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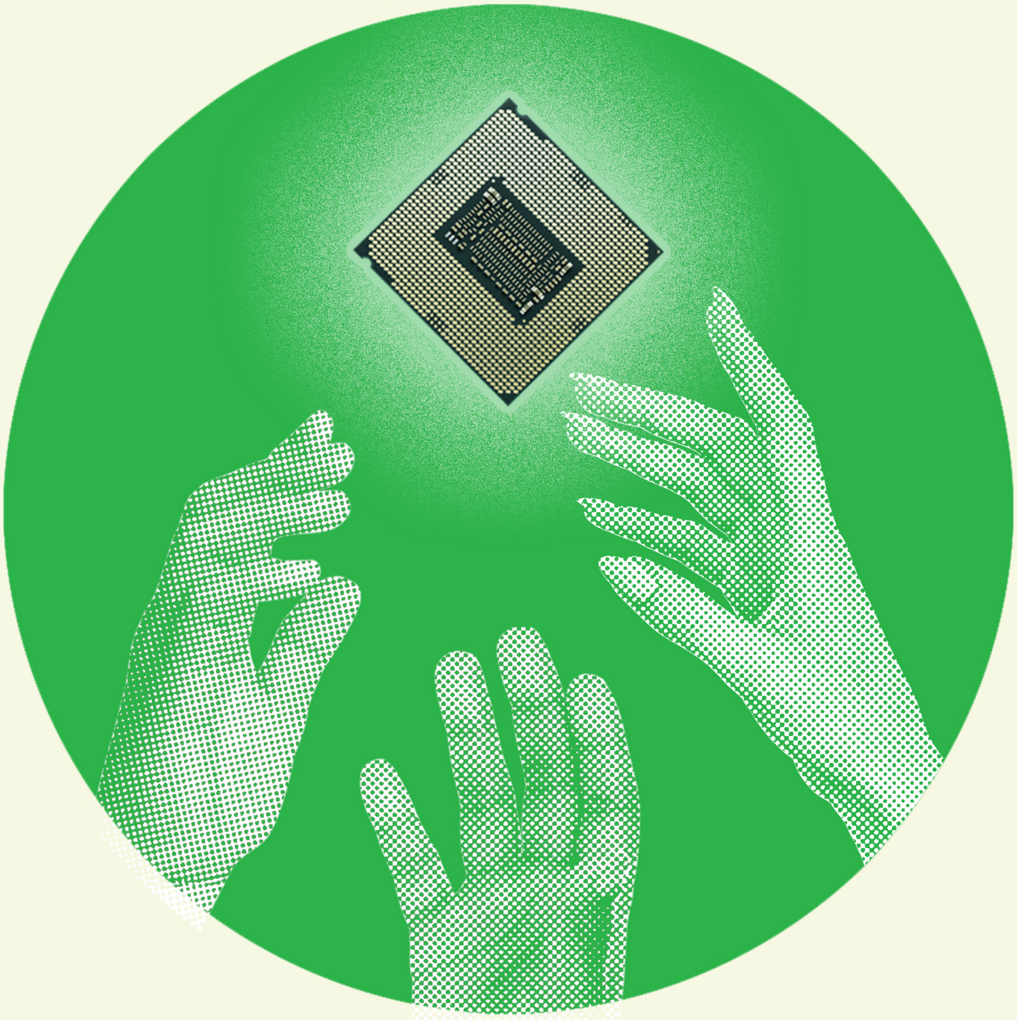

Five fixes for the semiconductor chip shortage

While the current chip shortage is severe, it is not the first, and won't be the last. While we likely can't avoid chip shortages in the future, new supply chain strategies can make them shorter and less severe, for chip makers, chip buyers and governments.

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Traditional supply chains are evolving into sets of dynamic digital supply networks. Deloitte Consulting LLP's Supply Chain and Network Operations (SCNO) practice helps companies build supply network strategies and platforms, align processes with new technologies, develop persona-driven user experiences, and explore opportunities to grow and innovate. Through innovations like our digital capabilities model (DCM) for supply networks, our SCNO practice transforms traditional supply chains into tightly integrated and synchronized supply networks. Please contact us for more information, or read more about our Supply Network Strategy and Operations services at Deloitte.com.

