Frontiers of Challenges

for the semiconductor industry: Challenge = Opportunity

g dan hutcheson

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2022 International Conference on Frontiers of Characterization and Metrology for Nanoelectronics (FCMN)
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Who is TechInsights?

- World's Largest Reverse Engineering Firm
  - Everything sized from Angstroms to Audi's
  - Unmatched breadth knowledge of technology
  - 100's of employees with deep engineering experience
  - Based in Ottawa, Canada
    - With private equity backing
- With a vision to build the world's best technology information platform
  - Technology – Market Research – And More to Come
- Acquired VLSIresearch in 2021
  - "Because VLSI is the world's best in market research"
    – *Gavin Carter, CEO of TechInsights*
- *An explosive combination*
  - *Like Lava hitting the Sea*

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The Semiconductor Shortage

How we got here and the road ahead

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Challenges = Opportunities: The shortage

- 2020: The **COVID** curveball
  - What Looked like a drive into the ocean 3/21 …
  - was a **Decoupling** from the Macroeconomy
  - with a **Digitization pull-in**
- The **Shortage emerges** in the 4Q-2020
  - **Capacity Constrained** with no **Whitespace**
  - Lockdowns, Soaring Transport Costs, Substrate Shortages
- The Great Shortage of 2021 **makes Chips politically important again**
  - Drive for **Technology Sovereignty**
  - The **Taiwan Hyper-Coherence**
  - Pervasive, hidden **hoarding**
- 2022: The Great Shortage Continues
  - **Russo-Ukraine War** broadens constraints
  - China's **Zero-COVID** policy lockdowns

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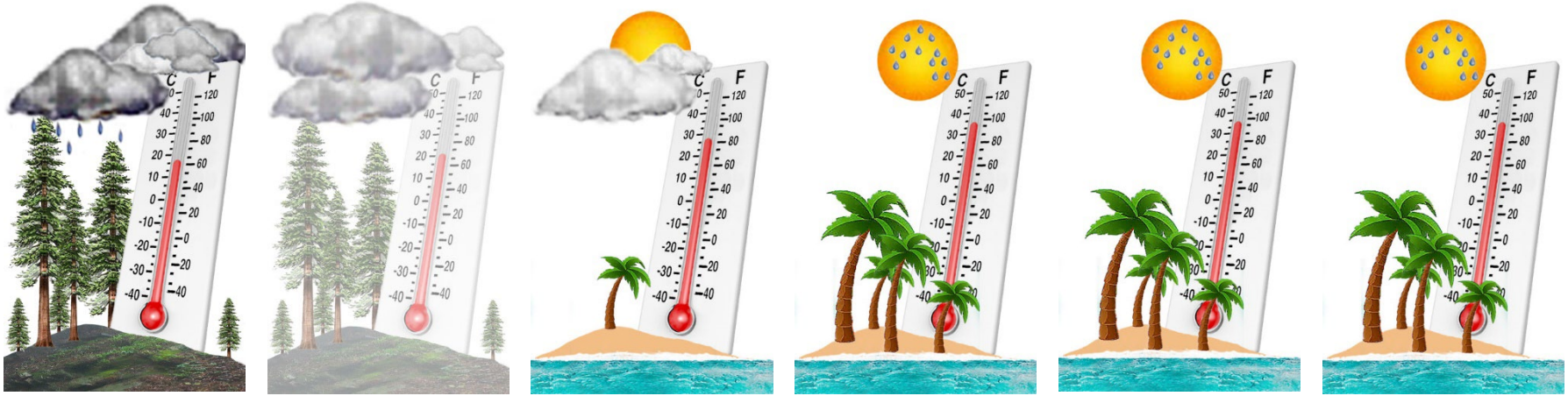
COVID's Semiconductor Weather Storms



Source: Semiconductor Analytics

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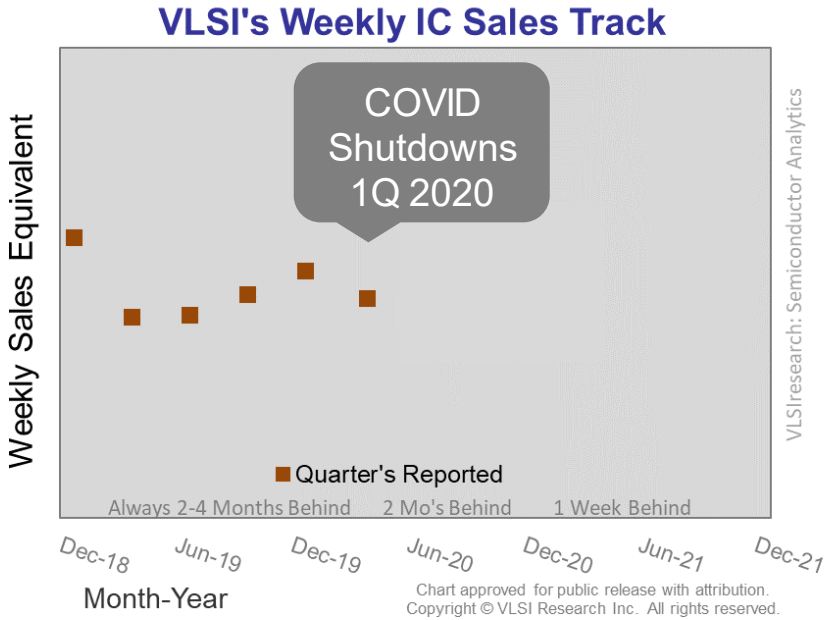
Semiconductor Market Reactions to COVID:

COVID would Close One Door and Open Another, but …



- With shutdowns there was 0 visibility past March, 2020
- Worse: *1Q 2020 results would not be available until Early May*

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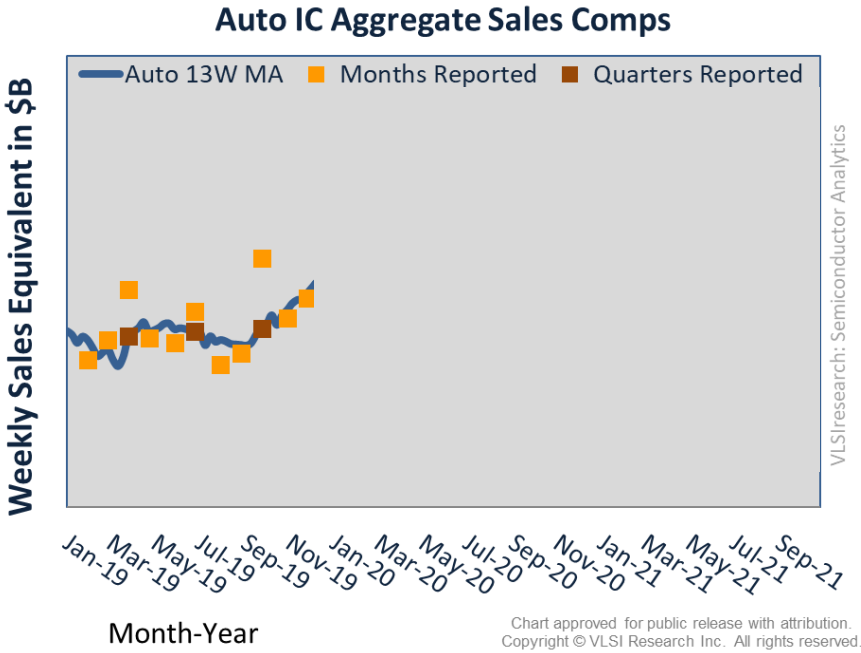
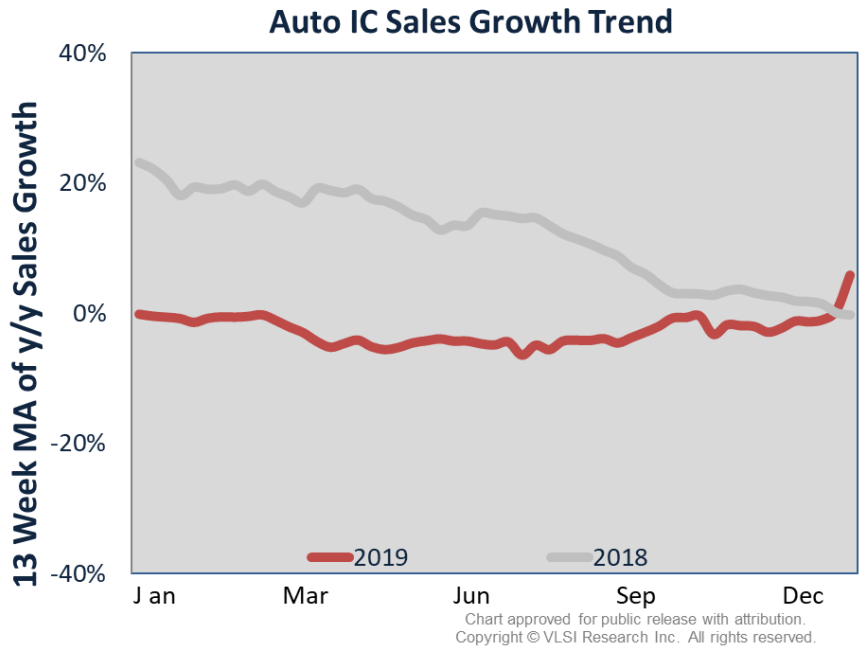
Auto IC Sales: Dec '19 – in recovery just before COVID

