herfindahl Index, even if with a degree of volatility

Source: Jefferies, Gartner, FactSet

Chart 83 - Herfindahl Index vs. Relative Stock Performance



Pricing in DRAM has also improved as the industry has become more concentrated

Source: Jefferies, Gartner, FactSet. Relative performance is indexed to December 31, 1999

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Appendix 4. Valuations Table

Chart 84 - Coverage Fundamentals Table

Ticker	Rating	Price Target	7/3/19 Price	Market Cap (m)	Cash (m)	Debt (m)	Net Debt (m)	Net Debt /Shr	EV/S		EV/FCF		JEF EPS		Cons. EPS		P/E		P/TanBk
									2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	
PC:																			
AMD	Buy	\$ 34.00	\$ 31.19	\$ 33,735	\$ 1,199	\$ 1,094	\$ (105)	\$ (0.10)	4.9x	4.0x	586x	46x	0.65	1.30	\$ 0.66	\$ 1.02	48x	30x	26x
INTC	Underperform	40.00	48.52	217,224	12,033	29,377	17,344	3.87	3.4x	3.3x	16x	14x	4.10	3.65	4.26	4.44	11x	11x	6x
MRVL	Buy	29.00	24.57	16,241	572	1,882	1,310	1.98	6.3x	5.5x	21x	15x	0.78	1.31	0.79	1.30	31x	19x	n.a
NVDA	Buy	210.00	162.75	99,115	7,802	2,554	(5,248)	(8.62)	8.6x	7.2x	33x	25x	5.01	n.a.	5.31	7.06	31x	23x	11x
PLDs:																			
LSCC	Buy	15.50	14.92	1,970	130	233	103	0.78	5.1x	4.9x	n.m.	n.m.	0.49	n.a.	0.48	0.61	31x	24x	n.a
XLNX	Buy	156.00	116.39	29,215	3,176	1,235	(1,941)	(7.73)	8.0x	7.2x	24x	22x	3.98	4.95	3.80	4.24	31x	27x	12x
Analog:																			
ADI	Buy	125.00	113.17	41,846	714	5,987	5,273	14.26	7.9x	7.4x	21x	20x	5.23	n.a.	5.15	5.66	22x	20x	n.a
MCHP	Buy	112.00	89.77	21,359	431	10,307	9,876	41.51	5.7x	5.4x	23x	20x	6.26	n.a.	5.94	6.91	15x	13x	n.a
MTSI	Hold	14.00	15.21	999	192	694	502	7.64	3.3x	2.9x	n.m.	n.m.	(0.55)	n.a.	(0.63)	0.37	n.m.	42x	n.a
MXIM	Buy	71.00	60.37	16,446	1,898	992	(906)	(3.33)	6.9x	6.3x	21x	18x	2.44	2.95	2.32	2.82	26x	21x	15x
NXPI	Buy	128.00	97.68	27,856	2,192	7,340	5,148	18.05	3.7x	3.4x	18x	15x	7.99	11.87	7.80	9.19	13x	11x	n.a
ON	Buy	29.00	19.83	8,178	957	2,770	1,813	4.40	1.8x	1.7x	16x	12x	1.83	2.20	1.79	2.02	11x	10x	5x
TXN	Buy	137.00	115.94	108,776	4,086	6,153	2,067	2.20	7.5x	7.1x	22x	21x	5.36	6.68	5.16	5.73	22x	20x	31x
TSEM	Buy	22.00	16.65	1,503	673	309	(365)	(4.04)	0.9x	0.9x	8x	7x	1.00	1.52	1.05	1.43	16x	12x	1x
Comms:																			
AVGO	Buy	324.00	284.89	113,407	5,328	37,548	32,220	80.94	6.5x	5.9x	15x	13x	21.22	22.65	21.39	24.68	13x	12x	n.a
IPHI	Buy	51.00	52.46	2,374	429	455	26	0.57	6.9x	5.7x	18x	15x	1.63	2.16	1.46	2.03	36x	26x	25x
Memory:																			
RMBS	Hold	13.00	12.14	1,336	306	165	(141)	(1.28)	3.4x	2.8x	13x	13x	0.90	0.92	0.60	0.96	20x	13x	2x
SGH	Buy	33.00	24.34	562	126	208	81	3.53	0.6x	0.5x	8x	n.m.	3.45	3.21	2.55	3.62	10x	7x	3x
Average:									5.3x	4.8x							24x	20x	

Source: Jefferies, company data, FactSet

Company Valuation/Risks

Analog Devices, Inc.