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Introduction

THE ABSENCE OF a US$1 chip can prevent the sale of a device, appliance, or vehicle worth much more. The world experienced a severe and long-lasting semiconductor shortage across multiple chip products from 2020 through fall of 2021, and we predict the chip shortage will last at least through 2022, with lead times for some components pushing out to 2023, meaning it will have lasted over 24 months. The impact is still being felt across PCs, smartphones, data centers, other consumer goods, and especially the auto sector.[1] The cumulative revenue impact of the shortage will likely be over US$500 billion globally from 2020 to 2022.[2]

The next semiconductor shortage could be as big or bigger than this one. Given the ever-increasing importance of chips to multiple industries,[3] the economic harm could be even greater. What can semiconductor manufacturers, distributors, customers (the semiconductor supply chain), and governments do to avert another potential catastrophe? It likely needs to be all of them: The problem is so big that no single company, or even industry, can make a difference on its own.

The world experienced a severe and long-lasting semiconductor shortage across multiple chip products from 2020 through fall of 2021, and we predict the chip shortage will last at least through 2022, with lead times for some components pushing out to 2023, meaning it will have lasted over 24 months.

Don't let the unprecedented fool you

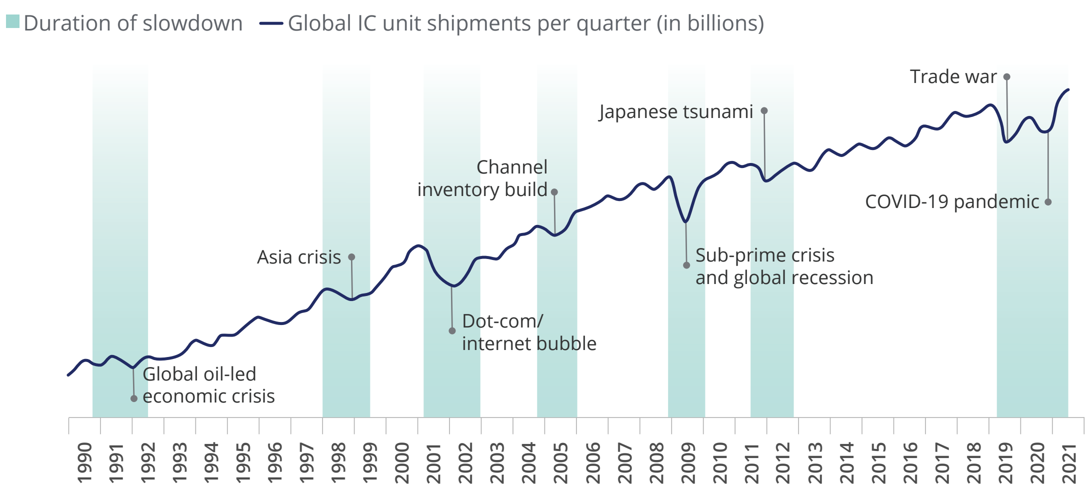
SOME MIGHT THINK that today's shortage is a one-off. As long as we don't have a once-in-a-century global pandemic, a massive fire at a key Japanese chip plant, a Texas freeze, and a ship stuck in the Suez Canal—all coinciding—the next shortage couldn't possibly be as severe.

History never repeats, but as the saying goes, it often rhymes. In the coming decade, it's a near certainty that some combination of events such as a global recession, major weather event, and disruption near a critical maritime port or strait could all occur roughly at once. The chip manufacturing industry and supply chains, as they currently exist, inherently are vulnerable to disruptions, which makes shortage inevitable.

The current disruption is nothing new. Over the last three decades, we've seen six shortages of similar duration or magnitude to today's (figure 1). Sometimes shortages occur or are exacerbated by external shocks such as the tech bubble or 2009 recession, but sometimes they "just happen." Adding capacity in the chip industry has always been expensive and chunky. It occurs in waves driven by both technology and market forces and has long lead times between deciding to build a fab (or semiconductor fabrication plant) and that fab producing its first output (finished wafers). So, the real question is not if there will be another shortage, but "when and how severe?"

FIGURE 1

Global Integrated Circuit (IC) unit shipments across various downturns, quarterly, 1990 to Q2, 2021 (log scale)



Source: Deloitte analysis based on secondary research and data gathered from publicly available articles and reports.

