



# Steering through the semiconductor crisis

A sustained structural disruption  
requires strategic responses by the  
automotive industry

## Management Summary

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The global semiconductor shortage that has gripped the automotive sector and many other industries since 2020 is likely to last for several years in older technology nodes. Structural supply and demand imbalances, as well as a fundamental supply chain mismatch, were the root causes of the crisis, but it was triggered and amplified by Covid-19 and other external shocks. Unfortunately, the growing number of such disruptions, driven by climate change, geopolitical tensions and black swan events, make future supply crunches ever more likely. So, what can the automotive industry do to address the current crisis and protect against a future one?

The implications for the traditional industry are clear – its cars are heavily reliant on older, legacy semiconductors. But investments in building capacity for these devices are low, hitting future production and increasing the industry's exposure to the shortage. The cars produced by new OEMs, on the other hand, use more advanced architectures often built on new, leading-edge nodes. These chips are receiving the lion's share of capacity investment, giving the companies that use them an advantage, which also extends to their sourcing of older semiconductors.

The crisis has led many players to rethink semiconductor supply chains. New models to secure long-term demand and share risk reflect a rebalancing of negotiating power. Consequently, automotive OEMs and suppliers must not wait for the crisis to end: they need to be proactive in implementing a set of strategic measures instead.

## The semiconductor supply crisis

### What's causing it and what are its effects?

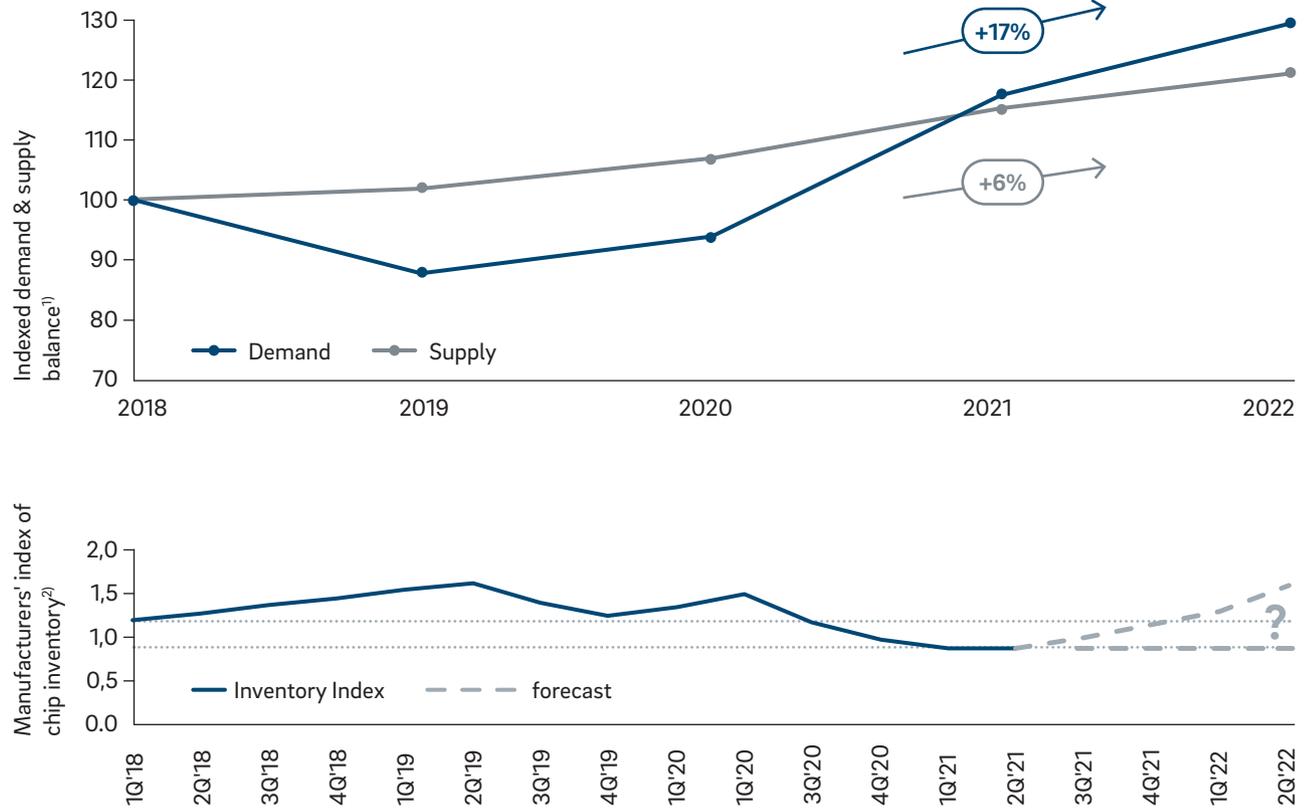
A systematic gap between demand and supply has developed in the semiconductor market. The root causes include structural imbalances and a fundamental supply chain mismatch, which have been exacerbated by external shocks such as the Covid-19 pandemic. Manufacturer inventory levels have reached a new low point as demand remains high and customers overstock, a natural reaction to supply chain uncertainty.

