Semiconductor Industry Challenges
Industry Resilience

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A challenging three years

Rethinking global semiconductor supply chains

Rising environmental concerns

Challenges and opportunities
During the pandemic we experienced an unprecedented scarcity of chips

2018/2019: “normal” market cycle

Q1 2020: demand contraction

2020-Today: demand shock

2023: return to “normal” market cycle

Demand¹ & Supply² for semiconductors excluding memory³

Indexed to 2018 average quarter

1. Past and forecasted IC sales: forecast derived from expected demand of representative industries
2. Past and forecasted foundry capacity
3. Due to surplus of memory supply from 2019 onward

Note: semiconductors are purchased one quarter before actual end-market sales

Source: BCG IC Model Forecast, BCG analysis (November 2022)
The world now knows that supply chains and chips are important to daily life

Long production cycles make the bullwhip effect pronounced in our industry

**Demand signal**
- Materials & equipment
- Manufacturing (F/S/A/T)
- BU/Fabless
- Electronics OEM
- Electronics retailer

**Amplifying impact**
- 3-12 month planning and production cycle
- 2-6 month production cycle
- 1 month planning cycle
- 1-1.5 month production cycle
- 1 month planning cycle

- Highly fluctuating prices and stockpiles
- Over time & idle time
- Obsolescence
- Rush orders
- Stock outs
In April 2020 I simulated the PC supply chain dynamics for a GSA webinar

Assumptions
- 10% drop in demand for 26 weeks
- 110% recovery for 13 weeks

Conclusions
- A 10% disruption could cause 2+ years of supply chain disruption
- Be careful about cutting production too much
But PC demand *increased*, making the supply chain challenges greater

Work from home practices reversed the downward trend of client PC shipments

Wafer fabs were taxed to support unforested client demand on top of growing data center demand

Source: Statistia; BCG analysis
We experienced widespread shifts in demand that continue to impact us today.

2018/2019: “normal” market cycle

Demand$^1$ & Supply$^2$ for semiconductors excluding memory
Indexed to 2018 average quarter

2023: return to “normal” market cycle

![Chart showing demand and supply trends from 2018 to 2023.](chart.png)
Devices of all types became short of supply

Severity of shortages by buyers of different types of chips

<table>
<thead>
<tr>
<th>Category</th>
<th>Weighted Average (Months)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logic - Leading (&lt;= 7 nanometers)</td>
<td>3.9</td>
<td>39</td>
</tr>
<tr>
<td>Logic - Advanced (10 - 22 nanometers)</td>
<td>3.4</td>
<td>56</td>
</tr>
<tr>
<td>Logic - Mature (28 - 90 nanometers)</td>
<td>3.7</td>
<td>44</td>
</tr>
<tr>
<td>Logic - Legacy (&gt;90 nanometers)</td>
<td>3.7</td>
<td>29</td>
</tr>
<tr>
<td>Optoelectronic</td>
<td>3.1</td>
<td>63</td>
</tr>
<tr>
<td>Other memory¹</td>
<td>2.8</td>
<td>45</td>
</tr>
<tr>
<td>Other / unknown²</td>
<td>4.4</td>
<td>7</td>
</tr>
<tr>
<td>Analog / Power / RF</td>
<td>2.8</td>
<td>84</td>
</tr>
<tr>
<td>MEMS / Sensors</td>
<td>2.8</td>
<td>66</td>
</tr>
<tr>
<td>DRAM</td>
<td>2.9</td>
<td>59</td>
</tr>
<tr>
<td>Discrete</td>
<td>2.4</td>
<td>67</td>
</tr>
<tr>
<td>NAND</td>
<td>3.0</td>
<td>42</td>
</tr>
</tbody>
</table>

1. "Other memory" was described as including EEPROM, NOR flash, SRAM. 2. "Other" chips include MOSFETs, Wafers for PV panels

Source: BCG Study on Semiconductor Purchasing (February 2023); n = 128
Almost every industry was impacted by the shortages