Auto IC sales account for 10% of market





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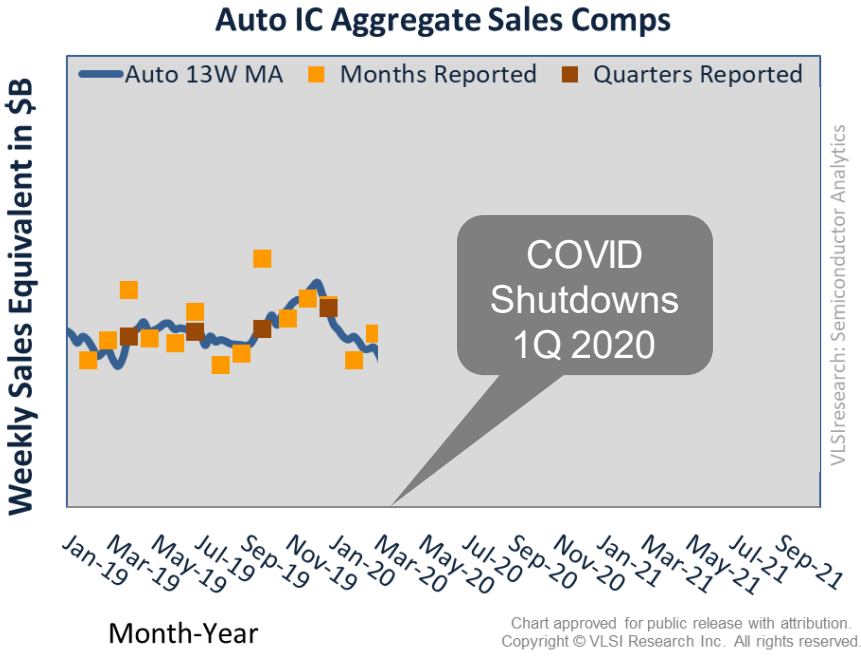
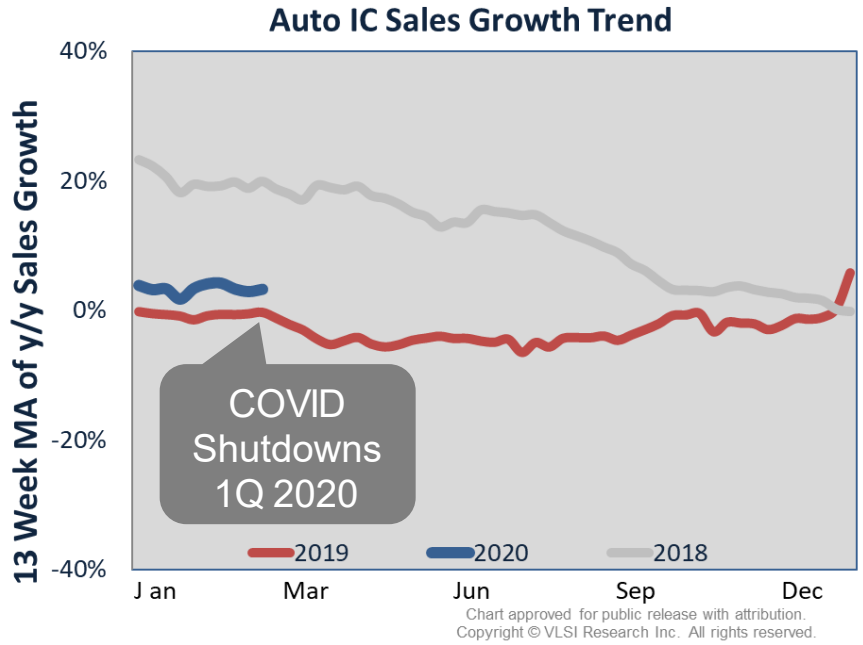
Auto IC Sales: Early on, it looked like a normal start to the year





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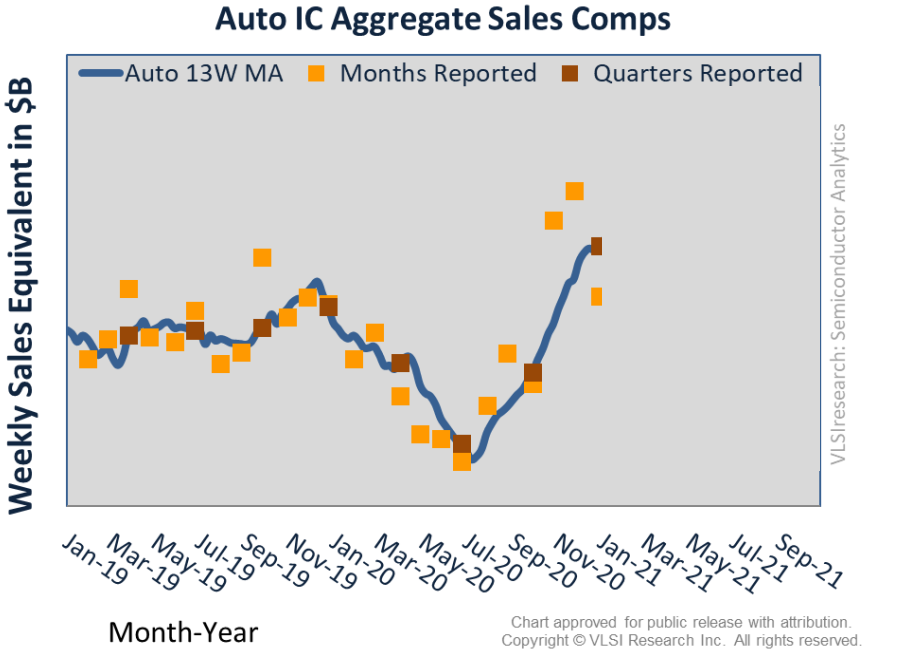
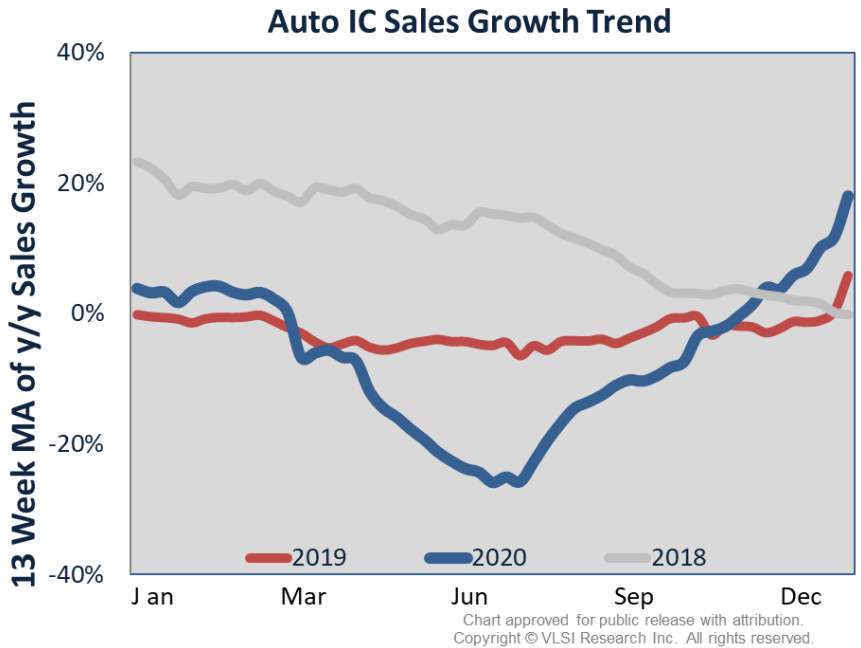
Auto IC Sales: And then … it was pedal to the metal

Problem was depleted inventory with few auto wafers in the fabs and a 12 to13 week cycle time





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Auto IC's snapped from Glut to Shortage

When it went to shortage,
foundries were already in shortage

IC Supply/Demand Heat Map

Qtr or Week	Overall	DRAM	NAND	IDM	Foundry:	More Moore	More than Moore	OSAT	Analog & Power	Auto	Qtr or Week
1Q 2020	Tight	Shortage	Tight	Balanced	Shortage	Shortage	Shortage	Shortage	Balanced	Balanced	1Q 2020
2Q 2020	Tight	Saturated	Balanced	Tight	Shortage	Shortage	Shortage	Shortage	Tight	Glut	2Q 2020
3Q 2020	Tight	Tight	Balanced	Tight	Tight	Tight	Shortage	Tight	Tight	Glut	3Q 2020
4Q 2020	Tight	Shortage	Balanced	Tight	Tight	Tight	Shortage	Tight	Tight	Tight	4Q 2020
1Q 2021	Shortage	Shortage	Tight	Tight	Shortage	Shortage	Shortage	Tight	Tight	Shortage	1Q 2021
2Q 2021	Shortage	Tight	Tight	Tight	Shortage	Shortage	Shortage	Tight	Tight	Shortage	2Q 2021

