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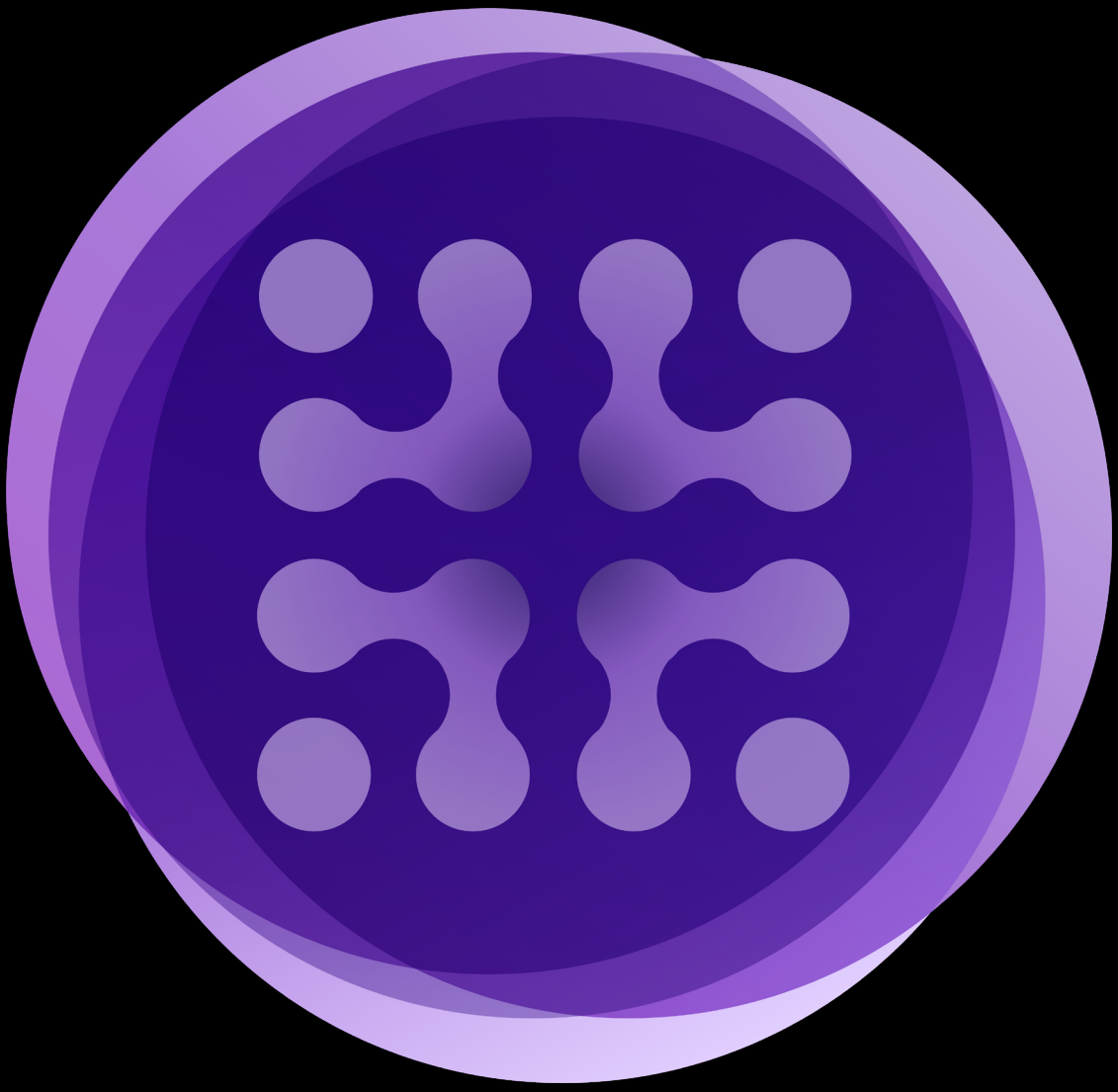


# 2022 semiconductor industry outlook

# Contents



*About outlooks*
*Deloitte's 2022 semiconductor industry outlook seeks to identify the strategic issues and opportunities for semiconductor companies to consider in the coming year, including their impacts, key actions to take, and critical questions to ask. The goal is to equip US semiconductor (aka semi or chip) companies with the information and foresight they need to position themselves for a robust and resilient future.*





Semiconductors have now established their place as a truly essential industry. There are multiple "essential" industries, of course: We can't do without food, energy, logistics, and so on. But it took the chip shortages of 2020 and 2021 for semiconductors to cement their "critical" status.