You can't prevent a shortage, but you can lessen its impact

THE TABLE BELOW summarizes five possible actions, and which players are most involved with each action (figure 2). Our research suggests that no single one of these is a panacea, capable of fully mitigating the next shortage. All are important to some extent, with breaking the bull whip, in particular, requiring unprecedented global teamwork and coordination. All of the various players need to do all of their respective parts, work together, and at the same time not create a glut. Additionally, these recommendations are not meant to be absolute. Rather, companies should choose a specific action or a combination of actions depending on what role they play in the broader semiconductor ecosystem and value chain.

All of the various players need to do all of their respective parts, work together, and at the same time not create a glut.

FIGURE 2

Specific actions/steps—Key considerations for ecosystem players

Action	Chipmakers	Distributors	Customers	Governments
Build overall capacity	✓			✓
Build local capacity	✓			✓
Become strategically lean		✓	✓	
Break the bullwhip	✓	✓	✓	✓
Digital transformation	✓	✓	✓	

Source: Deloitte analysis.

Build overall capacity

THE GLOBAL INDUSTRY is committing to increasing overall output capacity at an unprecedented level. Capital expenditures from the three largest players will likely exceed US$200 billion from 2021 to 2023, and could reach $400 billion by 2025.[4] Governments have committed hundreds of billions more.[5] We expect annual global 200mm-equivalent wafer capacity to increase from about 80 million in 2020 to 120 million by the end of 2024. Capacity will grow at both the 200-mm and 300-mm wafer size, at about the same rate for each.[6]

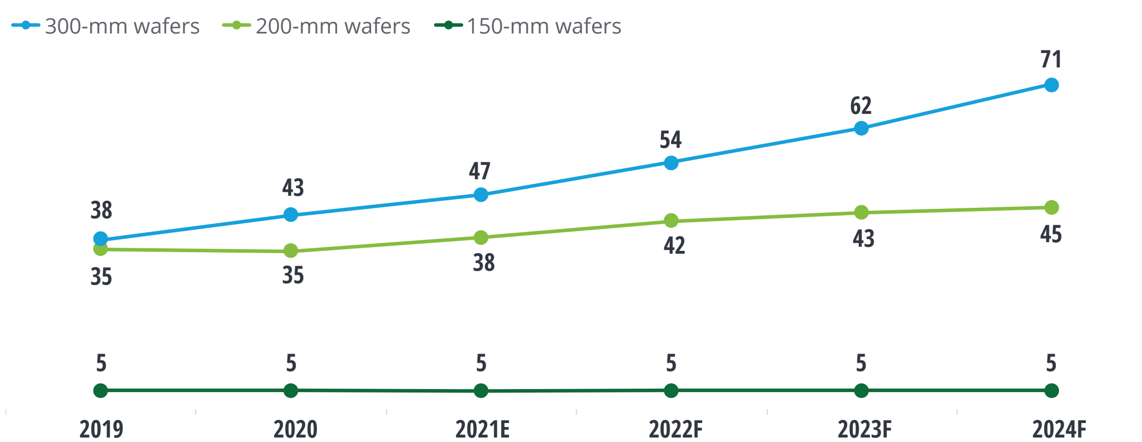
To be clear, growth in 200-mm is mainly from increasing capacity in existing fabs, rather than the construction of entirely new plants, which account for nearly US$12 billion of capital equipment spending between 2020 and 2022.[7] From a technology perspective, capacity at mainstream nodes and the more advanced 300-mm process nodes (under 10 nm, mainly at 3 nm, 5 nm, and 7 nm) will grow more rapidly than more mature process nodes (figure 3 and figure 4 below). It is worth noting that demand is growing for both wafer sizes, and at all process nodes, not just the most advanced.

Surely increasing capacity broadly by 50% in only three years will more than cover any future shortage, right? The answer is not so obvious.