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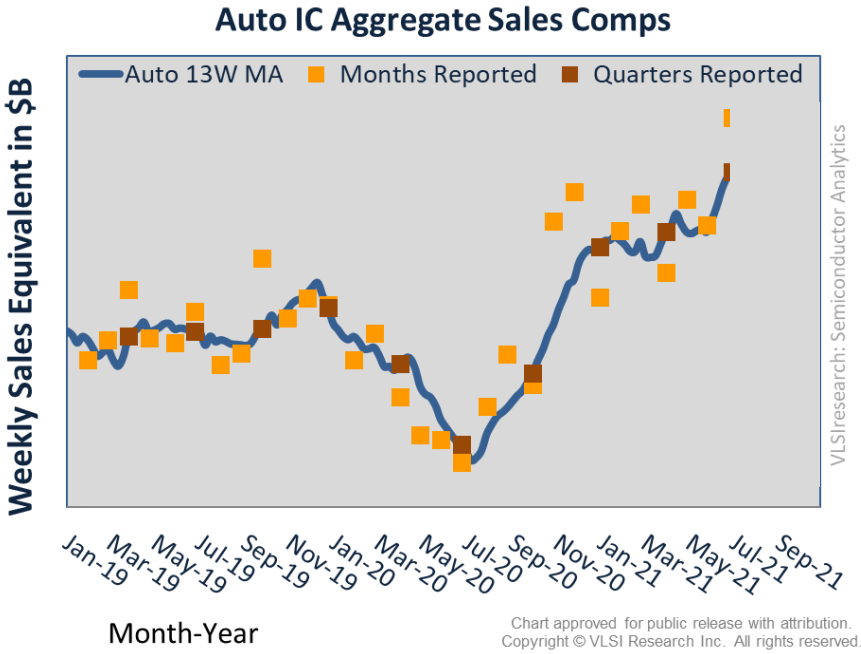
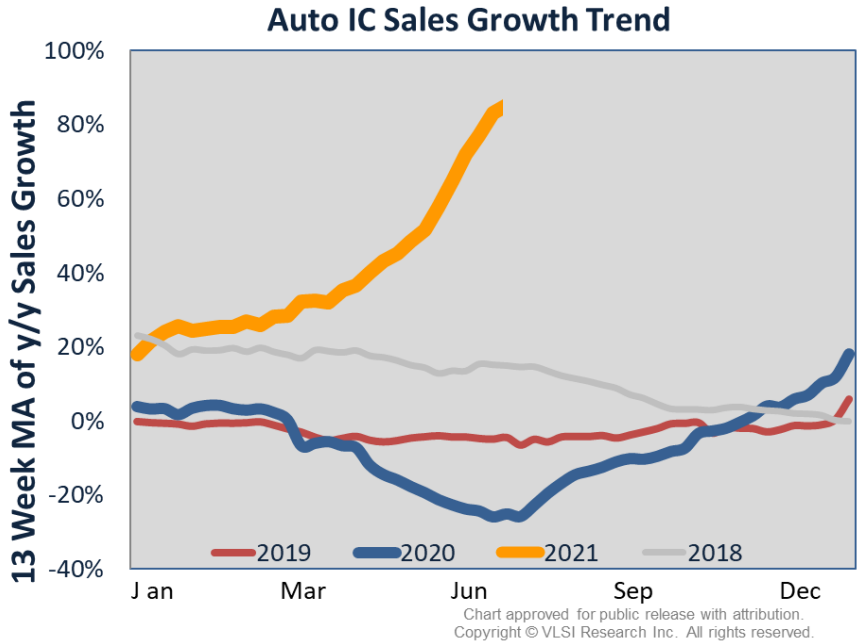
Auto IC Sales: It was buy, Buy, BUY in ’21

Wafers were coming out by Mar, but it was unevenly distributed





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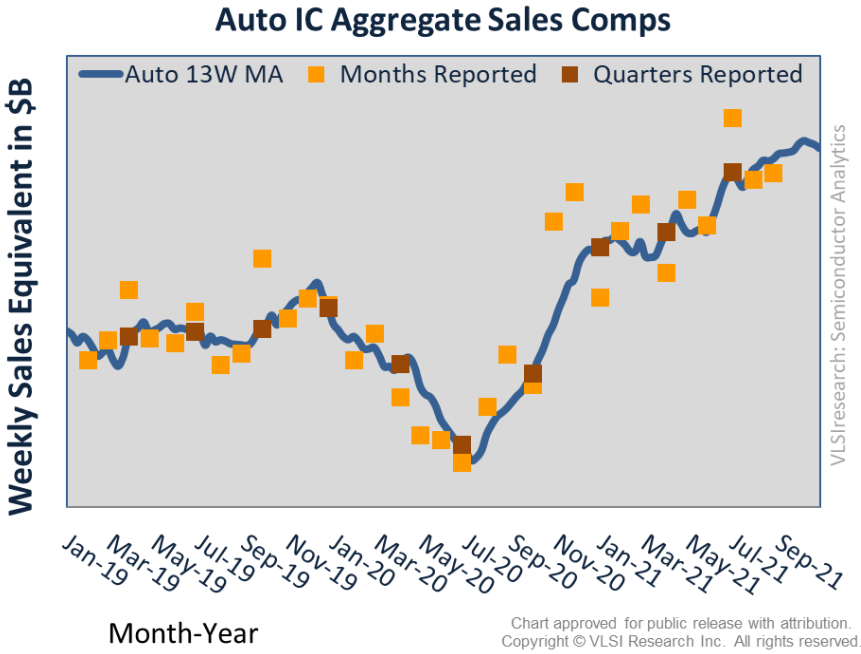
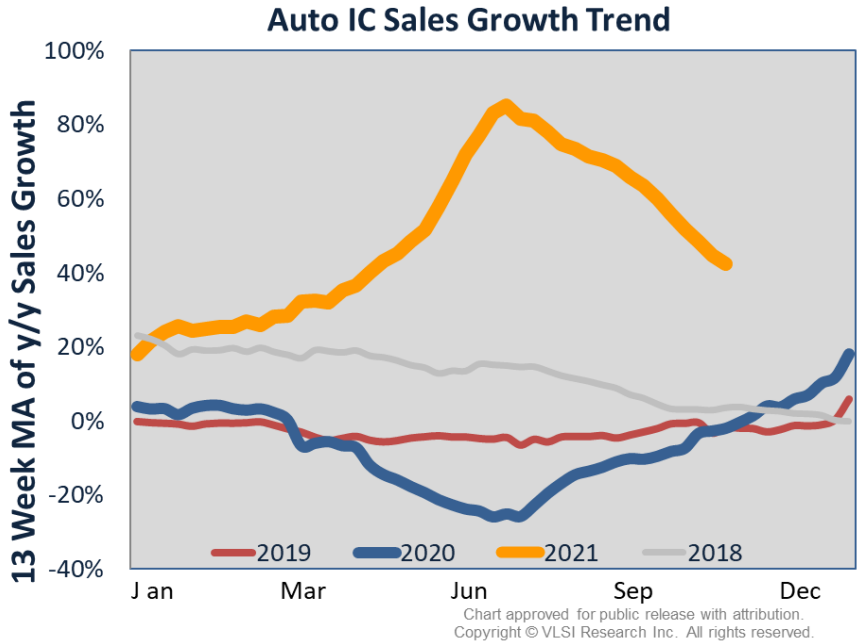
Auto IC Sales: Eventually conditions reversed …

but spot shortages persisted in the supply chain's depths





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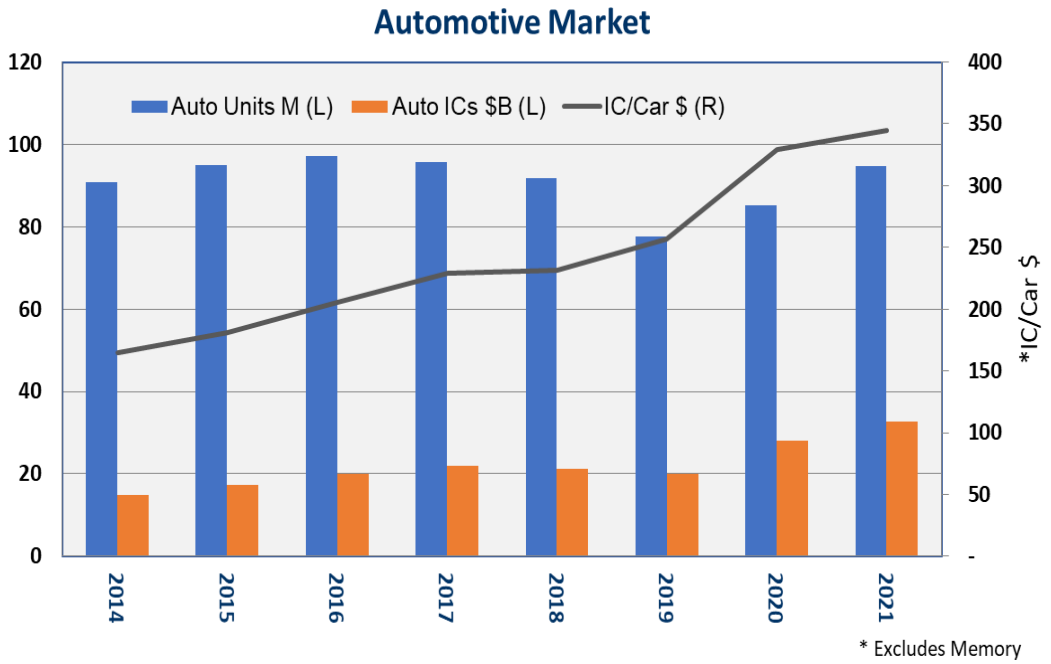
6 Lessons to Learn

from the Great Shortage of 2021

1. Avoid hyper-coherence to build in anti-fragility
2. Stay on top of demand shifts
3. Dynamically model product mix and technology changes that affect component needs
4. Look deeper into your supply chain
    1. Deeper: <visibility & >risk
5. Understand its complexity
6. Know where the weak links are



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The Geopolitical Outlook

and the Drive for Technology Sovereignty

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Challenges = Opportunities: Geopolitics

- Xi infects Globalization in 2015
  - Made in China 2025
  - Drive for **Technology Sovereignty**
- Trump spread infection in 2016
  - Responds with tariffs and access restrictions
- **The Great Shortage** of 2021 make Chips important again
- The **Taiwan Hyper-Coherence**
- The **China Enigma**
  - Taiwan as a part of China