In 2022, the global semiconductor chip industry is expected to reach about US$600 billion.[1] But while it's still dwarfed by farming, oil and gas—industries that are worth an annual US$10 trillion and US$5 trillion in revenue, respectively—80% of the world's food or fuel doesn't come from a handful of manufacturers concentrated in a just a few countries.

Across multiple end markets, the absence of a single critical chip, often costing less than a dollar, can prevent the sale of a device worth tens of thousands of dollars. Based on our analysis, the chip shortage of the past two years resulted in revenue misses of more than US$500 billion worldwide between the semiconductor and its customer industries, with lost auto sales of more than US$210 billion in 2021 alone.[2]

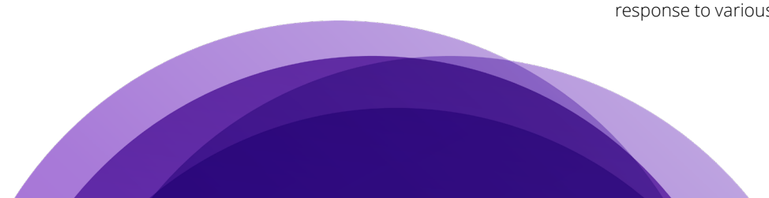
Although annual semiconductor sales have traditionally trended upward, they have also demonstrated a characteristic cyclicality, with periods of growth and contraction. In contrast, the growth in chip criticality has been a steady one that may even accelerate. Two factors are driving this trend. First, more and more products have at least some chips integrated into their design every year, and more and more products have more chips than they used to, from connected devices in our homes to smart tags on every box in a warehouse. That's not all; chips are also rising in their value and capabilities. For example, the semi content per car will roughly double between 2013 and 2030.[3]

Although shortages have been painful for some customers, the chip industry itself is thriving. The Philadelphia Semiconductor Index (SOX) is up 117% in the past two years,[4] while the Nasdaq has only been up 90%. Revenues, earnings, and cash flow are strong for chip companies, allowing for ongoing investment in new plants, new business models, and accelerated digital transformation.

Semi companies have also been making strides in their efforts at greater diversity, equity, inclusion, and sustainability. They are becoming more diverse and inclusive (specifically narrowing the gender gap[5]) and are committing to reducing their environmental footprint. Interestingly, the sector's biggest challenge may be water usage,[6] although improving their energy use is also a focus area.[7]

Over the long run, semiconductor revenues are likely to oscillate around a trend line. Still, that trend line looks steeper than ever before as we enter a period of robust secular growth.

- We expect the global industry to grow 10% in 2022 to over US$600 billion for the first time ever. Growth will likely be down from 25% growth in 2021, in line with the Semiconductor Industry Association and World Semiconductor Trade Statistics.[8] Chips will be even more important across all industries, driven by increasing semiconductor content in everything from cars to appliances to factories, in addition to the usual suspects—computers, data centers, and phones.
- We expect shortages and supply chain issues to remain front and center for the first half of the year, hopefully easing by the back half, but with longer lead times for some components stretching into 2023, possibly well into 2023.
- The ongoing talent shortage will be made even more severe by the addition of increased semiconductor manufacturing facilities outside Taiwan, China, and South Korea. The higher demand for software skills required to program and integrate chips into fast-growing markets such as electric vehicles, robotics, home automation, artificial intelligence, and 5G, as well as part of the shift from fossil fuels to green energy, will further exacerbate the shortage, and there is also an overall labor shortage.
- Finally, we expect the digital transformation within the industry to continue and accelerate. Nearly three out of five chip companies have already begun their transformation journey. Still, over half of those are modifying their transformation process as they go, in response to various pressures.[9]



