Business Cycle Upswing Impact on the Semiconductor Outlook

Surface Preparation and Cleaning Conference (SPCC)
April 11, 2018

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*A global outlook based on Consensus Economics, Inc.
CONSENSUS FORECASTS®
Outline

• Last year: forecast versus the results
• The new outlook: in the accelerating phase of the current economic cycle
• The implications for semiconductors
• What worries me the most
Metrics

• **Real GDP**: Gross Domestic Product (final “real” or “volume” demand for goods and services, in the largest 85 countries measured in Billions of 2010 US$ - that is, with inflation removed)
  – **Real consumer spending** (for key 45 countries in Consensus Economics)
  – **Real business investment** (for key 45 countries in Consensus Economics)
  – **WHY Real GDP and its final demand components?** Semiconductors have become so ubiquitous, used in almost every product and in support of almost every service, that broad final demand measures best explain MSI trends.

• **Million Square Inches (MSI)** of silicon wafers shipped to semiconductor manufacturers (Source: SEMI.ORG)
  – **WHY MSI?** Best volume measure of semiconductors, to relate to the volume of demand as measured by real GDP and other units of products

• **WSTS semiconductor revenue** (World Semiconductor Trade Statistics) - $000 sales by major region reported by WSTS.ORG

• **Semiconductor Equipment Billings** (~90% of worldwide semiconductor equipment sales)
  – Reported for North America by SEMI.ORG
  – Reported for Japan by SEAJ.ORG
Global Economic Outlook Summary: 2017-18

- Modest growth, faster than 2016
- Improving investment climate
- Slightly higher inflation, diverging interest rates
- Currency turmoil, stronger U.S. dollar
- Much higher economic policy uncertainty
- *MSI: Up a little in 2016, rises above trend in 2017, eases to around trend in 2018*
## Outlook by the Numbers

<table>
<thead>
<tr>
<th>% Change</th>
<th>2016</th>
<th>SPCC 2017</th>
<th>2017 Prelim</th>
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<tr>
<td>Real GDP</td>
<td>2.3</td>
<td>2.7</td>
<td>3.1</td>
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<tr>
<td>Consumption</td>
<td>2.6</td>
<td>2.8</td>
<td>3.2</td>
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<td>Investment</td>
<td>1.2</td>
<td>2.8</td>
<td>4.3</td>
</tr>
<tr>
<td>PC Units</td>
<td>(7.0)</td>
<td>(0.3)</td>
<td>(2.4)</td>
</tr>
<tr>
<td>MSI</td>
<td>2.9</td>
<td>6.5</td>
<td>10.0</td>
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<tr>
<td>US 10YR Treasuries</td>
<td>1.8</td>
<td>Higher</td>
<td>2.3</td>
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<tr>
<td>Dollar</td>
<td></td>
<td>Stronger</td>
<td>Weakened</td>
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<tr>
<td>CPI: China</td>
<td>2.0</td>
<td>2.5</td>
<td>1.6</td>
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<tr>
<td>Japan</td>
<td>(0.1)</td>
<td>0.7</td>
<td>0.5</td>
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<tr>
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- **Solid green:** actual stronger than forecast
- **Green outlined in red:** actual weaker than forecast
- **Solid red:** direction wrong
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Summary Overview: 2018-19

• In the **accelerating phase of the economic cycle**
  – Investment upsurge driving the global economy stronger
  – Slightly higher inflation, diverging interest rates
  – Currency turmoil
  – Potential for much higher economic policy uncertainty: trade, geopolitics the current wild cards

• **Healthy semiconductor industry:**
  – Demand for semiconductors grows above trend through 19
  – Wafer Fab Equipment investment strong
Accelerating: Growth Gets Stronger Than Past Five Years

World* Real GDP Growth
2017: 3.1%  2018: 3.2%  2019: 3.1%

*World: 85 major economies,
Data: World Bank, Hilltop Economics,
Consensus Forecasts, Mar 18

Cyclical Upswing
Consumption Strengthened in 2017

Little downside risk in consumer outlook in the current upswing

World* Real Consumption

97-07: 3.2% TLGR
World: 45 Key Countries
Src: World Bank, National Sources,
Hilltop Economics, Consensus Forecasts Mar 18

Consumption roughly 60% of real GDP
Global Investment Out of a Cycle Low in 2016

World* Real Investment

92-07: 3.7% TLGR World: 45 Key Countries
Src Hist: World Bank, National Sources,
Fcst: Hilltop Economics, Consensus Forecasts Mar 18