Overall semiconductor demand is increasing by about 17% per annum, compared to a 6% p.a. increase in manufacturing capacity between 2020 and 2022. To address the shortage, key semiconductor suppliers have announced significant capacity expansion. These investments are focused on leading-edge and advanced semiconductor nodes and will take several years to ramp up volume production. We do not expect the supply crunch to be fully resolved in 2022.

The demand/supply mismatch is not evenly distributed across the different semiconductor types. Production capacities of most advanced logic, memory and discrete devices will significantly increase in the short term. But logic IC semiconductors with nodes older than 40 nm, analog chips and MEMS devices, which are largely reliant on legacy manufacturing capacity, will see prolonged shortages that are likely to last several years.

#### A GROWING GAP:

Semiconductor demand is likely to continue to outstrip supply in 2022, with manufacturers' inventories at their lowest level for years



<sup>1)</sup> Supply and demand indexed to 100 for 2018; <sup>2)</sup> Based on Gartner's Index of Inventory Semiconductor Supply Chain Tracking

# Implications for the automotive industry

## Carmakers hit hard due to their reliance on legacy semiconductors

Current distributed automotive architectures rely on legacy technology, often containing more than a hundred microcontrollers (MCUs), each with limited computing power. Accounting for about 40% of market demand, the automotive industry is one of the primary users of legacy MCUs, which are manufactured in legacy and mature nodes. The expansion of this capacity will be limited. These are also the chips most affected by the supply crunch.

Consumer electronic devices need an increasing number of semiconductors in older technology nodes – not for computing/logic as in the car industry but for differentiating new features such as 3D audio, fast charging and 5G. These features require power electronics, RF and audio semiconductors, which are typically manufactured in 40-90 nm. The consumer electronics OEMs often have significantly higher purchasing and bargaining power than their industrial/automotive counterparts, further amplifying the shortage in automotive and industry.

Going forward, the semiconductor mix in cars is undergoing a profound change as the automotive industry transitions to new electronic architectures. Like laptops or cell phones, cars are becoming software-defined advanced computing devices. Domain-centralized and zonal architectures, as found in high-end laptops and other devices with high computational needs, offer more centralized and powerful computing tools to meet these demands.

### Supply chain shift

The shift to these more centralized architectures means the share of leading-edge and advanced logic chips in cars is increasing. They are needed, for example, for autonomous driving technologies, infotainment systems and powertrain management systems. Advanced semiconductors (and their manufacturers) are therefore contributing a higher share of value. This is leading to a change in supply chain dynamics, with more direct collaboration between OEMs and tier-2 semiconductor suppliers.

The move away from legacy semiconductors gives new OEMs an advantage. Their products are often built around centralized architectures that rely more on advanced semiconductors than mature or legacy nodes. As these are less affected by the supply crunch, it reduces their exposure to it. This gives traditional OEMs an additional incentive to speed up their transition to centralized architectures.

