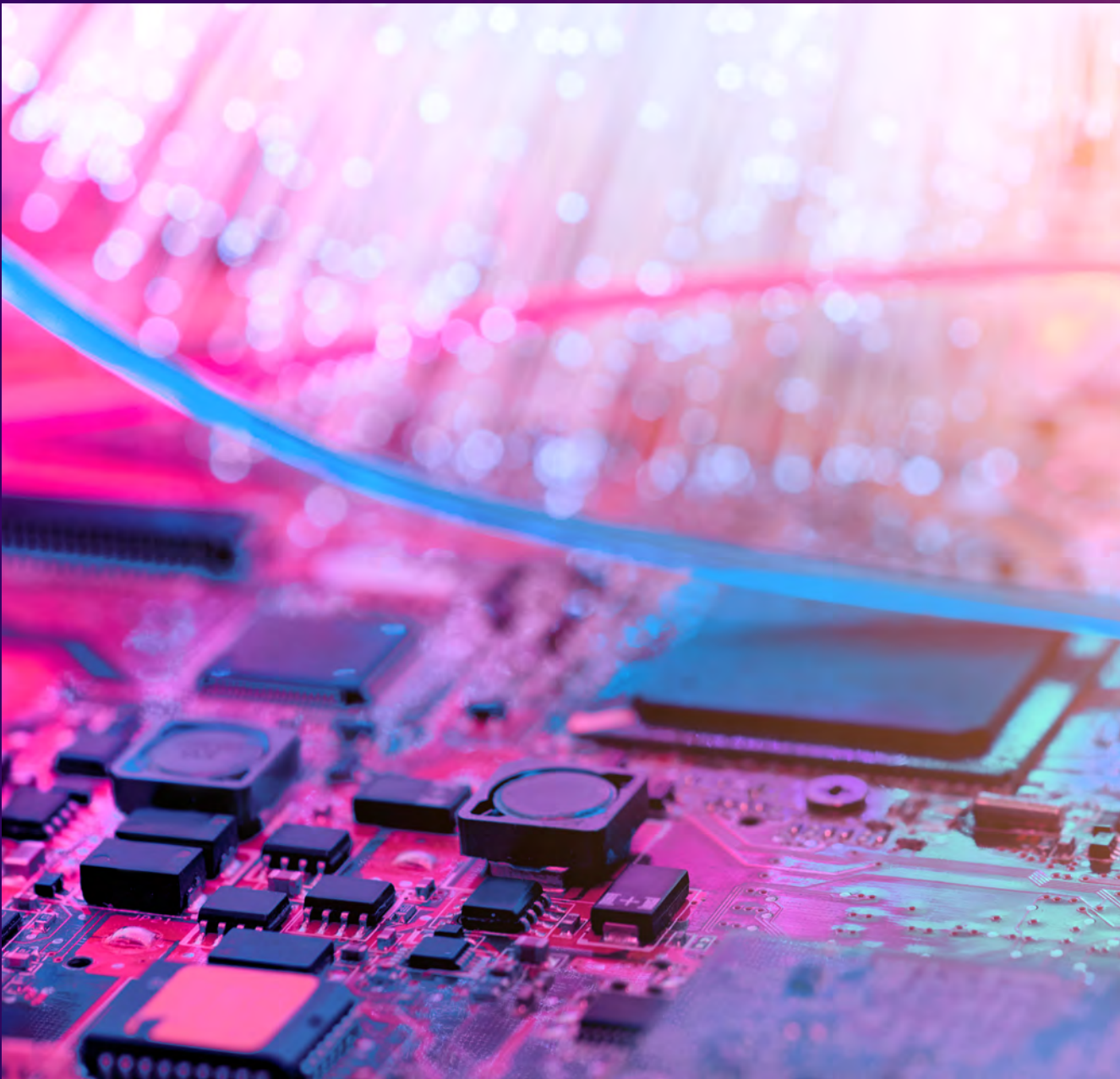


The long view of the chip shortage



**Building resiliency in
semiconductor supply chains**



Table of contents

- 03 Executive summary
- 04 Hit by a perfect storm
- 08 Strengthening supply chain today
- 11 Reimagining supply chain resilience for the future
- 17 Every business is now a semiconductor business

Executive summary

The COVID-19 pandemic has impacted global industries of all kinds. However, few have felt greater supply chain pressures than semiconductor companies. Faced with a serious disruption in both supply and demand, semiconductor companies were forced to react with unforeseen speed to effectively manage their business and operations.

As demand for chips continues to soar, supply chains will remain constrained for the foreseeable future. That means everyone—semiconductor companies and those reliant on chips—should build a more resilient supply chain.

