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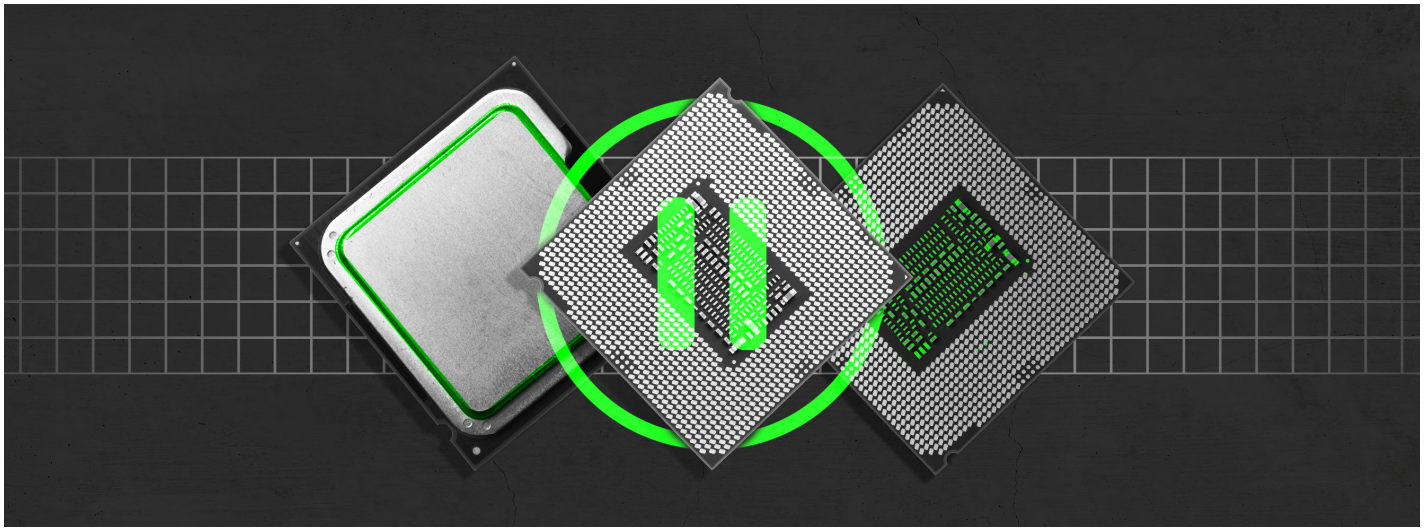

My kingdom for a chip: The semiconductor shortage extends into 2022

As consumers, industry, and government clamor for chips, the semiconductor industry is scrambling to keep up

Duncan Stewart, Dan Hamling, Ariane Bucaille, and Gillian Crossan

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THE WORLD IS hungry for products enhanced by a growing volume of chips, but they'll be kept waiting throughout 2022 until supply catches up with rising demand, especially for chips made locally. Deloitte Global predicts that many types of chips will still be in short supply throughout 2022, and with some component lead times pushing into 2023, meaning that the shortage will have lasted 24 months before it recedes, similar to the duration of the 2008–2009 chip shortage.[1]

Now for the good news. While the shortage will endure through 2022, it will be less severe than in fall 2020 or most of 2021, and it will not affect all chips. In mid-2021, customers were waiting between 20–52 weeks for multiple kinds of semiconductors, causing manufacturing delays or shutdowns which led to revenue losses in the tens or even hundreds of billions of dollars. By the end of 2022, we predict those lead times will be closer to 10–20 weeks and that the industry will be in balance by early 2023.

It's a simple matter of demand and demand

The lengthiness of the chip shortage boils down to one overarching factor: A significant surge in demand, driven by digital transformation and accelerated by the pandemic. And consumer devices aren't the only thing, or even the main thing, driving this demand. Every mechanical product in industry is becoming increasingly digital, and every vertical sector is becoming ever more reliant on digitization. For example:

- Chip demand for both devices and data centers shot up in 2020 and 2021. The pandemic caused PC sales to rise by more than 50% year over year in early 2021,[2] while cloud computing data center chip purchases went up by 30%.[3] Although growth in both areas slowed a little in 2021's later months, demand in 2022 is predicted to stay well above long-term trends.
- The automotive industry's use of chips is growing fast and will probably keep growing for the foreseeable future. The average car in 2010 contained US$300 worth of microchips. As cars become increasingly digital, that figure will likely rise to more than US$500 in 2022, totaling more than US$60 billion for the year.[4] Although there were some signs that the auto industry's chip shortage was easing by the summer of 2021,[5] lead times were still longer than usual and automakers were still cutting production.[6]
- The health care industry's use of chips will likely grow. Regulators are approving connected home health care devices such as wearables and smart patches whose use may span hundreds of millions of units, especially given the rise in virtual visits.[7]
- The demand for chips specialized for artificial intelligence—specifically, for machine learning training and inference—is predicted to grow at over 50% annually across all computing categories for the next few years, with most of these chips requiring the latest and greatest manufacturing techniques.[8]