# The chip shortage continues, as production will take time to catch up to demand

The top semiconductor issue of 2021 was the imbalance between supply and demand. This imbalance led to chip shortages that affected both traditional chip end markets, such as data centers and smartphones, and traditionally less dependent markets, such as automotive, consumer white goods, and—rather infamously—dog-washing machines.[10]

If you guessed that supply and demand will also be a top issue of 2022, you're likely to be right. However, next year will not be an identical repeat of 2021. In contrast, we expect the severity and duration of the chip shortage, and its economic ramifications, to be less pronounced because of increased capacity, but also from supply chain improvements that chipmakers, distributors, and end customers make.

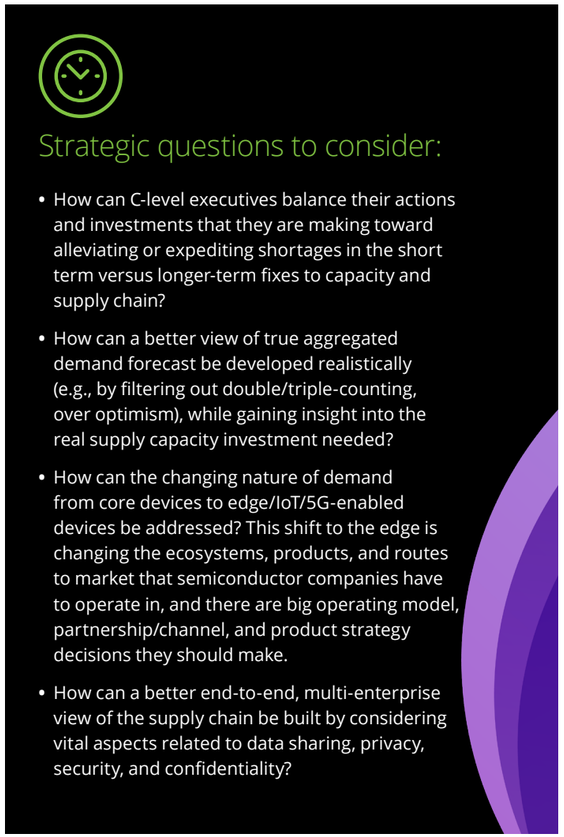
Adding new capacity began in 2021 but won't be operational until 2023 at the earliest. Luckily, some new capacity additions were already in the pipeline before the shortage—we expect to see 200-mm wafer capacity rise by more than 10% for the year, while 300-mm will be up by 15%.

In terms of process technology, our analysis (based on Gartner® data) suggests the most advanced nodes (10 nm and under) will grow 24% year over year in 2022; intermediate nodes (14 nm to 45 nm) will grow 14%; and mature nodes (65 nm and above) will grow by 9%.[11] Although much attention has been paid to more advanced nodes, it's worth noting that even in 2022, mature node manufacturing is expected to account for nearly 64% of global chip output, measured in wafer equivalents.[12]

More capacity is a good thing; however, other, less obvious supply chain improvements may positively impact excessive lead times just as much. These fall into two interdependent trends: moving to a digital capabilities model and collaborating on a digital supply network. And while neither trend started amid the pandemic and its related shortages, both were accelerated because of it.

To find their footing in 2022, semi companies should move to a digital capabilities model, and should redesign their traditional organizational silos to create a more connected and integrated model—one that encompasses their customers, talent, suppliers across all tiers, channel partners, and internal facilities. They should also work to adopt better customer connections, synchronized planning, dynamic fulfillment, supplier collaboration, operations command centers, and digital development.