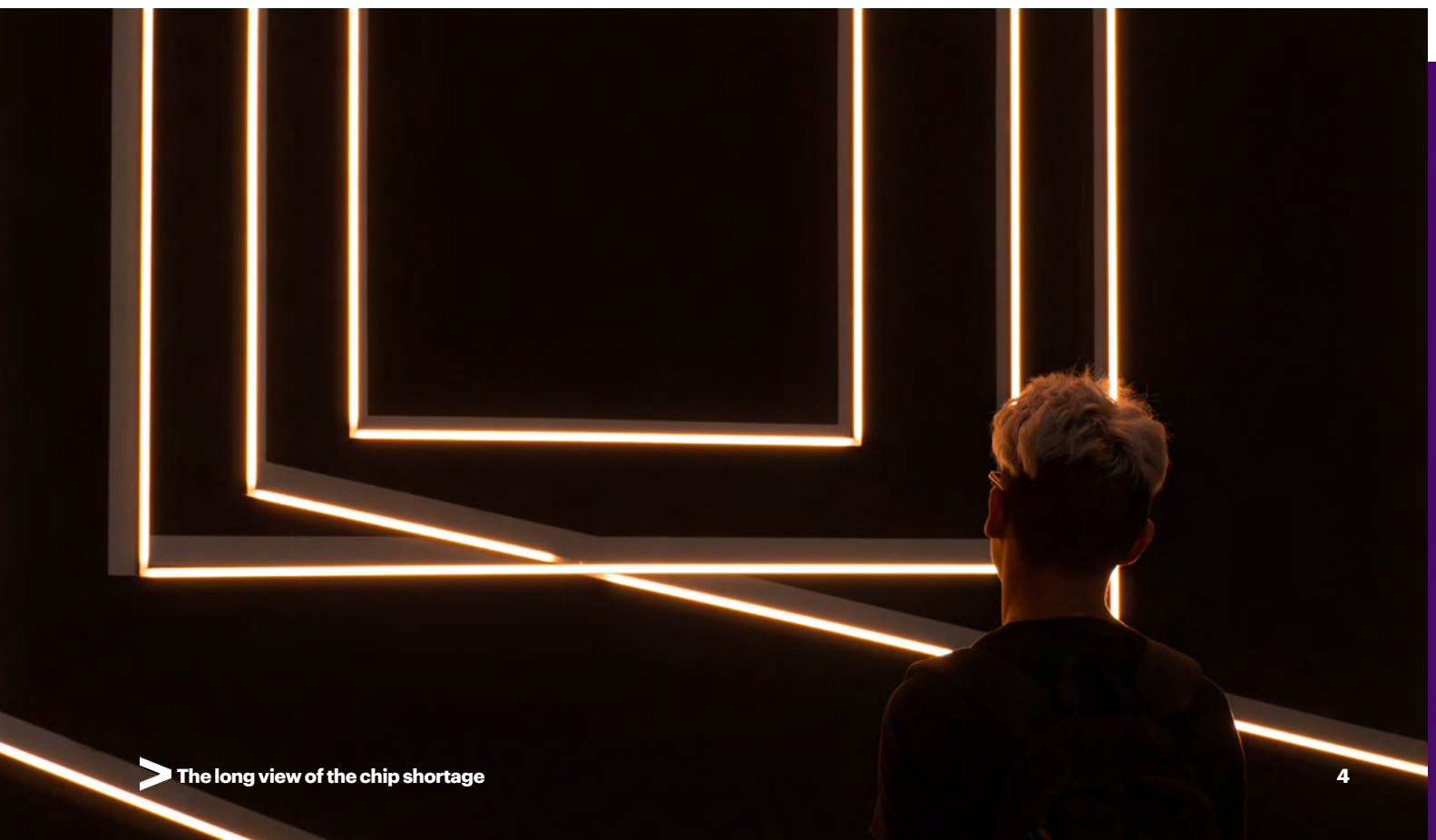
Being better prepared for the future depends on re-examining near and long-term strategies, and acting on lessons learned from chip shortages that disrupted manufacturing for numerous valuable industries worldwide.

Hit by a perfect storm

The chip shortage of 2021 sparked a crisis in the global economy. Apple, the world's largest buyer of chips, delayed the launch of the iPhone 12 by two months; Samsung, the second-largest buyer—and also the second-largest producer—will likely have to do the same for its new smartphone.¹ The global auto industry is expected to lose \$60.6 billion in revenue in 2021.² The semiconductor shortage even caught the attention of US President Joe Biden who hosted a virtual summit with CEOs from affected industries.³

So, what caused the shortage?

A perfect storm of skyrocketing chip demand, manufacturing capacity and logistics constraints.





Electronics demand goes into the stratosphere

As working and learning from home became the norm during COVID-19—and dollars went from going out for entertainment to streaming and gaming at home—our behaviors fundamentally changed. This resulted in a booming demand for consumer electronics.⁴

Growing demand for devices in turn drove up demand for semiconductors. Every video game console, TV or tablet required numerous chips that were needed for display, power, connectivity and other functionalities.⁵



Long lead times

Strong demand drove an imbalance in supply. For an industry that has long production lead times of ~18 weeks—and where building additional capacity requires 6 to 9 months and billions of dollars of revenue, this meant supply recovery would be slow and costly.

Average Semiconductor Manufacturing Lead Time (weeks)



Logistics constraints limit chip shipments

To make matters worse, chip shipments themselves were delayed due to the reduced amount of flights and closure of airways. Additionally, global shipments of COVID-19 related items taking up capacity and the global grounding of dozens of B777 due to engine failures further put pressure on air cargo capacity. In total, global air cargo capacity declined a staggering 20% in 2020.⁶

And on top of that, substrates—the basis on which chip components and their connections are built—were limited in supply due to a factory fire in Taiwan, which further impacted chip production.⁷