FIGURE 3

Worldwide wafer capacity by size (150-mm, 200-mm, and 300-mm wafers), 2019–2024

Wafer capacity, based on 8-inch equivalent wafers (in millions)

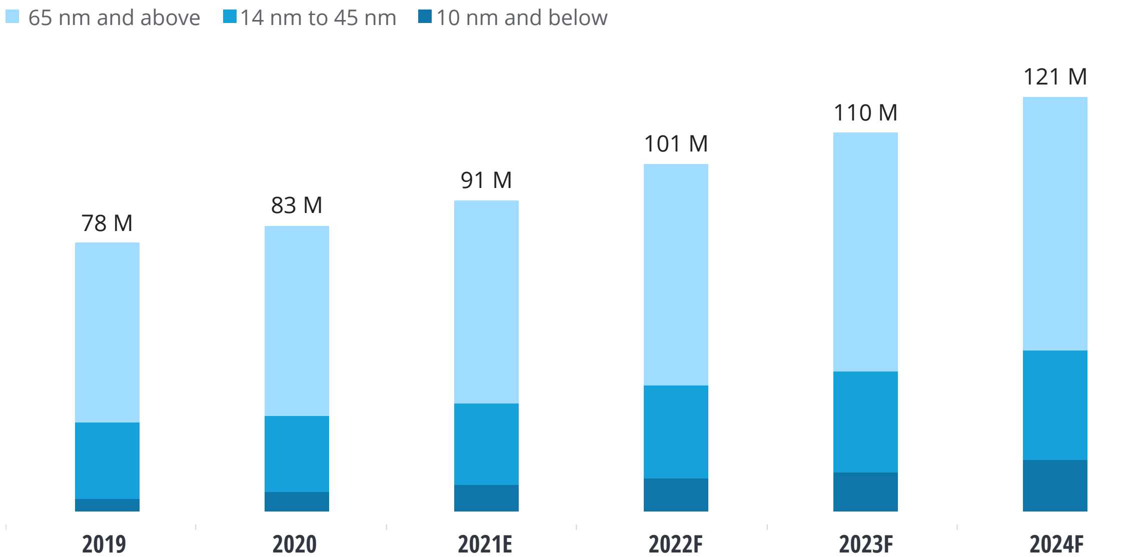


Note: E denotes estimated values; F denotes forecast numbers.
Source: Graphic prepared by Deloitte based on data from 2021 Gartner®-Forecast: Semiconductor Foundry Revenue, Supply and Demand, Worldwide, 3Q21 Update, September 2021.

FIGURE 4

Worldwide wafer capacity by process nodes, 2019–2024

Wafer capacity, based on 8-inch equivalent wafers (in millions)



Note: E denotes estimated values; F denotes forecast numbers.
Source: Graphic prepared by Deloitte based on data from 2021 Gartner®- Forecast: Semiconductor Foundry Revenue, Supply and Demand, Worldwide, 3Q21 Update, September 2021.

Demand is growing roughly as quickly (or more) than planned capacity growth. Demand drivers include 5G, artificial intelligence and machine learning (AI/ML), intelligent edge, and Internet of Things. Some of these are about delivering increasingly powerful chips to products that already use a lot of chips, but some are about adding chips to products that had no chips before.

Build local capacity

CHIP MANUFACTURING IS highly geographically clustered, both at the overall chipmaking capacity level and at the third-party wafer foundry level (figure 5).

At a high level, it's completely normal for half or more of the total global capacity to be found in a few countries or regions. It was the United States and Silicon Valley at first, then the United States and Europe in 1990, and most recently Taiwan and South Korea. The 2020 level of concentration in East Asia (including Japan and China, which are nearing 60%)[8] has attracted significant government attention from the United States, Europe, and China, and plans are already underway to build new plants in those countries or regions, as well as Israel, Singapore, and others.[9] This process is also known as "localization."

Almost certainly, distributing manufacturing capacity to more regions and decreasing extreme local concentrations will reduce geographic-specific supply risk and help alleviate the severity of future supply shortages … to some extent. It will likely not solve the problem entirely:

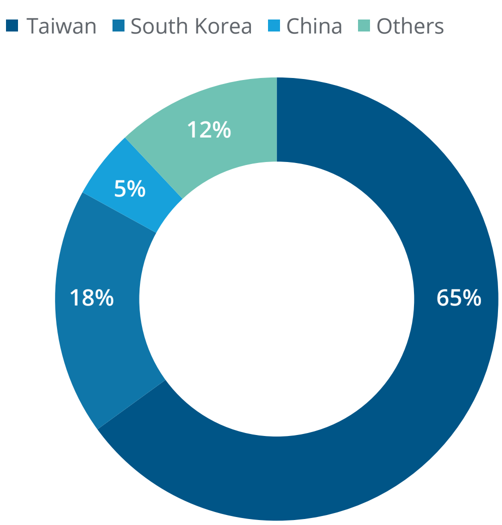
- Moving the needle on the geographical concentration of chip supply is hard. There are over 400 semiconductor manufacturing facilities globally, and there are announced plans to add 24 new 300-mm fabs by 2022, but only 10 new 200-mm fabs in the same period.[10] Some of those are in South Korea and the Taiwanese region. Adding a couple of dozen in new locations outside these clusters may help. As per our estimate, new locations will only cause concentration in East Asia to drop a few points, meaning it would still produce more than half of all chips by 2023.