Meanwhile, semiconductor producers, distributors, and customers should work together to transform their legacy supply chain into a digital supply network, by sensing, collaborating, optimizing, and responding with greater agility. As an example of effective collaboration, companies can work closely with ecosystem partners (both upstream and downstream) to facilitate real-time information sharing and understanding, in addition to greater capturing and addressing of the potential impact to sensed signals. As an example of better data sharing from 2021, one prominent Silicon Valley company that shared its chip needs with manufacturers for the next 12 months moved to five-year forecasts instead.[13]



## Strategic questions to consider:

- How can C-level executives balance their actions and investments that they are making toward alleviating or expediting shortages in the short term versus longer-term fixes to capacity and supply chain?
- How can a better view of true aggregated demand forecast be developed realistically (e.g., by filtering out double/triple-counting, over optimism), while gaining insight into the real supply capacity investment needed?
- How can the changing nature of demand from core devices to edge/IoT/5G-enabled devices be addressed? This shift to the edge is changing the ecosystems, products, and routes to market that semiconductor companies have to operate in, and there are big operating model, partnership/channel, and product strategy decisions they should make.
- How can a better end-to-end, multi-enterprise view of the supply chain be built by considering vital aspects related to data sharing, privacy, security, and confidentiality?





# The hunt for silicon talent intensifies

A widespread post-pandemic worker shortage prevails, propelled in part by the "Great Resignation," in which more than 4 million American workers quit their jobs in August 2021 alone.[14]

The semiconductor industry is also feeling the pinch, albeit exponentially worse. In addition to sharing the factors affecting other industries, the chip business has four megatrends that are making the war for talent even more severe:

1. Global semi industry revenues by the end of 2022 will be almost 50% higher than at the end of 2019.[15]
2. There were already talent shortages in Taiwan and South Korea in 2017. The talent pool in those areas was relatively well developed, but recent growth has nearly exhausted it.[16]
3. Over time, building more local chip fabrication plants (aka fabs) in the United States, China, Singapore, Israel, and other countries will allow chip companies to access a broader, deeper pool of talent. In the short term, although there are millions of talented workers in those areas, they must be trained to acquire essential skills—a necessary step that will not be resolved in 2022.
4. The mix of job skills is changing, and the industry has a strong need for software skills. Our analysis of multiple industry estimates suggests that global electronic design automation (EDA) software revenue is anticipated to double from approximately $10 billion in 2020 to $19 billion by 2027. The need for software hires is likely to follow a similar trend.

On a global level, the most severe talent shortage this year is likely to be in China. There were about 510,000 professionals in semiconductor design and manufacturing in the country as of 2019. A 2021 report suggested a talent shortfall that year of about 300,000 workers, a number projected to fall only slightly to 250,000 by 2022.[17]

There are about 280,000 American professionals in semiconductor design and manufacturing.[18] New plants in Arizona and Texas will likely create close to 5,000 high-tech manufacturing and engineering jobs, and other proposed new plants could more than double that number.[19]

Even as domestic chip companies are experiencing engineering and manufacturing talent shortages, they are also facing competition for talent from other tech majors aggressively expanding in high-growth areas, including artificial intelligence (AI), edge computing, robotics, 5G, and smart devices.[20] These technologies demand similar types of skills, intensifying the ongoing battle for semiconductor talent.

The chip industry can help address its talent shortage by more proactively engaging with universities to advance STEM skills of graduates and bolster innovation. Both efforts are critical to helping the United States sustain its long-term global semiconductor leadership and competitiveness.[21] Another step chip companies can take to address the talent gap is to directly tap into international alliances and ecosystems.[22]

To cater to the growing hybrid work model, semi companies need innovative ways to help enable collaboration between core manufacturing, technical, and R&D staff. Several companies already seem to be on this path: 42% identified corporate culture/environment and collaboration as crucial for their business transformation.[23]

Major chip manufacturers also enhanced their work/life balance initiatives, employee assistance, and well-being programs to better support their organizations during the pandemic. 2022 will likely require them to be even more agile with their workforce development and employee benefit programs, both of which will prove crucial to their ability to retain and grow talent.

## Strategic questions to consider:

- As companies adopt alternative talent strategies to cater to a distributed workforce, what local- and state-level tax policies should be considered, and what specific roles should be permanent or full-time versus contract-based?
- How can companies develop and train their talent pool in a hybrid work model by leveraging a banquet of options such as on-the-job training, self-paced learning, and onsite/offsite mentorship?
- What specific tasks can be automated or robotized within each job role? How can companies enhance the human-machine connection, such as using augmented reality (AR), virtual reality (VR), mixed reality (MR), or AI for more effective teaming and productivity?