Abatement period for semiconductor shortages, by industry

<table>
<thead>
<tr>
<th>Industry</th>
<th>0-6 Months</th>
<th>6-12 Months</th>
<th>12-18 Months</th>
<th>18-24 Months</th>
<th>24+ Months</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy &amp; Utilities</td>
<td>27%</td>
<td>33%</td>
<td>11%</td>
<td>7%</td>
<td>7%</td>
<td>67%</td>
</tr>
<tr>
<td>Comms Infrastructure</td>
<td>33%</td>
<td>20%</td>
<td>33%</td>
<td>7%</td>
<td>7%</td>
<td>40%</td>
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<tr>
<td>Automotive</td>
<td>33%</td>
<td>22%</td>
<td>23%</td>
<td>15%</td>
<td>13%</td>
<td>67%</td>
</tr>
<tr>
<td>Aerospace &amp; Defense</td>
<td>33%</td>
<td>31%</td>
<td>13%</td>
<td>13%</td>
<td>13%</td>
<td>67%</td>
</tr>
<tr>
<td>Healthcare</td>
<td>33%</td>
<td>38%</td>
<td>13%</td>
<td>25%</td>
<td>13%</td>
<td>67%</td>
</tr>
<tr>
<td>Consumer Electronics - Smartphones</td>
<td>31%</td>
<td>33%</td>
<td>13%</td>
<td>33%</td>
<td>14%</td>
<td>67%</td>
</tr>
<tr>
<td>Consumer Electronics - PCs / Laptops</td>
<td>25%</td>
<td>32%</td>
<td>14%</td>
<td>41%</td>
<td>6%</td>
<td>67%</td>
</tr>
<tr>
<td>Data Center / Servers / High Perf. Computing</td>
<td>5%</td>
<td>14%</td>
<td>14%</td>
<td>6%</td>
<td>6%</td>
<td>67%</td>
</tr>
<tr>
<td>Industrial Goods</td>
<td>11%</td>
<td>33%</td>
<td>11%</td>
<td>5%</td>
<td>5%</td>
<td>67%</td>
</tr>
<tr>
<td>Other</td>
<td>7%</td>
<td>7%</td>
<td>7%</td>
<td>7%</td>
<td>7%</td>
<td>67%</td>
</tr>
</tbody>
</table>

1. Other industries included: Gaming, Memory Manufacturer, Beverage, Food Manufacturing, Real Estate, Consulting; Source: BCG Study on Semiconductor Purchasing (February 2023); n=128
Many companies are now thinking differently about cost-resiliency tradeoffs

"Would you be willing to pay a premium for a US-manufactured chip of this type?"

1. "Other memory" was described as including EEPROM, NOR flash, SRAM
2. "Other" chips include MOSFETs, Wafers for PV panels
Source: BCG Study on Semiconductor Purchasing (February 2023)
Semiconductors are increasingly becoming more central to global geopolitics

1. Big Fund = National Integrated Circuits Industry Development Investment Fund. Note: Capacity plans are rounded estimates; SII = Statute for Industrial Innovation; PERTE = Strategic Project for Economic Recovery and Transformation


Incentive
Restriction

US Restrictions
US data center chip sales restrictions to China and Russia
US Export Control Reform Act restricts chip/technology transfers

EU Restrictions
Chip export restrictions on Russia due to invasion of Ukraine

US CHIPS Act
$52B of incremental semi funding

Spain PERTE CHIP
$12B of semi funding

Indian incentive scheme
$25B of semi funding

European Chips Act
$45B of semi funding

China Big Fund¹
$73B of semi funding

Korea Special Act
Tax breaks up to 20%; 30-40% tax credit for R&D

Taiwan SII amendment
Corporate income tax rate of 20%. Up to 15% of R&D tax deduction end of year

China Restrictions
Data Security Law (DSL)
Applies to all data activities in China that impair the country’s national security
Updates to export restriction list included cryptographic chip design

US Export Control Reform Act restricts chip/technology transfers

Restriction

Non-exhaustive

¹ Big Fund = National Integrated Circuits Industry Development Investment Fund.

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The semiconductor industry directly produces ~0.2% of global emissions.
Vast majority of Semiconductor industry emissions are tied to electricity use

1. Emissions from other upstream and downstream sources
Source: GHG Protocol, CDP, SEMI FAB, Gartner, BCG analysis
Challenges and opportunities abound!

**Challenges**
- Autonomous/EVs
- Generative AI workloads
- C&S pressures
- Geopolitics
- Leading node yields and costs

**Opportunities**
- Increasingly regionalized supply chains
- Increased focus on power consumption & device efficiency
- Advanced node technology
- Chiplet-based architectures

Source: BCG research
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