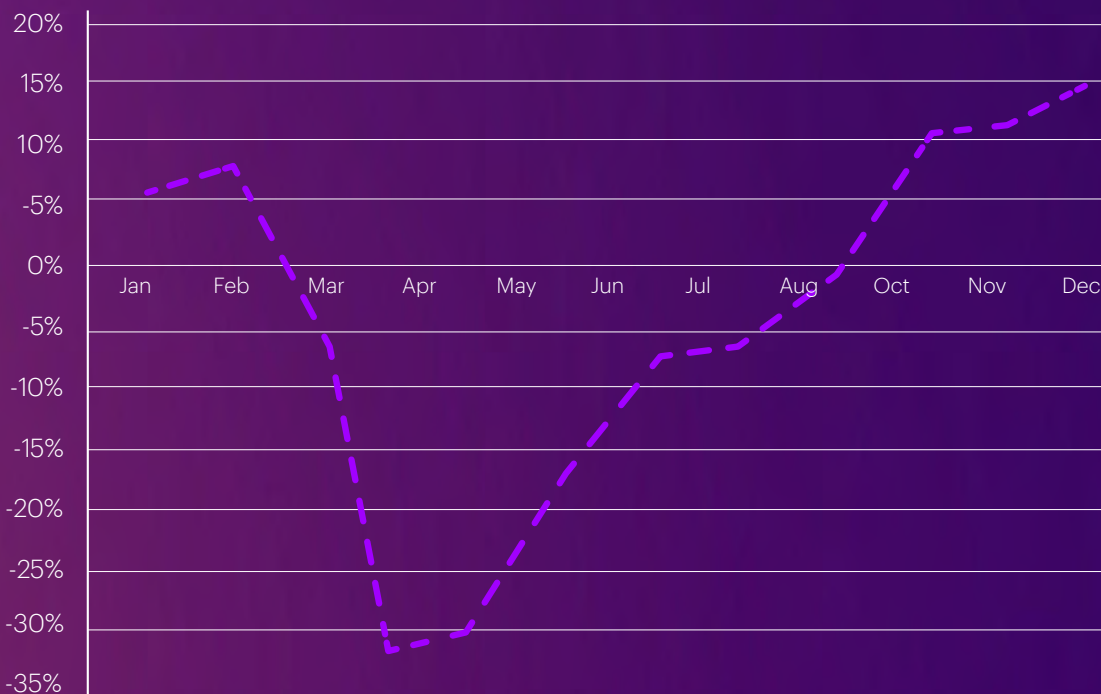
Shortage strikes automakers first

In the spring of 2020, automobile sales began to drop precipitously as showrooms closed their doors. With a bleak outlook for the automotive industry due to the pandemic, companies forecasted a sustained drop in demand for their products and made decisions to reduce their demand for chips. This capacity was quickly claimed by the boom in electronics and other markets.

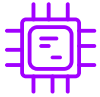
But contrary to forecasts, vehicle sales rebounded incredibly fast, within just a few months, as a V-shaped recovery (see chart below). Imperfect inventory planning caused chip shortages and halted production.

“The problem is even if that 10-cent chip is missing, you can’t sell your \$30,000 car,” said Gaurav Gupta, semiconductor analyst at Gartner.

Year-over-year (2020 vs. 2019) monthly sales growth percentage change in automotive ICs



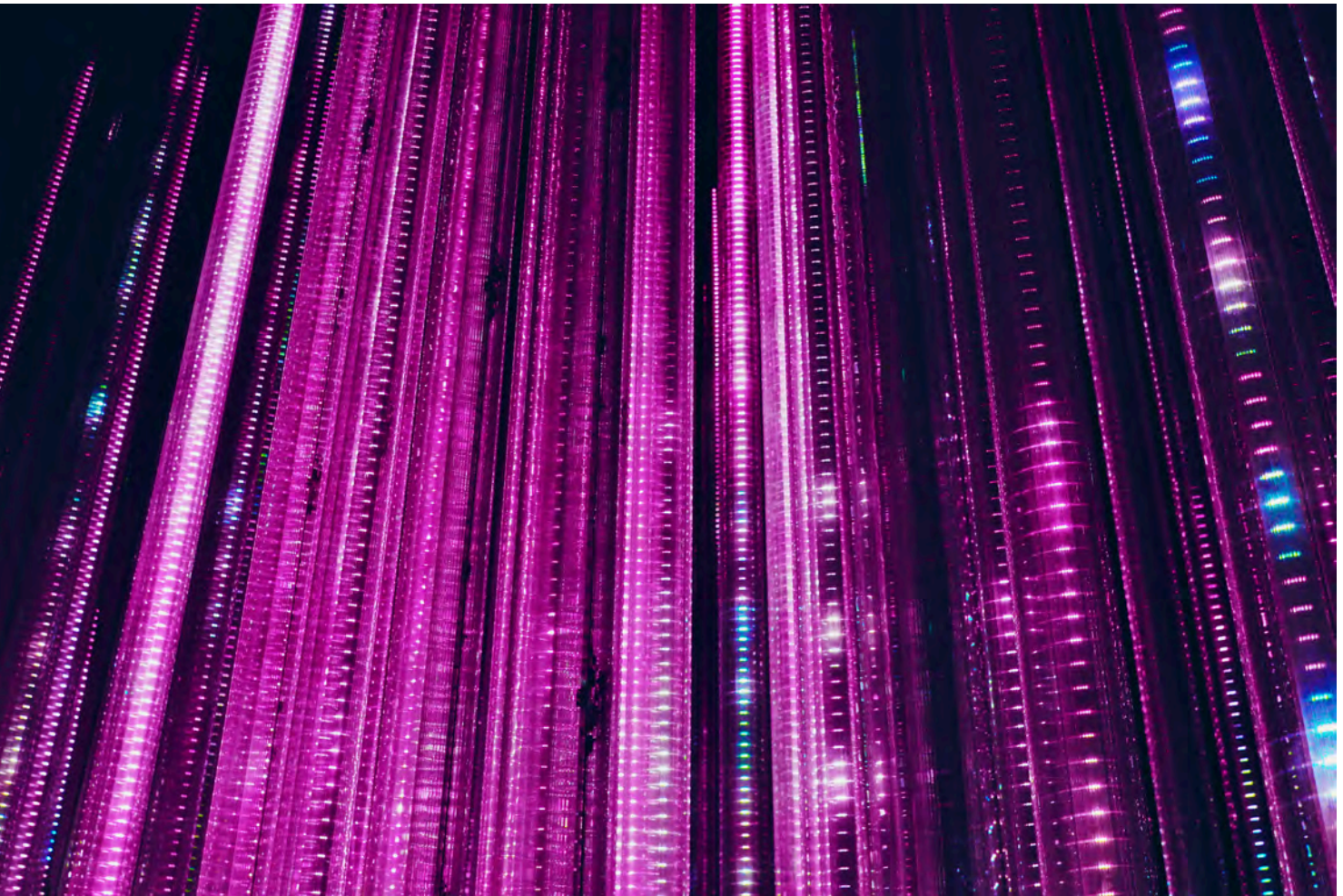
Source: World Semiconductor Trade Statistics Bluebook sales data 2020-2019



The new normal?