- The chip industry has a natural tendency to form highly concentrated clusters based on talent and resource availability (figure 6). Having all parts of the manufacturing process (making the chips, testing the chips, and packaging the chips) close to each other offers

FIGURE 5

More than 85% chip foundry capacity/production is concentrated in the APAC region

Worldwide foundry capacity share by region, 2021 (projected)



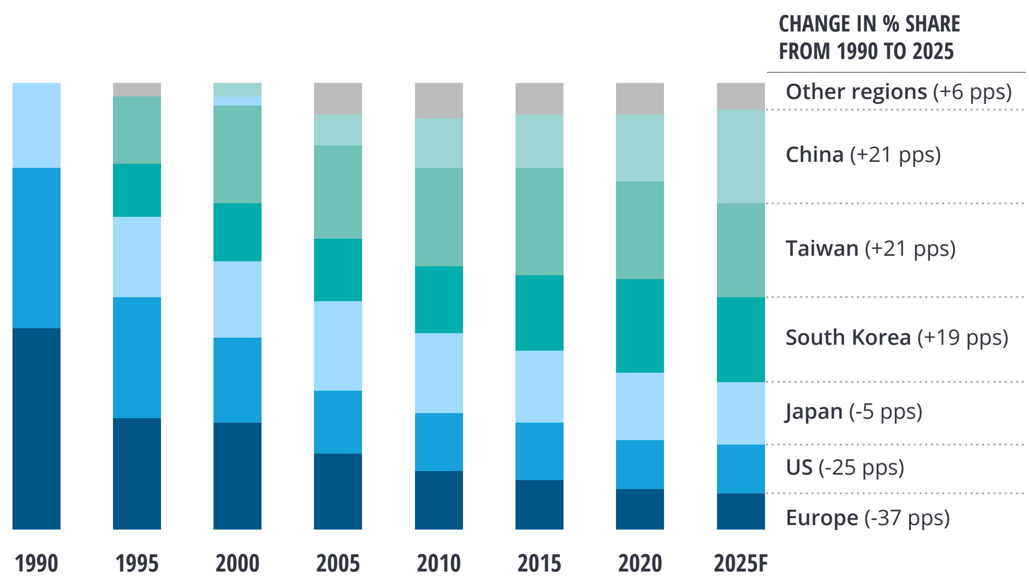
Note: Others mainly include Europe, North America, and Japan.
Source: Morningbrew.com article, based on TrendForce data (March 2021).

many benefits in terms of cost and speed. Clusters create strong pools of talent and skills. Prior attempts to build more geographically distributed manufacturing capacity (such as Silicon Glen in the United Kingdom in the late 1970s) came to naught.[11]

FIGURE 6

Global semiconductor capacity: Percentage share by region, 1990–2025

Semiconductor manufacturing capacity: Percentage share by location



Note: F indicates forecast.

Source: Deloitte analysis based on information gathered from publicly available third-party sources.

Become strategically lean

CHIP BUYERS (DEMAND side) and their wholesale distributors and retailers have multiple levers to become more or less lean. Being less lean is about buying early and building buffers or slack. Being leaner is about buying later with limited buffers or slack. Buyers and distributors can have a purely just-in-time supply chain management system or opt for a hybrid model. They can stockpile. They can single-source or dual-source.

They can be more or less aggressive on pricing. They can have purely quantity-based pricing or have non-cancellable, non-returnable (NCNR) options for extended periods: During the current shortages, some companies are giving firm NCNR orders for the next 12 months, and others are giving five-year projections for their chip needs to suppliers, up from 12 months prior.[12] Most companies or industries use a mix of these approaches, but two things jump out:

1. There is such a thing as too lean. Those buyers with less lean supply chain models fared better with the chip shortage, at least at first.