Investment Roughly 1/4 of GDP Demand

Mar 18 Fcst
2017  +4.3%
2018  +4.2%
2019  +3.8%

The main driver of Real GDP’s cycle upswing
Investment Positive: A Key Cycle Driver

• Revenue growth more assured
  – Real GDP growth (volume) keeps looking a little stronger
  – Some inflation (price) on average from ~0 to 1% to ~1% - 2%

• Most economies are at capacity (labor & capital)
  – “Output gaps” closed, need capital to grow

• Profitability still positive
  – Productivity-related investment needed
  – Interest rate increases still modest
  – Tax law changes, at least in U.S., positive for investment (at the margin)

• Risk aversion declined
  – Consumer attitudes back to normal
  – Small business attitudes finally recovered
  – Economic policy uncertainty down
  – Improving more than expected in earlier forecasts
What Worries Me About the Economy

The factors that could disrupt the outlook

• Forecasters under-anticipate business investment and consumer spending: **actual data is better than the expectation (+)**
• Global trade protectionism (-)
• Differential global monetary policy
  – Interest rates (U.S. tightens as others still easing/loose)
  – Currency & financial asset turmoil
  – U.S. yield curve flattening
• China post 19th Party Congress (geopolitical, debt, property market bubble, etc.)
• Political extremism (US & EU)
• Geopolitical
  – N. Korea, Middle East
  – Global terrorism
• Oil
Stock Prices Reflect Uncertainty, Volatility

But remain up 10% versus this time last year

S&P 500 Index

Year % Change SP 500

09 10 11 12 13 14 15 16 17 18

-60 -40 -20 0 20 40 60 80

09 10 11 12 13 14 15 16 17 18


Trade war rhetoric
Stock Prices Over Time:
Not A Clear Leading Indicator of Recession

Shaded areas indicate recessions
Improving Economy: Rising Interest Rates

But watch that short-term rates don’t exceed long-term rates

Sign of optimism: stronger demand + tighter supply
Not too high to dampen investment (through 18)
Yield Curve Continues to Tighten

Consensus Forecast Mar 18: a flatter yield curve by March 19, but consistent with accelerating phase of the business cycle

Economic Risks
The impact of uncertainty in the model began to lessen in late 2016: evidence the financial crisis impact on investment may have begun to fade.
Healthy Investment Despite the Risks: Healthy Investment = Healthy Semiconductors

96-17
98% correlation
MSI Multiple: 1.7X

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Servers Now Providing a Boost to MSI

_Growth pattern follows real investment pattern_

%CH VS YR AGO

Server Units
Server Revenue

Src: Gartner News Releases

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SPCC April 11, 2018
Smartphones: Rapid Penetration Now Past

Outlook: low single digit growth in 2018, 2019

Smartphones

Milion Units


TOTAL

EXCLUDING APPLE

APPLE

Src: Gartner, public announcements
Stable PC Outlook, Minimal Growth

Estimated Global PC Sales

Annual Percent Change

-7.0%  -2.4%  0.7%  0.9%  -0.4%

Source: Hilltop Economics
Shaded area indicates main period of tablet penetration

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Healthy Final Demand Outlook Drives MSI

Semiconductor MSI Outlook

- MSI Forecast (March 2018)
- SEMI MSI History

Annual Percent Change In MSI
11.4%  3.3%  2.9%  10.0%  6.7%  5.2%

History: Semi.org
Forecasts: Hilltop Economics, LLC
What Worries Me About Semiconductors

The factors that could disrupt the outlook

• Downside risks
  – Pricing/revenue reversal
  – Excess capacity (see pricing reversal)
  – Wafer supply

• Upside risks
  – A new penetration leg (with 5G, AI, even more ubiquitous semiconductors)
Semiconductor Volume Momentum Starting to Ease

Momentum in MSI Peaked in Q1, revenue momentum peaking now

%CH VS YR AGO, 3MMA

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Negative Risk: Semiconductors

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Negative Risk: Semiconductors
Revenue Growth Does Not Deviate from Volume for Long – And Overshoots Have Been Followed by Undershoots

%CH VS YR AGO

SEMI: MSI (17Q4)
WSTS: Revenue (Feb 18)
Equipment Billings Continue to Set New Record Levels