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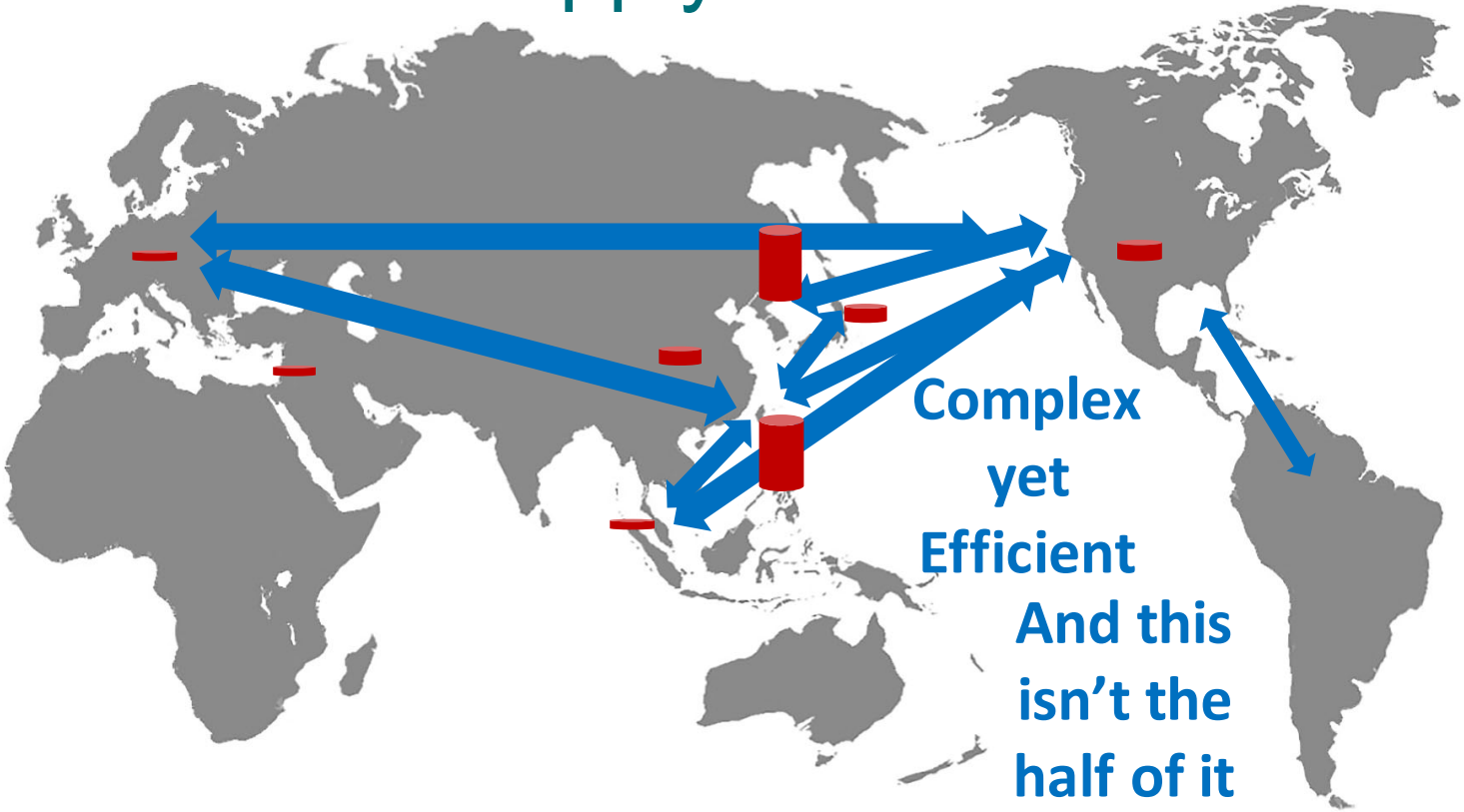
The Globalized Supply Chain from the 60s-10s



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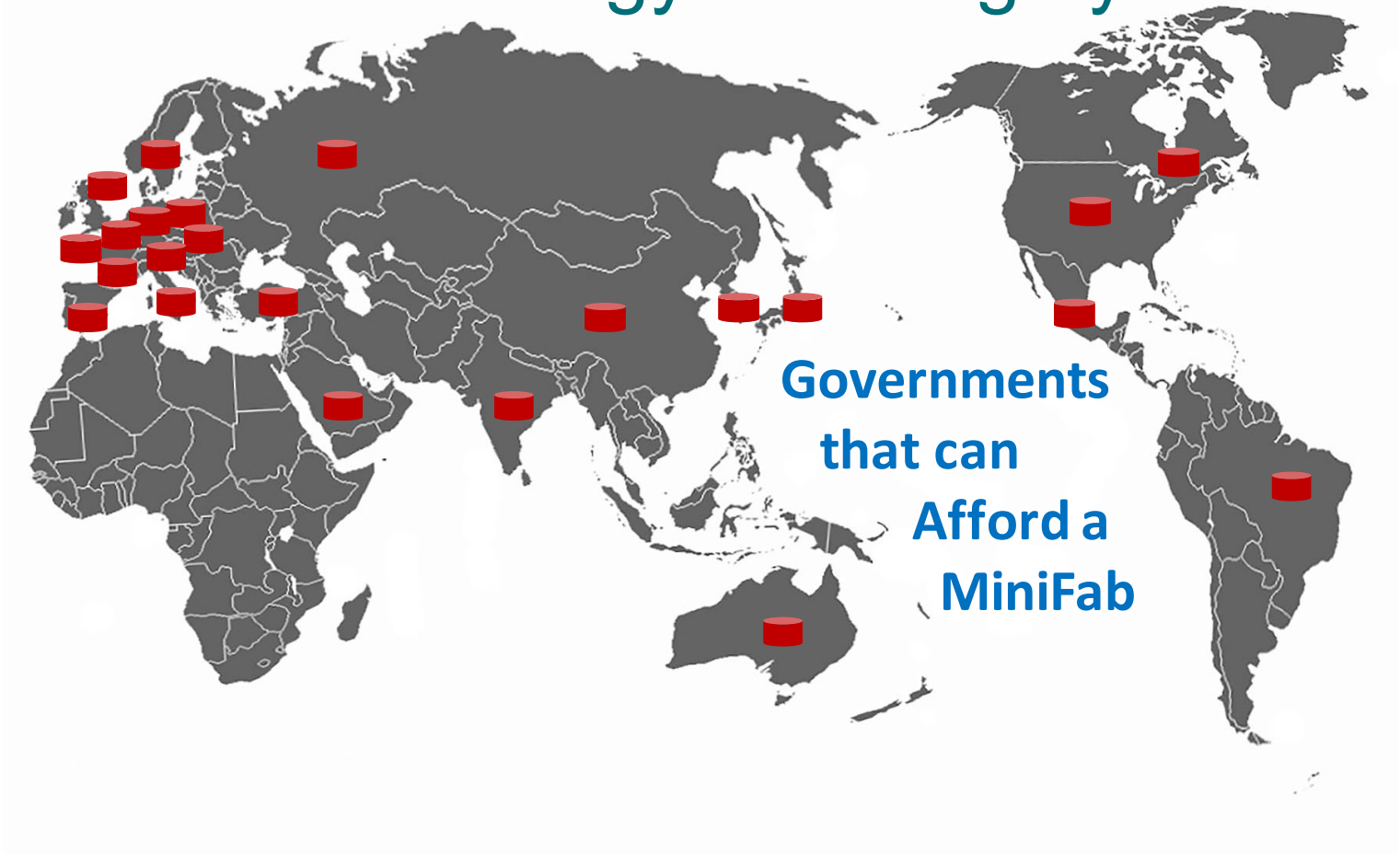
Post-2016 Technology Sovereignty



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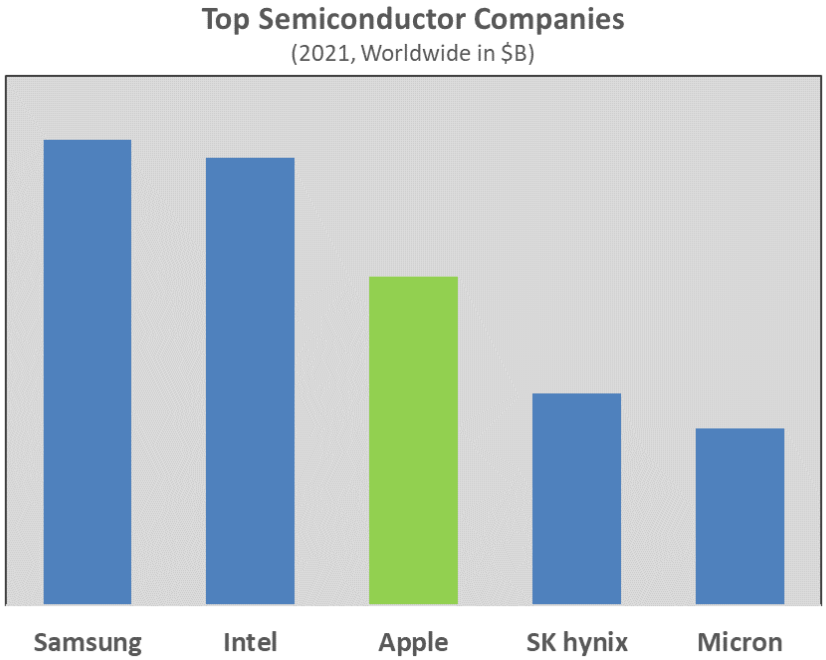
Why Governments are Concerned



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If you're American or South Korean…

Why Worry?