ADI trades at NTM P/Es ranging from 14x to 22x. Our \$125 PT assumes a P/E of 20x applied to our CY20 ADI EPS estimate of \$6.27. We expect P/E to expand as the company enters capital return cycle. Downside risks include integration risk with the LLTC acquisition, weakening of consumer, automotive, and communications infrastructure markets.

Maxim Integrated Products, Inc.

Our \$71 PT assumes a P/E multiple of 24x applied to our CY2020 EPS estimate of \$2.95, exceeding the recent range of 15x-23x. Downside risks include share loss at mobile/wearables OEMs, a slowdown in its Auto or Industrial businesses, extended inventory recession or macro-driven downturn.

Microchip Technology Inc.

Our base-case price target of \$112 assumes a 15x multiple on our C2020 EPS estimate of \$7.49. Multiple of 15x falls within MCHP's 5-yr range before correction of 9x-18x Risks to our thesis: 1) increasing competition in the MCU market; 2) failure to successfully integrate acquisitions; and, 3) a pronounced cyclical inventory correction.

ON Semiconductor Corporation

Our ON price target of \$29 is based on C2020 EPS of \$2.2 and a P/E ratio of 13x, above the mid point of the 5-yr range of 8x-15x, which we think is justified due to 1) ON's competitive positioning and our view that the analog group in general and ON specifically will benefit from demand dynamics described in our "4th Tectonic Shift in Computing Thesis," and our view that it will benefit from a sustained period of upward revisions 2) GM margin expansion potential based on our view that analog industry consolidation will positively impact the pricing environment and ON's margins combined with additional margin tailwinds from ON's recently announced M&A deals and margin mix shift in 2H19 3) bottoming out fundamentals. Downside risks include: 1) share loss; 2) inventory correction; and 3) ASP compression.

Texas Instruments Incorporated

Our \$137 PT assumes a 20.5x multiple on our 2020 EPS est. of \$6.68. A 20.5x P/E is in the middle of the 5-yr range of 16x-25x and we think warranted given its exposure to secular trends (IoT, Auto, Industrial, Consolidation). Downside risks include inventory correction, macro and/or geopolitical-driven demand weakness and multiple compression.

Analyst Certification:

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Investment Recommendation Record

(Article 3(1)e and Article 7 of MAR)

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- Microchip Technology Inc. (MCHP: \$87.93, BUY)
- ON Semiconductor Corporation (ON: \$19.51, BUY)
- Texas Instruments Incorporated (TXN: \$114.93, BUY)

Rating and Price Target History for: Analog Devices, Inc. (ADI) as of 07-08-2019



Rating and Price Target History for: Microchip Technology Inc. (MCHP) as of 07-08-2019



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Rating and Price Target History for: Maxim Integrated Products, Inc. (MXIM) as of 07-08-2019



Rating and Price Target History for: ON Semiconductor Corporation (ON) as of 07-08-2019



Rating and Price Target History for: Texas Instruments Incorporated (TXN) as of 07-08-2019



Notes: Each box in the Rating and Price Target History chart above represents actions over the past three years in which an analyst initiated on a company, made a change to a rating or price target of a company or discontinued coverage of a company.

Legend:

- I: Initiating Coverage
- D: Dropped Coverage
- B: Buy
- H: Hold
- UP: Underperform

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Distribution of Ratings						
			IB Serv./Past12 Mos.		JIL Mkt Serv./Past12 Mos.	
	Count	Percent	Count	Percent	Count	Percent
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