### A change in approach

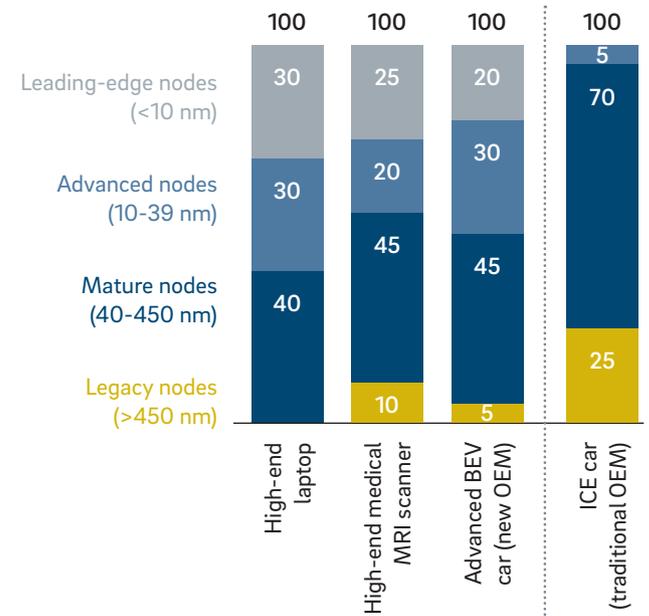
The semiconductor crisis has made most automotive OEMs and suppliers start thinking more strategically about semiconductor supply, rather than treating them as just another vehicle component. Automakers are moving from a just-in-time to a just-in-case approach, building semiconductor inventory. Unfortunately, this intensifies the crisis in the short term, pushing temporary demand above the actual level of semiconductor usage, and may lead to overstocking and a semiconductor downturn in the future.

### IN THE SLOW LANE:

Conventional cars are heavily reliant on legacy and mature nodes, unlike many more advanced devices

Extrapolation

Semiconductor usage in selected OEM devices [in % of total 8" wafer equivalents]



Source: desk research, interviews with market participants, Roland Berger

## Why capacity investments aren't helping the auto industry

### The current ramp-up in production is focused on the wrong nodes

Investments in new semiconductor capacity typically focus on expanding leading-edge nodes. This maximizes the lifetime of the assets to protect the required multi-billion-dollar investments and optimizes the long-term manufacturing cost. Production of leading-edge nodes is expected to see growth of around 26% (CAGR) between 2020 and 2022. On the other hand, capacity investments in legacy nodes will be only about 2% per annum. This pattern of capacity expansion has been prevalent within the semiconductor industry for many years and is bad news for traditional automotive OEMs.

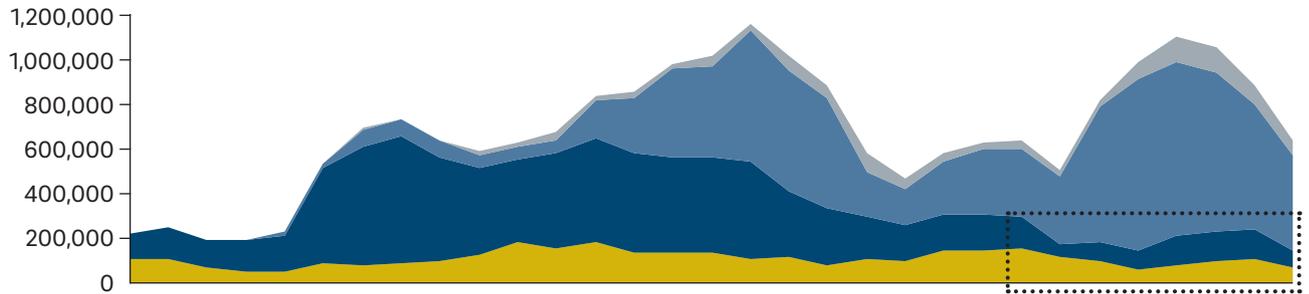
Ramping up new semiconductor production will not solve the supply crisis in the short term. As factory assets age and memory and advanced computing devices move on to next generation leading-edge nodes, the now obsolete memory and digital capacity is being converted to "More than Moore" technologies, that is, analog, power or MEMS devices. But this repurposing of capacity takes time – while it takes three to four years to build and ramp up leading-edge capacity, it takes around two years to shrink or move to larger wafer diameters and re-qualify the automotive devices.