Semiconductor companies have experienced supply disruptions before, such as the 2011 Fukushima earthquake, tsunami and subsequent nuclear disaster and flooding in Thailand later that year.

But this time is different. The supply constraints and demand surges that caused the shortage are not one-off instances. The rising demand for electronics—and the fierce competition for chips—is not going away.



Strengthening supply chains today

It's imperative that semiconductor companies, as well as all companies that need chips for their products, take immediate action to build a more resilient supply chain for the future.

These steps can help mitigate risk and minimize disruption to business and operations that can set the stage for short-term and long-term impact that requires greater investments in time and resources.



01

Know what chips you use, and where they come from

02

Learn current time to failure and time to recovery

03

Step into the supplier's shoes

04

Strengthen your analytics control tower capabilities

01

Know what chips you use, and where they come from

Surprisingly, organizations often do not have an exhaustive list of all chips that are in their products. Instead, they often buy a functionality from suppliers, and do not have full access to a bill of materials or the buy items.

But even when they do, organizations are challenged to reconstruct the supply route for those specific chips, as they would need to understand how their supplier's supplier or multi-tier supply base is set up.

An accurate map of the multi-tier supply chain will help to identify the trouble areas—such as where there is risk exposure that needs to be addressed.⁸ This is critical if companies want to address existing shortages, and those they might encounter in the future.

02

Learn current time to failure and time to recovery

As part of understanding their current exposure, it's essential that companies also identify the impact disruptions would have in terms of time.

Together with MIT, Accenture co-developed a supply chain resilience stress test to assess operational and financial risks created by major market disruptions, including global chip shortages.⁹ The stress test starts with the creation of a digital twin of the organization's supply chain. This digital twin is then used to model various scenarios and their impact on the organization's ability to serve its ecosystem.

The outcome of the test uncovers both the time it would take for a particular supply chain node to be restored to full functionality after a disruption (time to recovery), and the maximum duration the supply chain can match supply with demand after a disruption (time to survive).

03

Step into the supplier's shoes

Suppliers are often servicing multiple industries, each with their own terms of product margin, volume and stability. Companies with their individual terms need to ask themselves honestly: how attractive are you to constrained suppliers?

Organizations should consider how to improve their position as a client. Some levers to pull that could improve attractiveness include their willingness to:

- Pay higher price and supplier margin
- Maximize volumes by aggregating demand and acting as one voice for your entire supply chain (representing multiple tier-one suppliers in the negotiations)
- Expand volume commitments

04

Strengthen your analytics control tower capabilities

Centralizing supply chain monitoring helps enable companies to gain insights into the severity of any problems that are occurring, such as limited capacity to meet demand. Leveraging analytics also helps predict what may lie ahead, such as a V-shaped recovery that would necessitate maintaining chip capacity or surging demand in other sectors. Centralized monitoring can also put the spotlight on rising geo-political tensions that could lead to further disruption or pressure on an already constrained semiconductor supply chain, so that contingency plans or new strategies can be made accordingly.

These capabilities are crucial to being able to proactively adjust manufacturing and/or order commitments to clients.

Reimagining supply chain resilience for the future

Looking at long-term preparations, companies can build supply chain resilience into their planning and manufacturing processes by evaluating these key considerations:

- Know your supply competitors
- Rethinking supply networks and co-location
- Time's up for just-in-time

Know your supply competitors

Companies typically forecast for their customers based solely on their customers' needs; that means a smartphone manufacturer will forecast for the chips they need based on demand for their smartphones.

While that does make sense, the recent shortage has clearly highlighted the need for companies to look across the entire ecosystem and consider which other sectors they might have to compete with—both from a demand and supply perspective.

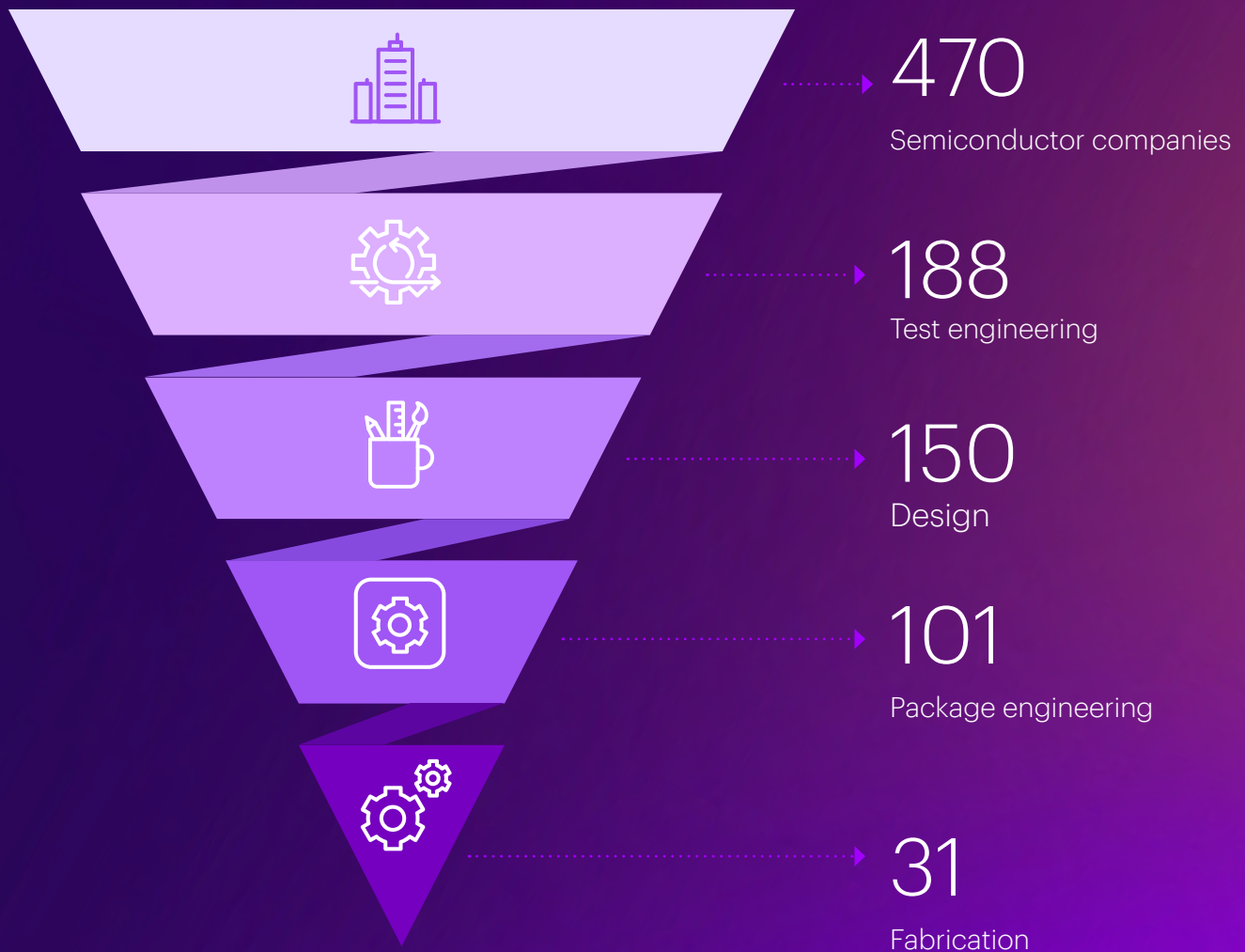
Traditionally, companies look at competition in terms of who else is selling similar products to their customers. However, supply competitors are equally important to keep in mind. Foundries are serving businesses across different industries and the threat of supply competitors monopolizing capacity might be greater than that of their direct competition.