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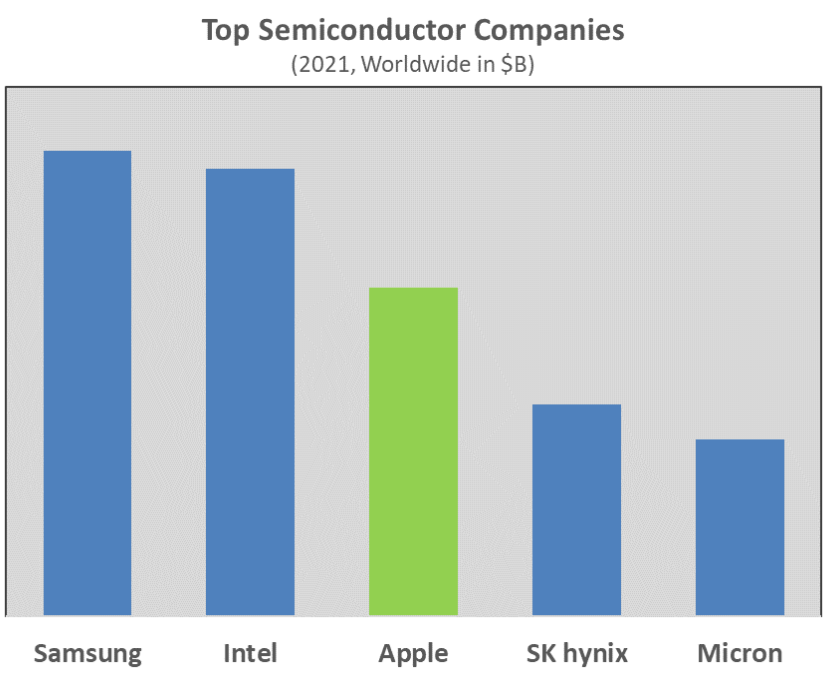
What keeps Governments up at night

The Taiwan Hyper-Coherence



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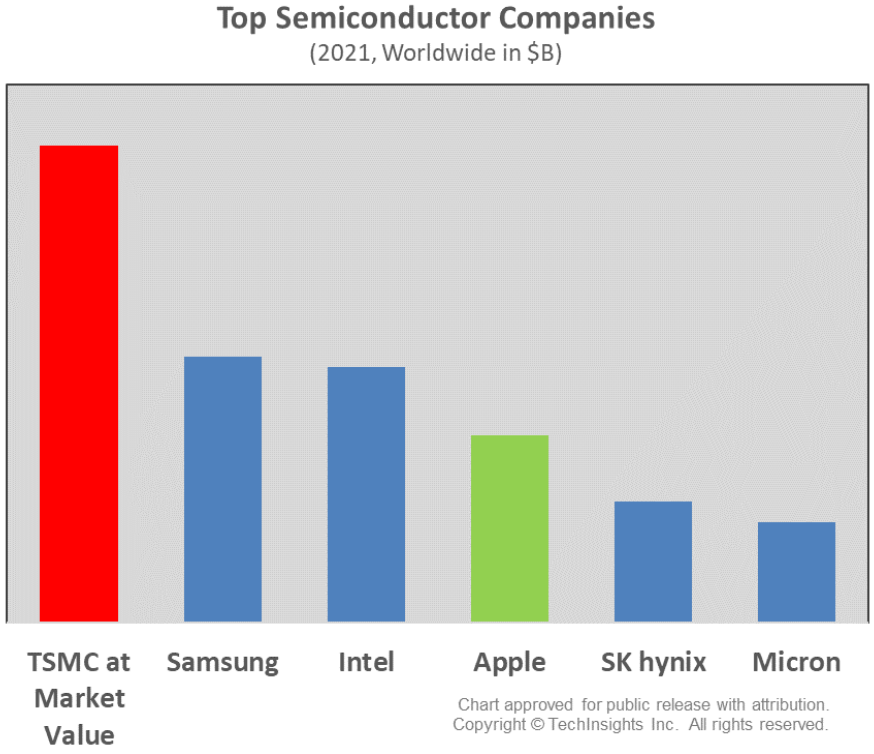

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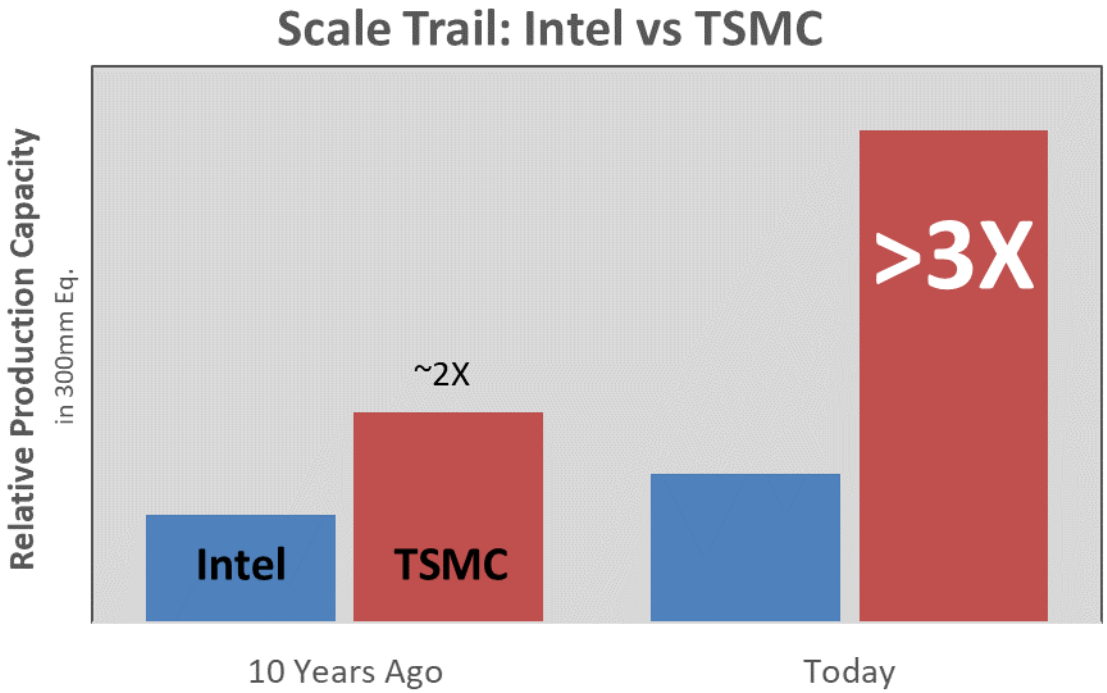
the Taiwan Hyper-Coherence

- China vs US
  - Taiwan has lost its Wei Chi game of a Silicon Shield
    - Taiwan: the **Hope Diamond of Semiconductors**
- The question is…
  - Who gets it … or …
  - Who denies the other from getting it



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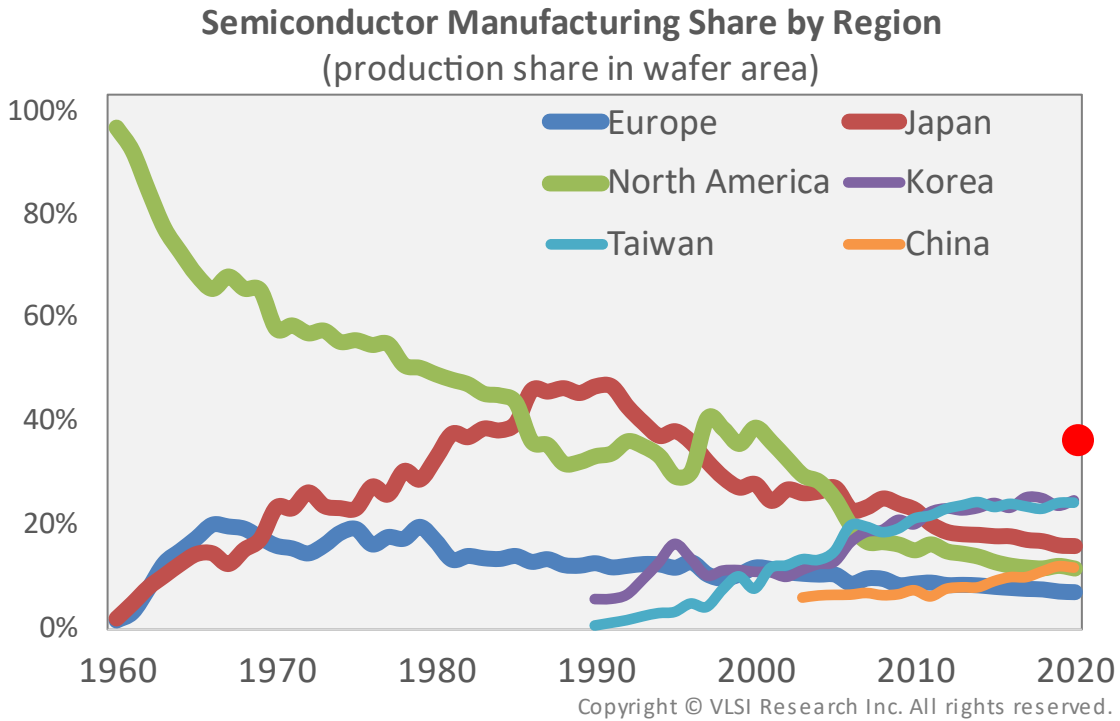
Taiwan + Korea = ~Half of Semiconductor Production

- US fallen since the 60's
  - A brief recovery in 90's
- Japan day in the sun
  - Peaking at ~50% around 1990
- Europe peaked at ~20% in mid-60s
- *Share loss trends reflect strategic importance*



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The Bottom Line on De-Globalization

It’s not going away

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Market Outlook: *Billions are no longer cool…*
A only a Trillion Dollars is cool

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Semiconductor Analytics

In 2021 semiconductor sales blew past a

Half-a-*Trillion*

Growth was 4-5X trend

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The Road Ahead for Autos

Big Opportunities for Every Tier of the Supply Chain

The Auto Industry is Reinventing itself Again

- Battery Technology
- Hydrogen fuel cells
- A new golden age of design
  - Virtualized Development
  - Big Data/AI
  - Faster time to market
  - New reliability methods allow faster node adoption