As a result, we do not expect a rapid easing of the shortage of legacy nodes – the nodes most relevant to the automotive industry. Multiple suppliers have announced fabrication plant (fab) conversions, but they are unlikely to be sufficient to address the supply gap in mature nodes before 2023.

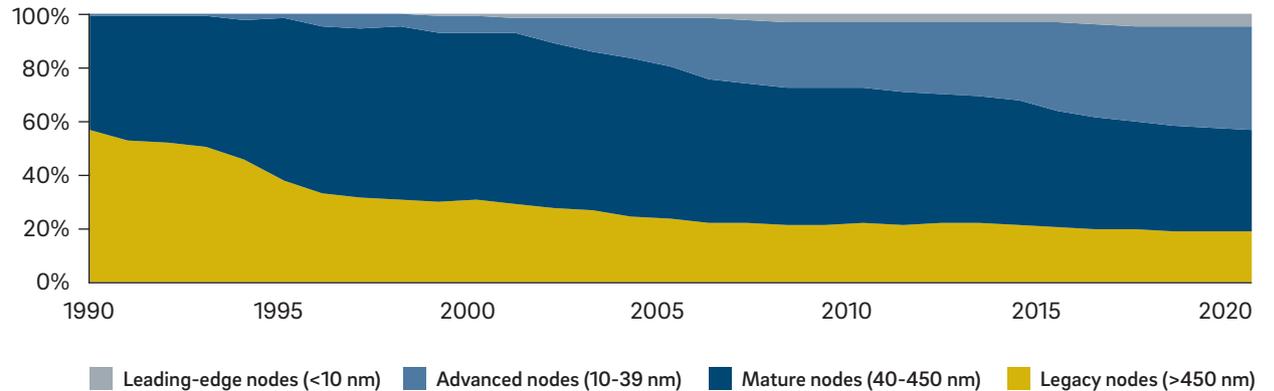
#### MIND THE GAP:

There has been no significant additional capacity in mature and legacy nodes since 2010

New capacity [three-year rolling average, 8 in wafer equivalents]



Share of total installed capacity [%]



## Risks to the semiconductor supply chain are growing

### Decision-makers must closely monitor and mitigate the threats

Disruptions in the semiconductor supply chain are likely to become more frequent, more pronounced and less predictable as a result of climate change, rising political uncertainty and other factors. For example, semiconductor manufacturing centers in Southeast Asia are experiencing more dangerous tropical storms, while severe droughts in Taiwan will have a growing impact on the water-intensive semiconductor manufacturing process.

In addition, shipping disruptions have caused a sharp increase in air and sea freight costs, and a significant transportation backlog. And geopolitical tensions are particularly relevant to the semiconductor industry due to the concentration of capacity in Asia. Such tensions, including growing protectionism and the trade war between the US and China, have impacted market access, cut off customers and often involved national security threats. One effect of such disruptions has been higher prices.

While all of the main economic centers have initiated policies to strengthen their regional semiconductor manufacturing capacity, it's clear that supply chain disruptions can no longer be considered unfortunate black swan events. They are a systemic risk to the global supply chain. As a result, automotive OEMs, tier-1 suppliers and electronics manufacturing service companies need to secure their supply chains, mitigate their deteriorating negotiating power and protect themselves against future supply chain disruptions.