2. Ask not "for whom the [shortage] bell tolls; it tolls for thee." Although some industries and some companies within hard-hit industries did relatively better than others in late 2020 and the first half of 2021,[13] by summer of 2021 the shortage was affecting almost every industry and every company. As one example, the smartphone industry was generally unaffected for months, but multiple smartphone manufacturers were announcing delayed new product launches or possible shortfalls in mid-2021.[14] Several auto manufacturers, who had also been seemingly immune, announced they were cutting capacity too. Being strategically lean can buy time, but a severe and prolonged enough shortage seems to hit everyone.

Although some industries and some companies within hard-hit industries did relatively better than others in late 2020 and the first half of 2021, by summer of 2021 the shortage was affecting almost every industry and every company.

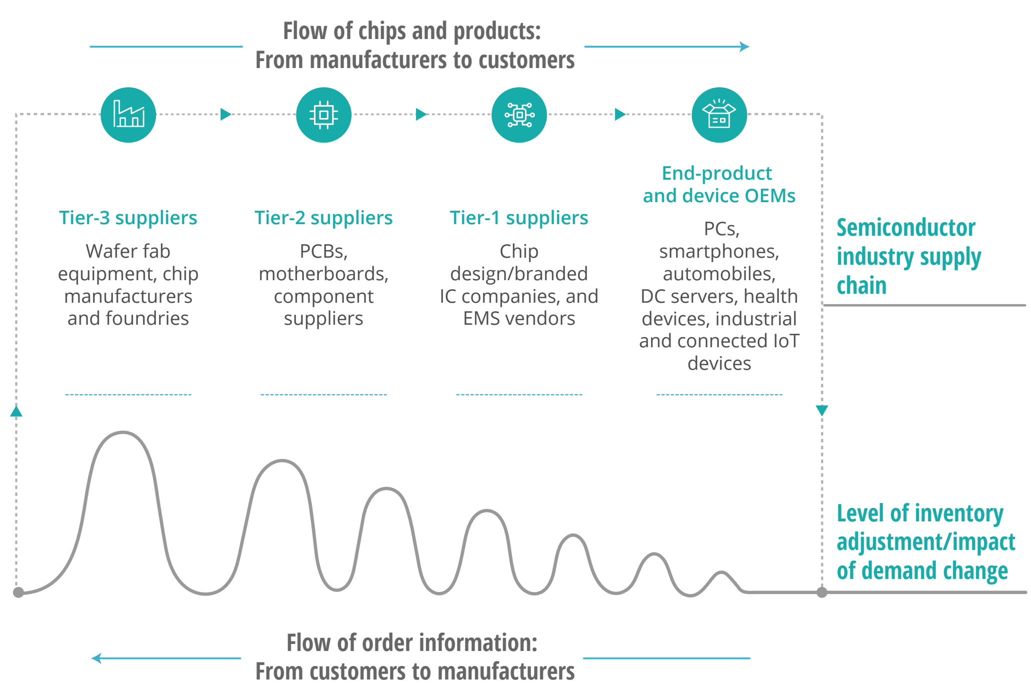
Breaking the bullwhip

STILL ON THE demand side, most OEMs, distributors/suppliers and customers have not adopted systems or processes to enable real time information exchanges. Hence, large fluctuations in production planning volumes happen at sub-tier levels in response to even small shifts in customer demand. This is typically known as a bullwhip effect where delayed communication between stakeholders at each tier in the supply chain is often amplified by judgments placed on the demand signals received (figure 7).[15]

Semiconductor companies can transform their traditional supply chains by developing and bolstering six key digital capabilities, which can allow them to transcend the physical-digital boundaries to include people, processes, and technologies (figure 8). Using a digital capabilities model, they can redesign their traditional organizational silos into one that is more connected and integrated, encompassing their customers, talent, suppliers across all tiers, channel partners, and internal facilities.[16]