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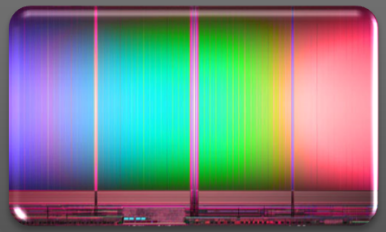
Chip Innovation Engine *Relentlessly Drives Opportunity*

Macroeconomic

COVID MMT National Security PowerGrid
AI-everywhere AR/VR Zooming Lifestyle Data Security Climate
Auto\SDV\ADAS Data Center *as a Profit Center* Data Economy Change
IoT SSD iMC 5G Cloud 3D Printing\Etching China
Computational Medicine Factory 4.0 Quantum Computing



Semiconductors

Law of PPACt Heterogeneous Integration
GAA GaN CNT 2D Compound Semi NPUxPU Disaggregated Design
Nanosheets DRAM 3DNAND 3DLogic CIS Trusted Fab
AI-in-design DCTO PCRAM RRAM CrossPoint RF FPGA Chiplets

Equipment & Materials

Multi-beam litho/inspection
EUV revolution Optical DW EPE\LER Hi/LoK Curvilinear Masks
Hi-NA-EUV AI-in-fab CNT 2D ALD DSA Dry Resist NGinterconnect
hyper-NA-EUV HAR ALE Q-ALE Materials System Engineering Riblets
Advanced Assembly Materials Enabled Scaling Selective-dep/etch

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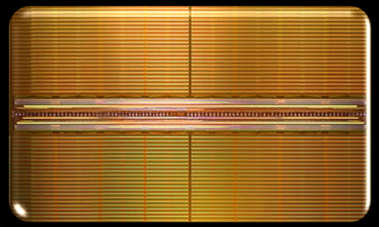
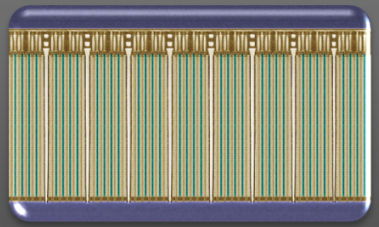
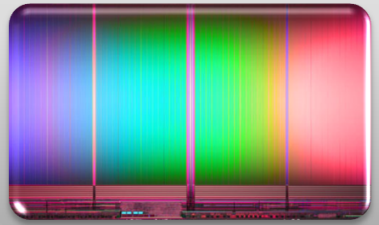
Chip Innovation Engine *made possible by us…*



DRAM DDR_{N+1} ALD HAR Gap Fill Selective-dep/etch NGMs
$3D\ DRAM_{GAAenabled}$ EPE\LER Co capping Hi-Mobility Channel TSV
Copper EUV revolution LoK Dielectric NGM-Hard Mask
Low R Metal DCTO AI-in-fab HKMG Advanced Doping
Advanced Interface Engineering



NAND V-Limit: H-Scaling Low-Dishing CMP 2D Nanosheets
ALE_{NG} RRAM Hybrid W2W Bonding NPU xPU CMOS Over/Under Array
Zig-Zag Staircase
PCRAM Hole-Thinning 3DNAND Hi-Modulus ON HAR Gap Fill
CrossPoint DCTO NGM-Hard Mask Advanced Interface Engineering
Optimized Implant/Anneal



LAP *Logic, Analog & Power* EUV Hi-NA-EUV GAA hyper-NA-EUV $GAA_{enabled}$ eDRAM
NGMs 3DLogic
Law of PPACt GaN TSV EPE\LER Hi/LoK NGM-Hard Mask
AI-in-fab Curvilinear Masks DCTO Q-ALE Dry Resist Chiplets CNT 2D
Heterogeneous Integration Compound Semi Selective-dep/etch
Materials Enabled Scaling Optical DW Advanced Interface Engineering

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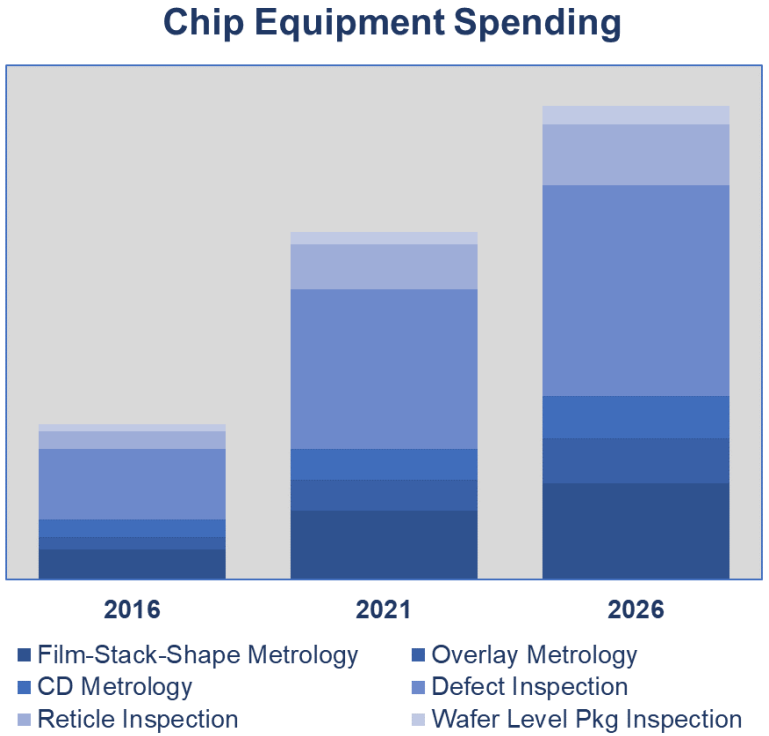
Semiconductor Equipment Market

- **Process Diagnostics**
  - **Forecast to reach $15B** by 2026 at a 6% CAGR
    - 2021 was 40+% year/year
  - Defect Inspection: $6B
  - Film-Stack-Shape: $3B
  - Reticle Inspection: $2B
  - CD & Overlay: $2B
  - Package Inspection: $0.5B



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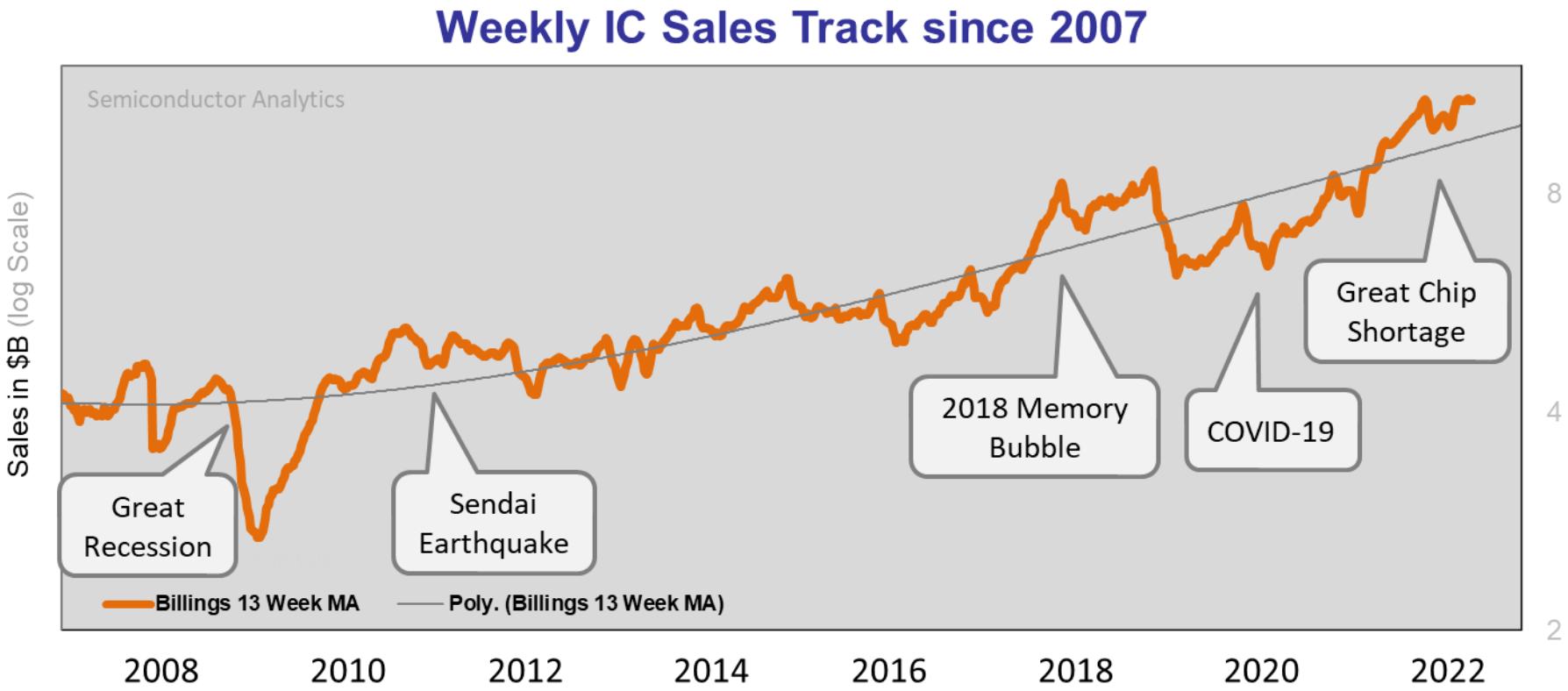
IC Sales Track: **Overheated or Underheated?**