Frustratingly, businesses have few choices for where they can go for chip fabrication—31 in the world, according to a 2021 Capital IQ report.¹⁰ Few options and fierce competition make for intense supply chain pressures.

Having a clear understanding of market trends, the supply landscape, and an expanded definition of the competition is all the more crucial in deciding how aggressive to be with capacity requirements to avoid shortages.

Limited number of wafer fabrication companies supporting the semiconductor ecosystem



Source: Capital IQ Company Screening Report, 2021

Rethinking supply networks and co-location

Owning fabrication houses is a costly investment, which is why many semiconductor firms prefer to outsource to major foundries overseas—particularly in Taiwan. Taiwanese contract manufacturers such as TSMC dominate semiconductor manufacturing, accounting for over 60% of total global foundry revenue in 2020.¹¹

But as we've witnessed with the pandemic of 2020—and the abrupt halt to overseas transit—dependencies on overseas vendors for critical supplies are a vulnerability.

Companies should give serious consideration to not only multi-sourcing strategies but also to a hybrid of insourcing and outsourcing. While building or procuring domestic fabrication houses is costly, investing in on-premises manufacturing can add supply assurance and increase leverage over supply during times of spiking demand. This type of co-location strategy would shrink the length of trade routes and move end points closer on the supply chain network.

Increasing capacity utilization for fabrication houses is just as critical to diversifying supply networks—and enabling greater speed. Over the past two decades, the semiconductor industry has been increasing utilization to keep pace with demand, but this effort takes time. A renewed focus on higher utilization is key to increasing chip output and allowing companies to fully meet the increased demand in the market.

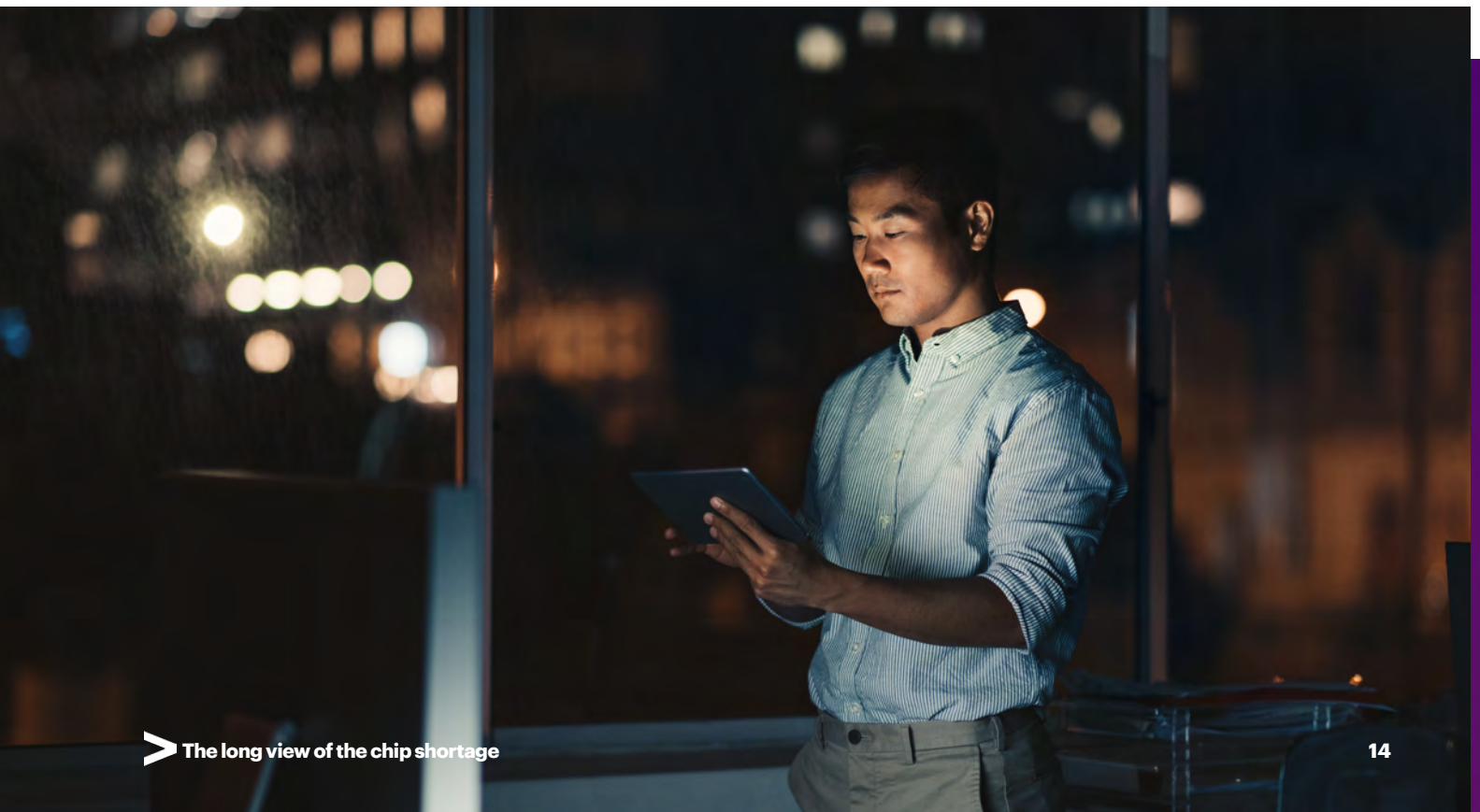
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Time's up for just-in-time