FIGURE 7

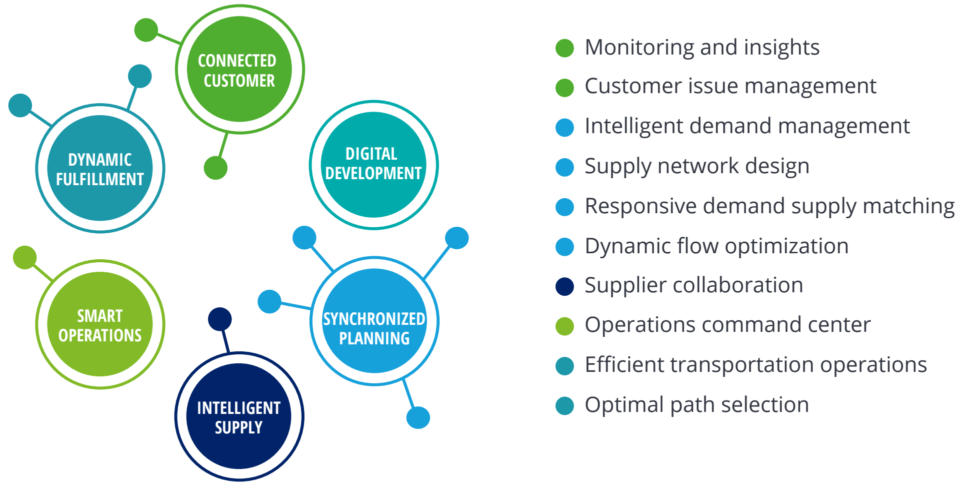
Breaking the bullwhip in semiconductor supply chains



Source: Deloitte analysis.

FIGURE 8

Top DCM capabilities for semiconductor/foundry archetype in a chip shortage environment



Source: Deloitte analysis.

1. With **connected customer** mindset at the core, chip companies have a more accurate and granular view of future customer demand trends to reduce the bullwhip effect resulting from demand swings. Beyond the supply chain implications, product tracking technology is enabling leaders to resolve quality issues more quickly.

2. **Digital development** embedded in every aspect of chip companies' product design process allows companies to make, build, and assess prototypes and proofs of concept more efficiently. The efficiencies and agility of digital development address the semiconductor industry expectations related to fast-moving innovation and product release.

3. **Synchronized planning** capabilities address the challenges that are characteristic of the complex semiconductor value network. They facilitate both long-range manufacturing capacity planning and near real-time demand and supply alignment, across a complex mix of internal and external suppliers.

4. **Intelligent supply** capabilities support the continued expansion of outsourced manufacturing through enhanced supplier collaboration, development, and monitoring. They can mitigate the risks inherent in the global semiconductor supply network when integrated with synchronized planning systems.

5. **Smart operations** capabilities are vital to semiconductor manufacturing, which is complicated and sensitive in nature, largely automated, and enabled by capital-intensive factories. Capabilities that facilitate digital process modeling (such as digital twins), operations monitoring, factory operations synchronized with materials availability, and responsive factory scheduling adjustments, allow the factory operations teams to operate efficiently and with high asset utilization.

6. **Dynamic fulfillment** capabilities support the multiple sales channels, production paths, and fulfillment service points in the semiconductor industry. Products ordered through various sales channels can be adaptively manufactured by multisourced supplier networks, and delivered through internal and third-party logistics warehouses, distributors, managed consignment hubs, and more.

Adopting some or all of these facets of a digital capability model could help semiconductor companies transform their traditional, linear supply chains into digital supply networks (DSNs).

Moreover, companies across the chip industry value chain can benefit from the distinct operating characteristics of a digital supply network by sensing, collaborating, optimizing, and responding (see sidebar, "The four digital disciplines of a DSN: Effective data-sharing to drive differentiated performance and value"). These digital disciplines could enable them to gain greater visibility and insight into demand, and to have a more granular and timely view of both the external and internal events across the supply network—allowing them to make timely decisions and adjustments.

THE FOUR DIGITAL DISCIPLINES OF A DSN: EFFECTIVE DATA-SHARING TO DRIVE DIFFERENTIATED PERFORMANCE AND VALUE

What is the difference between a supply network and a supply chain? Companies that operate supply networks are skilled at practicing four digital disciplines.