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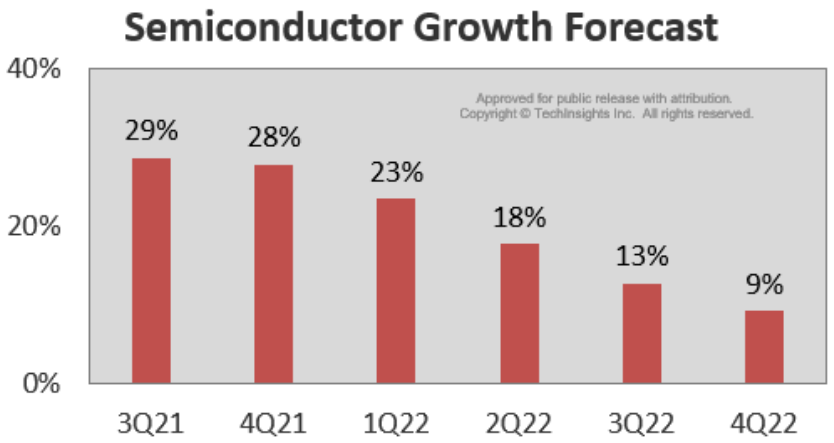
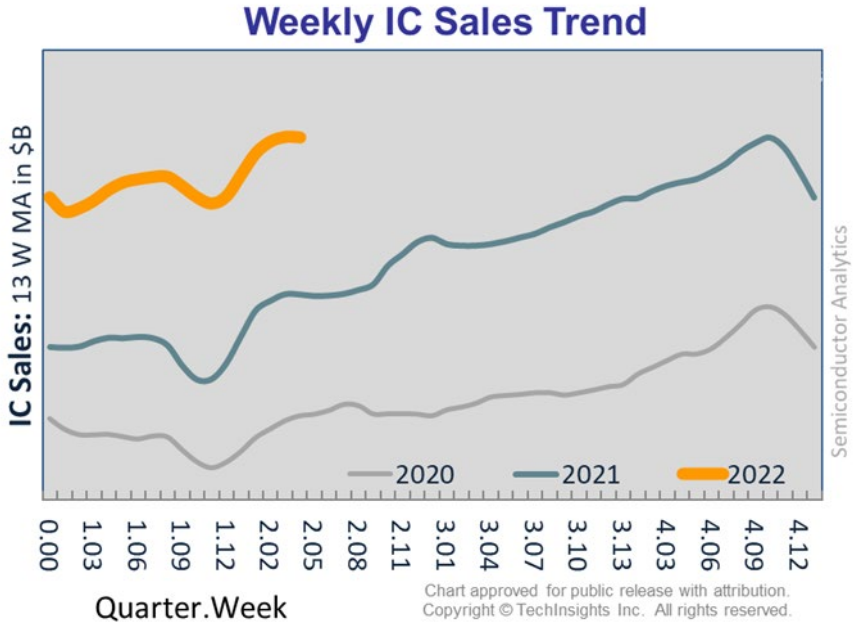
Semiconductor Forecast

2022 Forecast: 681 $B 15%

2021: 590 $B 25%





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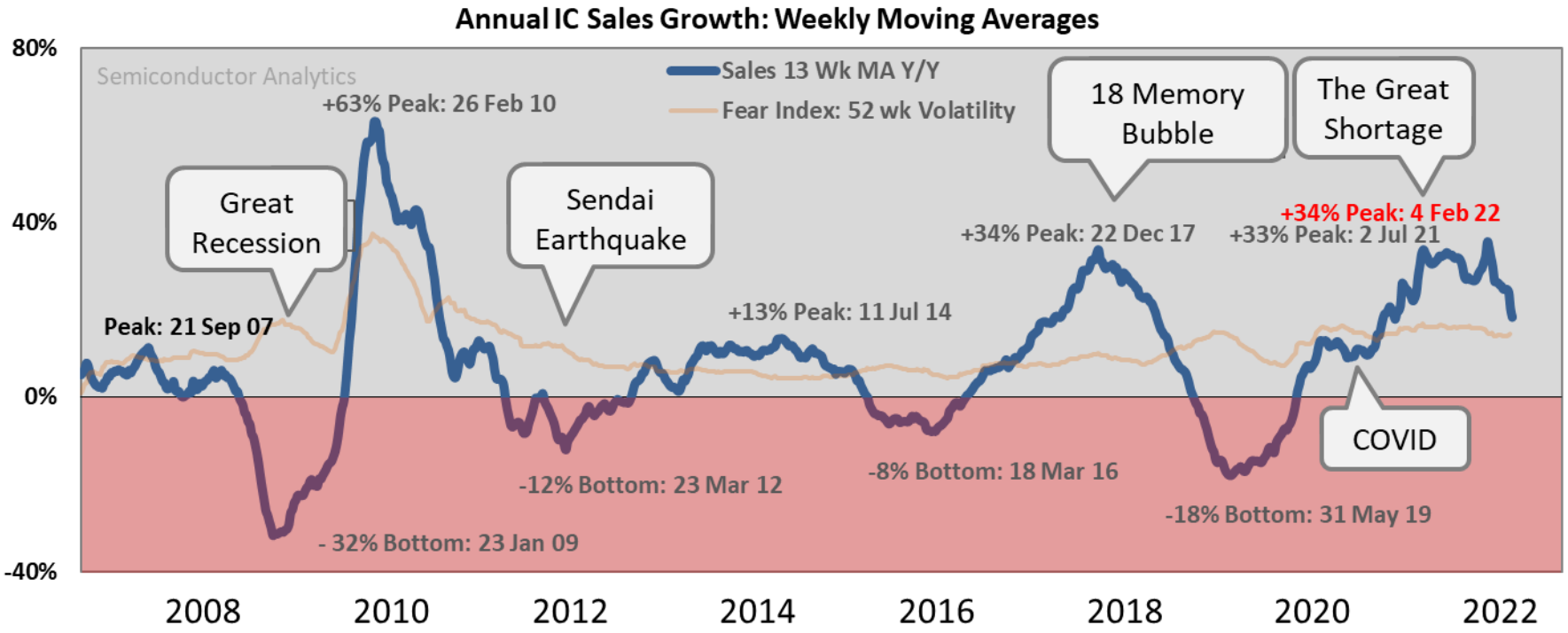
IC Sales Growth: **Overheated or Underheated?**



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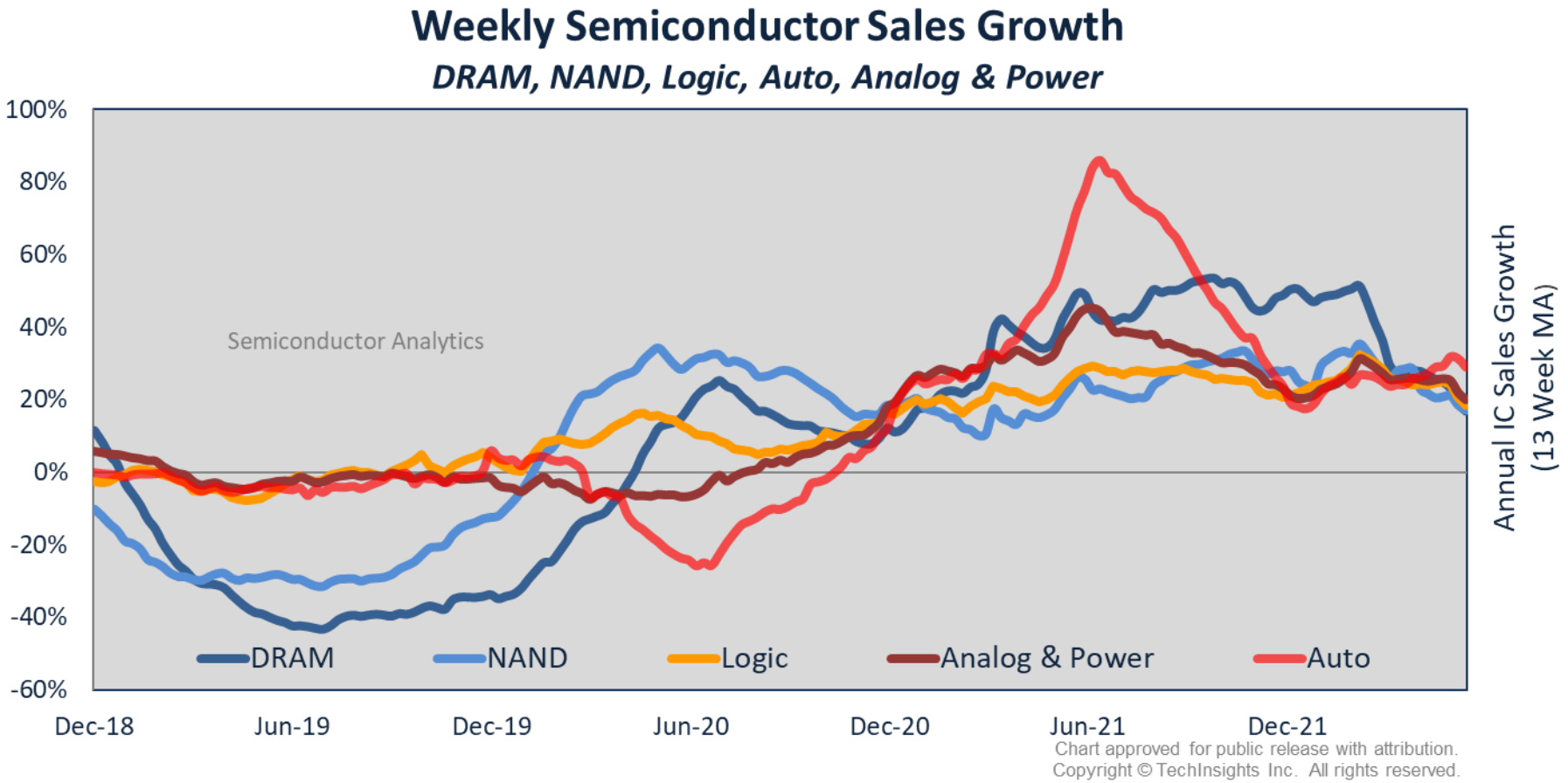
Weekly Sales Growth: DRAM, NAND, Logic, Analog & Power, and Auto



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IC Supply/Demand Trends

Last Week's Semiconductor Supply/Demand Heat Map

	3-Jun-22	10-Jun-22
Overall	Tight	Tight
DRAM	Saturated	Saturated
NAND	Tight	Tight
IDM	Tight	Balanced
Foundry:	Tight	Balanced
More Moore	Balanced	Loose
More than Moore	Tight	Tight
OSAT	Tight	Tight
Analog & Power	Tight	Balanced
Auto IC	Shortage	Shortage

Range: Shortage | Tight | Balanced | Loose | Saturated | Glut

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TechInsights' IC Supply/Demand indices loosened for the week, as IDM, Foundry, Analog & Power slipped out of Tight conditions. More Moore Foundry dipped to Loose, while DRAM held at Saturated levels. NAND, More than Moore Foundry, and OSAT remained Tight. Auto ICs are still in a Shortage.