Supply chains were built on the just-in-time efficiency principle for many components, including semiconductors: optimizing metrics under the assumption that things will always run in sync. However, this recent situation has clearly demonstrated that, when faced with semiconductor supply chain disruptions, working under this principle can have a devastating impact.

When the shortage of a 10-cent chip can potentially halt the entire production line of a \$30,000 car, and with demand for semiconductors ever increasing, it isn't difficult to see why the threat of chip shortages far outweighs the benefits achieved by just-in-time supply chains.

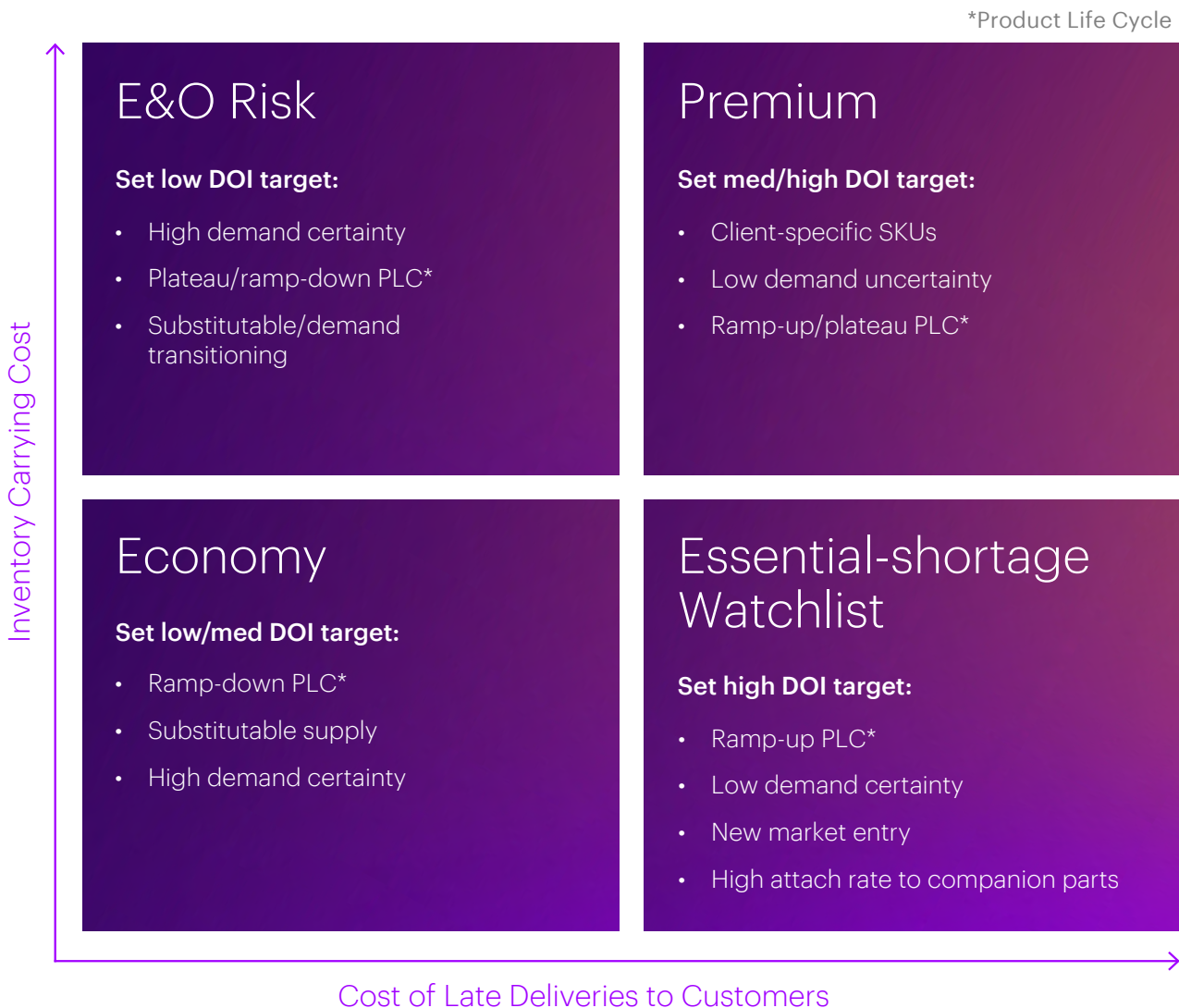
What is more useful is meeting "total target demand." This encompasses not just the customer demand, but the total demand to the supply chain, i.e., the total quantity that calls for the total supply. Striving to meet total target demand means considering a product-specific level of inventory to carry, also known as Days of Inventory (DOI). DOI measures how long the supply will last before depletion. Calculating DOI is taking on-hand supply and dividing it by the daily average forecast.