- **Sensing:** Identify environmental changes that occur at all nodes in the broader supply network and ecosystem (end-customers, electronics and foundry channel partners, manufacturing, and operations). Additionally, capture risks and opportunities (latent and imminent) assisted by sensors, internal and external datasets, and visualization tech.
- **Collaborating:** Work closely with ecosystem partners (both upstream and downstream) to facilitate live information sharing, and understand, capture, and address the potential impact of the sensed signals. Using a combination of technologies including text, voice, video, and social media analytics, companies can rapidly collaborate around a single source of truth dataset to resolve issues. As software tools become ever more important, companies should improve engineering and design cycle predictability and shorten that cycle overall with better orchestrated engineering teams and technologies.
- **Optimizing:** Identify the most plausible and implementable courses of action to optimize end-to-end networks, facilitated by advanced connectivity, pattern recognition, statistical analyses, AI, and optimization methods.
- **Responding:** Effectively convert decisions based on the collaboration and optimization steps into concrete actions and tasks. This is enabled by highly automated capabilities that integrate planning, collaboration, and transactional executional systems and processes.

Semiconductor companies can build a differentiated, value-based digital supply network in which data-sharing transcends physical boundaries. Such networks are enabled by advanced tech like blockchain and are established on strong cyber and data integrity principles.

Digital transformation

According to Deloitte's Semiconductor Transformation Study conducted in collaboration with the Global Semiconductor Alliance, most semiconductor companies that participated in the study had already embarked on some type of digital transformation journey by the spring of 2021 (figure 9).[17] Moreover, chip players have proven to be adept at innovating across the organization.

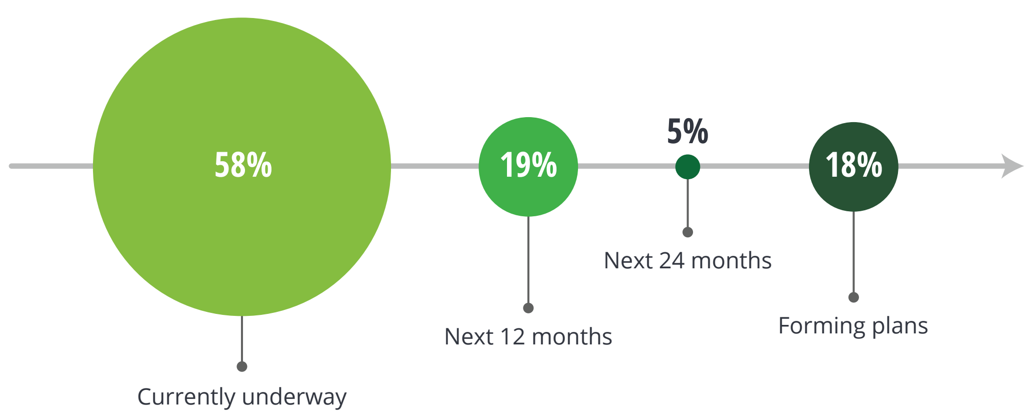
Taking a combined approach toward digital transformation by addressing business, technology, and workforce and operational considerations can enable them to be more adaptive to future supply chain–driven business disruptions.[18]

Semiconductor companies should consider keeping the end-customer demand patterns and buying experience at the core of their transformation approach, which requires working with supplier tiers (both upstream and downstream), distribution channel partners, and third-party logistics and transportation providers. By collaborating with their supply network partners, they can implement the advanced technologies they need such as blockchain, sensors, AI/ML, mobile, and broadband tech. These technologies can advance their business processes, and enhance data access and analytics across their extended supply network.

This strategy-based digital/tech-enabled transformation can help them gain greater visibility and insight into demand patterns. That can enable them to proactively manage capacity, production, inventory, and shipments, which in turn lets them build measured slack into their supply chain, allowing them to adapt and thrive in the face of any future disruptions.

FIGURE 9

Business transformation launch and plans of semiconductor companies



Note: Numbers may not add up to 100% due to rounding.
Source: Deloitte's Semiconductor Transformation Study (2021).

Conclusion

AS SEMICONDUCTOR COMPANIES navigate through this period of shortages and prepare for future shortage events, leaders should consider the following questions:

- Can I add incremental or bulk capacity in the near term?
- Can I geographically shift my capacity footprint to reduce risk in my supply network?
- Can I adjust supply arrangements and strategic inventory buffers to improve service levels?
- Can I leverage digital supply network capabilities to achieve the agility and visibility I need?
- Will my transformation effort address this and future shortages?

The semiconductor supply volatility which we are experiencing today will likely not be the last. To better prepare and deal with such future disruptions, companies in the broader semiconductor industry supply chain should build some measured slack into their overall supply chain to become more strategically lean. By doing so, chip players can be on a much better footing to be more agile and sustain and expand their competitive advantage in the long term.

Endnotes

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