The automotive industry is perhaps most widely known to have been affected by the chip shortage. But it isn't just automakers and other end customers who care about chip shortages, the entire supply chain cares too. Most supply chains are designed to be consolidated and cost-effective, but they can be brittle as a result. Limited visibility and lack of real-time communication between supplier tiers can lead to a "bullwhip effect" where small shifts in demand are amplified, resulting in high cumulative demand volatility.[9]

Chipmakers are scrambling to catch up. The world's three largest semiconductor manufacturers announced cumulative annual capital expenditures of more than US$60 billion for 2021 and will likely spend even more in 2022.[10] Some of that is increasing capacity at existing fabs, but some is construction of new facilities, such as Intel's two new fabs in Arizona for US$20 billion-plus.[11] In addition, aggregate venture capital investment in startup chip companies will have more than tripled in 2021 and 2022 compared to the annual average of the previous 15 years. Even though they are mostly focused on designing chips rather than manufacturing them, these companies will all want to make chips to use up still-tight capacity.[12]

To guard against future shortages, governments are pushing to increase local supply. As of 2020, 81% of semiconductor contract manufacturing was based in Taiwan or South Korea.[13] The United States,[14] the European Union,[15] and China[16] have all committed to growing their country or region's semi fabricating capacity, a process called localization. Localization is not just about avoiding shortages, but also about enhancing national security: The proposed US$52 billion CHIPS for America Act was a part of the National Defense Authorization.[17]

These localization initiatives are an effort to reduce the risk created by the chipmaking industry's historic concentration of manufacturing in a very few geographic areas: Silicon Valley in the past, and Taiwan and South Korea more recently. This clustering improved efficiency, turnaround times, and profitability in good times—but as we have seen, it also amplifies risk. If, as seems likely, multiple countries decide to mitigate that risk by building their own manufacturing capacity, the overall industry capacity utilization rate may trend lower compared to the last decades, though it will likely remain volatile. In the long run, this would likely mean fewer shortages at the cost of some efficiency.

Localization efforts, however, will take time. Increasing chip manufacturing capacity is a slow process, and rightly so: Cutting-edge chips have been called the most complex devices ever made, and it takes the most expert chipmakers in the world billions of dollars, years, and all of their expertise to get a new plant up and running.[18]

Complicating things further are shortages that casual observers may not know are key parts of chipmaking. One is a shortage of packaging substrates—the miniature interface layers in packaged chips. This shortage has constrained chip manufacturing for some time now, with lead times of one year or more.[19] Additionally, to make chips, manufacturers need not just buildings and wafers, but equipment such as photolithography tools and wirebonders, which respectively print nanometer-scale patterns on semi wafers and add thin wire interconnects to chip packages. Equipment of both kinds, new and even used, is in short supply. Photolithography lead times are more than 10 months, and lead times for wirebonders, which are normally abundant, stand at over six months.[20]

> "Digital transformation is built on silicon and broadens the drivers for semiconductor innovation. Demand for semiconductors is no longer about one or two killer applications, but rather an expansive, structural shift in the economy toward digitization and automation."
>
> — Gary Dickerson, president and CEO, Applied Materials, Q3 2021 earnings call, August 19, 2021.[21]

THE BOTTOM LINE

Considering that chip shortages are likely to last through 2022, everybody should be prepared for longer lead times and possible delays. The extent of these will likely vary by industry and application.

In mid-2021, some of the more acute shortages appeared to be easing, often depending on which *kind* of chip was needed. Growth in demand for chips for hyperscale data centers, AI, and cryptomining suggests that those chips will be in relatively tight supply for the next 6–12 months.

Chip users should expect chips made on the most advanced process nodes (3-, 5-, and 7-nanometer) to be in short supply until well into next year. These chips are the hardest to make; they tend to have lower yields, fewer fabs are capable of making them, and they are in high demand. Less advanced technology nodes may see supply/demand balance restored sooner.

Meanwhile, the biggest challenge for semiconductor makers, distributors, and equipment suppliers will likely be avoiding the boom-and-bust cycle for which the industry is known. Historically, every shortage has been followed by a period of oversupply, resulting in falling prices, revenues, and profits. The cycles of the past 25 years have been like a roller coaster that no human would voluntarily ride. Between 1996 to 2021, year-over-year chip revenue soared by more than 20% no fewer than seven times. It also plunged by almost 20% year-over-year five times over the same period. The drop was especially stomach-churning in 2001, which saw revenues fall by nearly 50% from a year earlier.[22]

Taking the long view, however, up and to the right has been the consistent trend. Global semiconductor sales were up by 25% in 2021 despite ongoing shortages, and they are predicted to rise a further 10% to US$606 billion in 2022.[23] This is almost ten times greater than the 1990 figure of US$58 billion. When measured as a percentage of global GDP, 2021 chip revenues were 130% larger than they were 30 years ago.[24] Given the continuing tail wind of demand from the digital transformation of every aspect of life, semiconductor revenues look to keep gaining share of global economic output, whether chips are scarce or abundant.

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