Take a trailing node power management integrated circuit (PMIC) device: the product cost is low, but the attach rate is high (meaning one PMIC variant may accompany shipments of hundreds of other chipset components going to thousands of customers).

No one wants to be in the dreaded position of a PMIC shortage, or other low-cost parts like display drivers. Why? Because that means manufacturing lines would come to a screeching halt as companies wait weeks (sometimes months) for receipt of a single inexpensive part, making such a shortage particularly painful.

The solution is for supply chain and business units to agree on a product segmentation strategy that parses the products into categories of cost to carry inventory vs. cost of shortage. Taking the PMIC as an example, we'd put that in the lower-right quadrant as low for cost to carry inventory and high cost of shortage. That categorization then drives a strategy that builds heftier safety stock.



Don't forget to factor in the other dimension of product life cycle (PLC), where, if the product is ramping up, then it's wise to increase the quantity of inventory (and conversely, if the product is more mature and ramping down, to dial back the safety stock level).

On the opposite end of the spectrum are the products that have a low attach rate, and ship to few (maybe even only one) customers. For those, if the tolerance to carry extra inventory is low, it's advisable to keep the safety stock target low if not nil. For those customer-specific SKUs, companies may want to consider entering a shared-risk program with the customer where they take on liability for assets built within lead time.

It may also be beneficial to consider designing products for greater flexibility. Defining substitutes in case preferred chips are not available can greatly alleviate supply pressures in times of shortages.

To apply a product segmentation strategy, start with grouping products into four categories: Essential, Premium, Economy, E&O Risk. The profile of each category calls for different safety stock levels (or Days on Hand targets) and considers:



Product life cycle

(Is the product ramping up? Is it mature? Is it ramping down?)



Demand certainty

(How much variation is expected in the demand?)



Attached other attributes that pose risk to supply shortage or excess

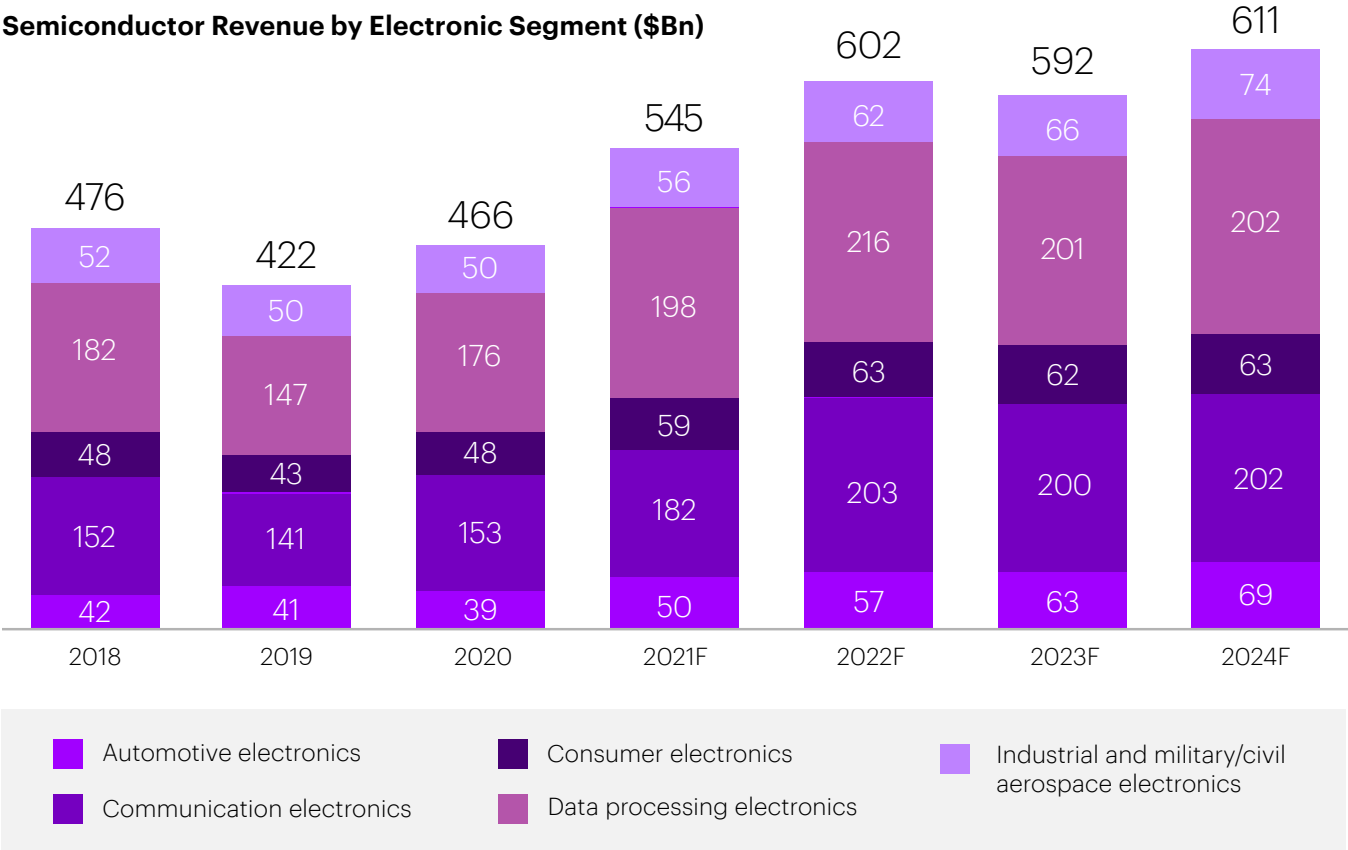
(i.e., if the product only ships to one client, any demand volatility could cause significant impact to the supply position)

Every business is now a semiconductor business

Semiconductors have become an integral part of the supply chain for more and more industries. Today, chips power everything from cars to smartphones to industrial equipment and can facilitate the widespread adoption of emerging technologies such as AI, quantum computing, and advanced wireless networks like 5G.