Chip demand – cooled by inflation and monetary tightening – and capacity expansion are working to ease the shortage.

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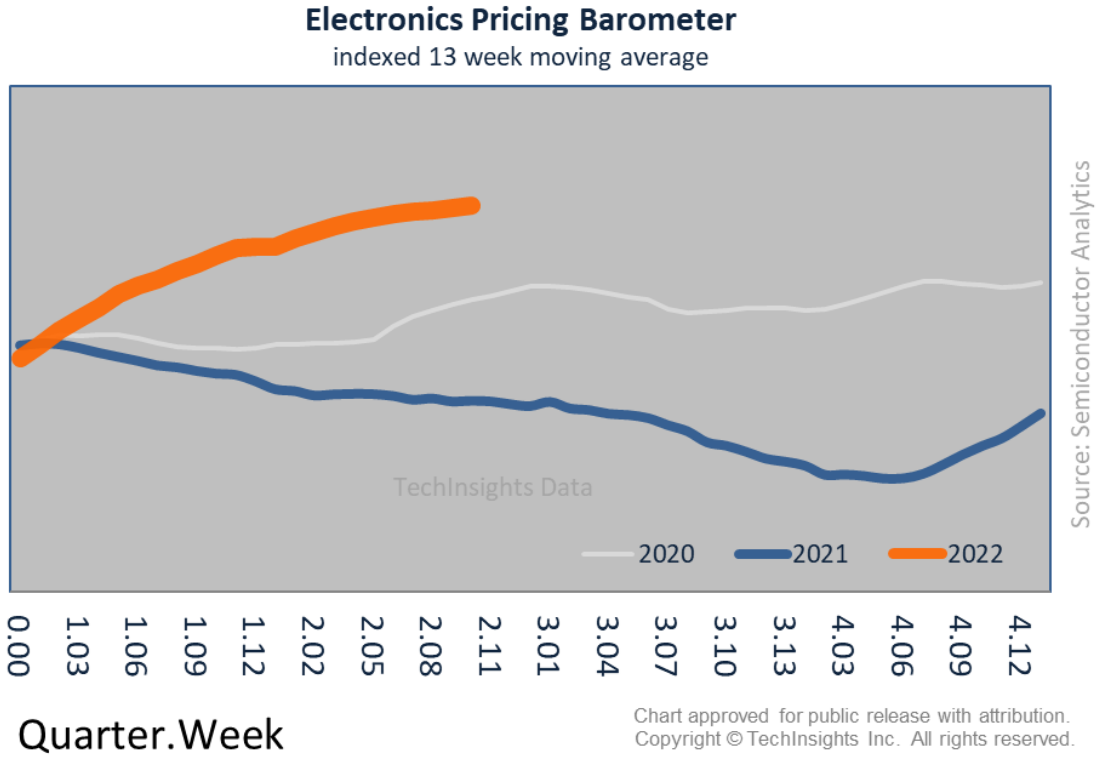
Electronics Retail Pricing Trends:

for PC notebooks Tablets Smartphones Cell phones Digital Cameras Appliances TVs

Electronics' Retail Prices are rolling over



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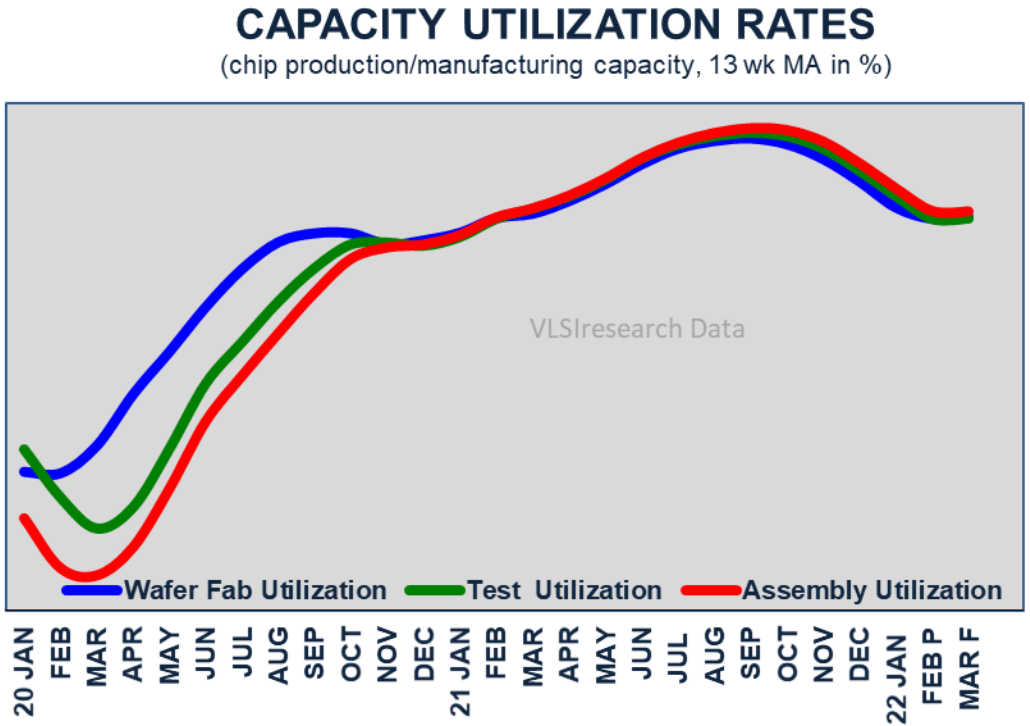
What about Semiconductor Utilization?

- All sectors still at high levels
  - Wafer Fab
  - Test
  - Packaging
- High enough that hot lot changes reduce overall output



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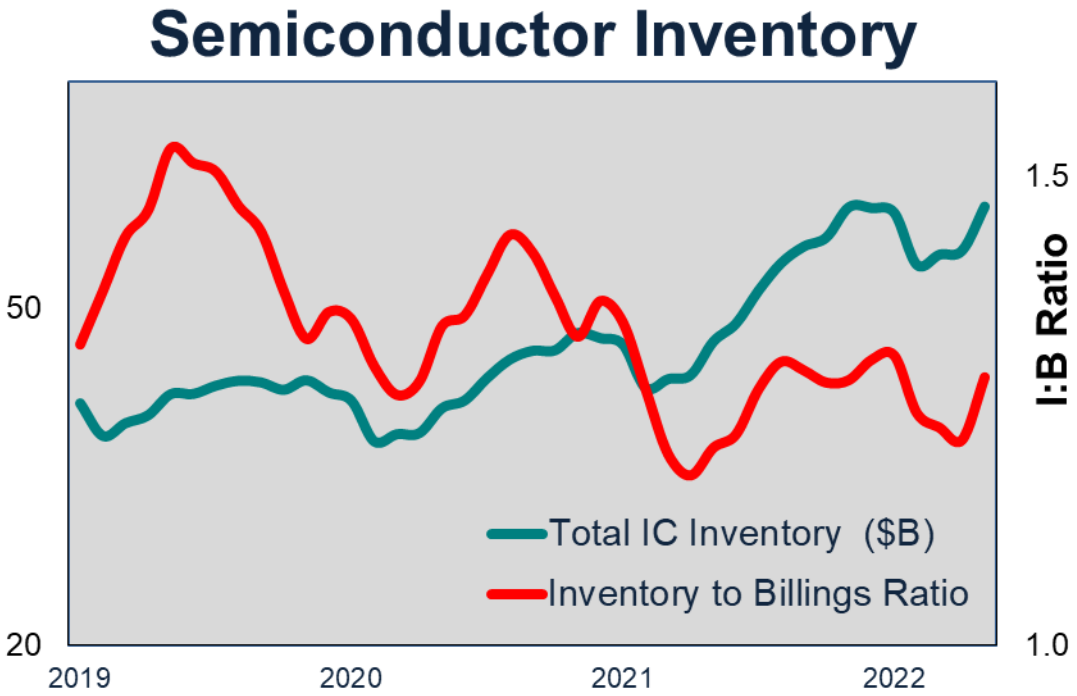
What about Semiconductor Inventory?

- The Inventory-to-Billings Ratio is…
  - in an expansionary range
  - ~0.20 below critical levels
- Customer complaints about extreme shortages a sign of multiple bookings



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Concerns

Hoarding

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Concerns

Inflation

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Concerns

Recession

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