False peak in July ‘17 on a seasonally-adjusted basis

- Billings (To Feb 18)
- Trend-Cycle

Src: SEMI.ORG and SEAJ.ORG,
Hilltop Economics (Census X-13)

North American & Japanese Semiconductor Equipment Billings

No hints of a turn, yet
Wafer Fab Equipment (50% of Capex)
Big Disagreement in 2018 Forecasts (& 17 History)
*Forecasts estimated from ISS 2018 Presentations*

Billion dollars

- **Etch**
- Deposition
- Lithography
- Other

2015 2016 2017 2018

Gartner VLSI SEMI

2018
Long-run Demand VS Capacity Forecasts (Annual Models)

Src: Hilltop Economics

MSI Per Year

KSEMI - From SEMI (WFF to '19)
KSEMI - based on WFE & MSI
KSEMI_ICINSIGHTS
SEMI MSI (March 2018)

Src: Hilltop Economics
Semiconductor Penetration of the Global Economy

QTR at annual rates, 12QMA
Shaded areas US recessions

MSI/Unit of Real GDP

Positive Risk: Semiconductors
Semiconductor Penetration of the Global Economy

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Summary – 2017-19

• The world economy has moved into an accelerating phase of the business cycle.
• Semi MSI growth peaked in 2017, remains above trend in 2018 & 2019 on strong investment-related demand.
• Semiconductor revenue forecasts are chasing actual data up – watch for an adjustment downward later this year.
• Semi equipment demand momentum booming through 2017, healthy growth in 2018, flattens in 2019

• Growth Rates:

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Wafer Supply-Chain Tightness

Excessively tight by inventory control measures: more than two standard deviations below post-financial crisis average since April 2017

Japan (METI) Wafer Data
Inventories Divided by Shipments

Src: METI, Hilltop Economics, LLC
Through January 2018

Excessively tight by inventory control measures: more than two standard deviations below post-financial crisis average since April 2017
Wafer Tightness Not Reflected in Pricing?

WAFER PRICE

WAFER COST PER MSI IN YEN

November 2017
(Dashed Line)

SRC: Hilltop Economics from METI data
(Japanese producers only)
Wafer Tightness Finally Reflected in Pricing?

WAFER PRICE

January 2018
(Dashed Line)

SRC: Hilltop Economics from METI data
(Japanese producers only)
## Total Equipment Spend Outlook Comparison

**Hilltop Econ estimates based on public sources of information**

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<td>Annual (Japan &amp; NA Eqpt)*</td>
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<td>+20</td>
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<td>Hilltop Econ (NA Equipt)</td>
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<td>IHS Markit (All, at ISS 2018)</td>
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<td>SEMI (All Equipment)</td>
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<td>VLSI (WFE at ISS 2018)</td>
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<td>“Consensus”</td>
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<td>+3</td>
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*Hilltop Economic Japan & NA Equipment annual model:
A function of MSI, capacity utilization and the yen-$ exchange rate in a simple dlog equation*
Equipment Billings Lead Global Investment

*Usually turning 2-3 quarters earlier than total investment*

Semi Equipment Billings (NA & Japan)

World Investment

Semi Equipment is 10X more volatile and leads all investment by about two quarters.
Equipment Billings Lead Global Investment

*Usually turning 2-3 quarters earlier than total investment*

Semi Equipment Billings is 10X more volatile and leads all investment by about two quarters.
Steady reduction in ‘16 and ‘17 forecasts
Global Consensus Real GDP Forecasts

Forecasts from Jan 15 to Jan 17 (left to right)

Forecasters began to settle on growth outlook in mid-2016
Back to “Trend” Expectations: ~3 – 3¼%/YR

Global consensus forecasts chasing the data up since early 2017

World Real GDP Forecasts

Bars Are Each Month the Forecast Was Released
From January 2015 to March 2018
Dollar Weakened, Trade War an Issue

Currencies Per U.S. Dollar

Trade war rhetoric: currency volatility

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Global Consumer Outlook

• Economies are growing
• Unemployment rates are coming down
• Wages are at least stable
• Inflation is low
• Oil prices are not a big problem
• Consumer debt is under control
• Risks (interest rates, trade wars, policy) are not immediate
• Confidence is high
Consumer Confidence Indexes Are High
US – Japan – Germany - China

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Oil Prices

Source: EIA, St Louis Federal Reserve Economic Database (FRED)
NBER - Recession dating
Forecast: Hilltop Economics based on Consensus Forecasts Mar 18

Current: $68.80