That’s a big reason why all six of the main semiconductor end-use categories—automotive, industrial, consumer, data processing, military/civil aerospace and communication—continue to grow. Gartner forecasts a 7.0% CAGR from 2020 to 2024F in the global semiconductor market. The automotive and industrial electronics segments are expected to see the fastest growth, at 15.6% and 10.5% respectively, while consumer electronics communication electronics growth will be relatively steady. Data processing electronics is likely to grow the least at a CAGR of 3.6% from 2020 to 2024F.

Semiconductor Revenue by Electronic Segment (\$Bn)



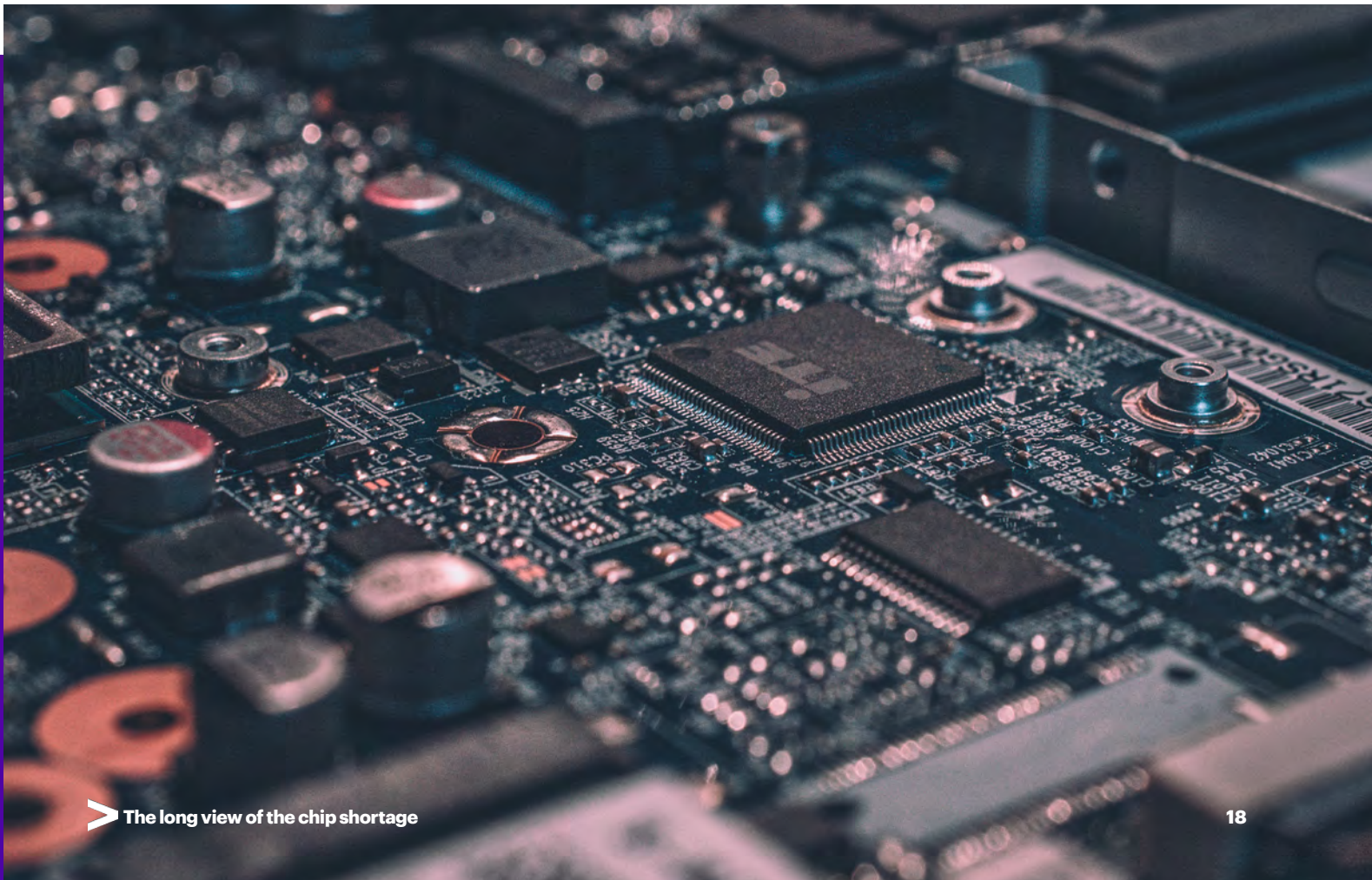
Source: Gartner (Semiconductor Forecast Database, Worldwide, 1Q20 Update and 1Q21 Update)

Given the increasing demand for semiconductors across the board, we will undoubtedly remain in a constrained environment because demand is not slowing down. Consumers are demanding a broader portfolio of product categories that contain chips—and so every business is now a semiconductor business.

As more and more companies come to rely on semiconductor chips, it is all the more crucial that they embrace this new characterization. They should build the expertise and capabilities in house to understand the market landscape, as well as procurement and manufacturing processes, to better plan and procure chips for their critical products.

This current shortage offers essential lessons for any company that relies on chips for their products. It is vitally important to understand that the whole value chain goes six to seven layers deep, and companies need insight into the whole process from fabrication, assembly and packaging all the way to the substrate factory—with a view on what's happening across multiple industries competing for limited supply.

The strain on capacity will likely continue for quite some time. While there is no silver bullet to solve current short-term issues, the steps outlined above can help companies avoid the next crisis, and becoming more resilient for the future.



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