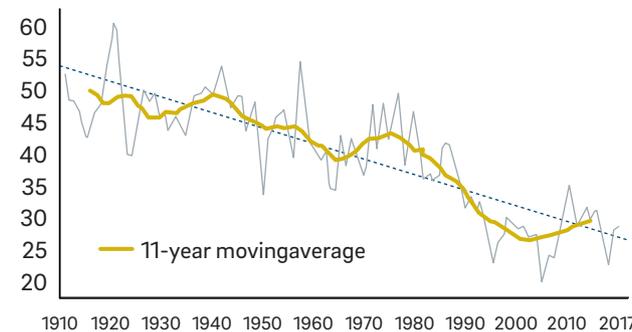
#### BAD FORECASTS:

Droughts and tropical storms affecting Asian semiconductor hubs have grown in intensity over the past few decades

Non-exhaustive examples

#### EXTENDED DROUGHTS IN TAIWAN

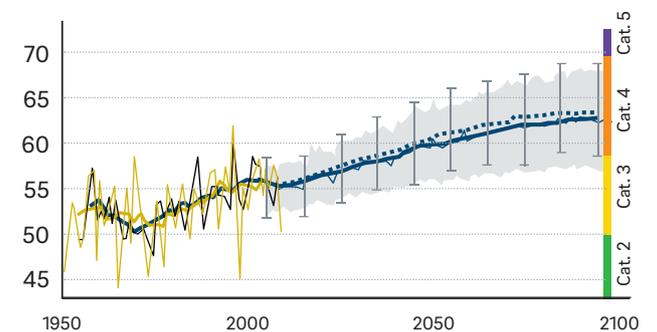
Number of light rain days



- Foundries such as Taiwan's TSMC highly dependent on water supply (TSMC uses c. **156,000 tons of water a day**)
- Continued fall in annual rainy days and declining water reserves will be a major concern for the industry

#### HIGHER FREQUENCY OF TROPICAL STORMS IN EAST ASIA

Typhoon peak intensity (m/s)



- Semiconductor hubs in East Asia are expected to experience disruptive **extreme tropical storms 2-3 times more often than today by 2040**

## What automotive OEMs and suppliers need to do Adopt the design and supply strategies of semiconductor firms

Automotive decision-makers need to be on the lookout for early indicators of potential disruptions. For example, even before the Covid-19 pandemic, average semiconductor fab utilization was already significantly above the 80% long-term average, which should have served as a warning to those OEMs canceling automotive chip orders in early 2020.

The question remains how automotive companies can get around the current shortage. Unfortunately, there is no silver bullet that will quickly bring a return to pre-crisis vehicle production levels. Instead, OEMs and suppliers need to initiate a broad set of measures covering the near, medium and long term to respond to the crisis and protect against a future one.

Roland Berger has identified a range of mitigating actions to help automakers address shortages and shape their future supply chain management approach to semiconductors.

Most importantly, OEMs need to speed up the transition to centralized E/E architectures and thereby move to advanced and leading-edge nodes. Capacity needs to be secured in direct contracts between OEMs, suppliers and semiconductor companies, including "take or pay" capacity agreements over 5+ years. The implementation of these measures is a significant challenge that will ultimately accelerate the transformation of the automotive industry.

### TRACKING TROUBLE:

Decision makers can detect signs of potential disruption by monitoring early indicators

Examples – Non-exhaustive

	Early indicator	What to look for	Implications
Short-term impact	Fab utilization levels	A decrease in the current high fab utilization levels	A fall in fab utilization rates towards the long-term industry average will indicate an improvement in the supply crunch
	Chip inventory lead times	A shortening of lead times for key nodes	Reduced lead times will indicate an easing of the shortages
Mid-term impact	Criticality signals from suppliers	Messages from semiconductor suppliers about specific nodes	Increased lead times for specific nodes will require action such as alternative sourcing of specific components or increased safety stocks
	Average price development changes	Average semiconductor prices leveling off	A reduction or increase in average prices is an indicator of the supply/demand gap closing – Likely approaching the end of the demand/supply imbalance
	New refurbishment announcements	Announcements of refurbishment of legacy memory fabs	Announcements of refurbishments will lead to a closing of the supply/demand gap in the mid term – Likely the final closing of the supply-side gap for specific semiconductor types

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