# The move to localize chip manufacturing gains momentum

The global semiconductor industry is committing to increasing their overall output capacity at an unprecedented level. Capital expenditures from the three largest players will likely exceed $200 billion from 2021 to 2023.[24] Governments have committed hundreds of billions of dollars more.[25] We expect global wafer starts to be fully 50% higher by the end of 2023 than they were in 2020. Some will occur in traditional manufacturing clusters located in Taiwan and South Korea; but increasingly, they will be in the United States, China, Japan, Singapore, Israel, and Europe—a trend known as "localization"[26]—increasing chip production closer to the next step in the supply chain.

There are multiple drivers for localization; although, it is worth noting that it reverses a multi-decade trend to a well-developed and fine-tuned global supply chain. From chip design and wafer manufacturing, to packaging, testing, original equipment manufacturer (OEM) assembly, and more, there are dozens of countries involved.

Moving global supply chain capabilities into a single country or region will not be easy, but when making the argument for localization, here are some things to consider:

1. As the pandemic has demonstrated, having "all your semiconductor eggs in one basket" leaves multiple industries vulnerable to the hazards from having manufacturer and consumer thousands of miles apart: blocked canals, jammed ports, and so on. Over 60% of all chips were made in East Asia in 2020.[27]
2. Moving manufacturing closer to end users is now seen as a prudent national strategy to reduce risk.
3. Heightened tensions in the East Asia manufacturing region have drawn attention to a global vulnerability of profound supply disruption due to blockades or military action.[28]
4. Ongoing trade restrictions and embargoes suggest a need for greater local autonomy of manufacturing, especially in China.[29]
5. Chipmaking is increasingly seen as a driver for the overall digital economy. In addition to providing local jobs, having a minimum critical mass of semi manufacturing capacity within borders is a key part of national or regional industrial policy in 2022 and beyond, an issue seemingly pressing in Europe at present.[30]

As is customary in industrial policy conversations, chipmakers are more than happy to build new plants in new locales as long as the incentives (usually tax-related) are large enough. Hundreds of billions of dollars will likely be needed going forward.

Moreover, one of the reasons the industry has been so highly concentrated geographically was that there were multiple economies of scale at work that rewarded concentrations. As chip companies move toward localization, they should consider inherent risks and other possible pitfalls.

### Strategic questions to consider:

- As companies pursue localization, what changes should they make in the near and long term with regards to manufacturing and supply-side capacity footprint?
- While companies intend to localize chip production, what potential sources of investments can they tap into—including national, local, and strategic partners?
- How might access to talent markets, support for technical services, energy and water availability, and tax structure and policies change and affect the long-term expansion strategy and road map?





# Digital transformation efforts accelerate

If semiconductor companies are to strengthen their competitive edge, they should be the first to launch new products, rapidly scale production, and focus on innovation and efficiency. These factors—coupled with the advent of new technology end markets, customers' shift to design chips in-house, global trade wars, and the supply chain disruption during the pandemic—have forced them to reinvent their business and operating models. In line with these external market drivers, the Deloitte Semiconductor Transformation Study (STS) found that nearly three out of five chip companies had already embarked on some form of digital transformation by mid-2021.[31]

Nonetheless, the survey revealed that half of semiconductor companies had yet to modify their transformation strategy to adapt to the dynamic marketplace changes that took place during 2021. For two-thirds of those surveyed, their transformation strategy did not fully align with their organization and culture. Moreover, nearly one in ten had no defined transformation strategy whatsoever. Little surprise almost half of chip companies experienced material changes to their digital transformation plans while they were in progress.

In 2022, chip industry executives should address the fallouts of a complex and unpredictable market environment that has affected their business functions and supply chains. They should establish a clear end-state vision, versus being hasty when planning and formulating a transformation strategy. As digital business model transformations require changing operating models and adopting new digital and talent capabilities, chip companies should take an integrated approach—considering various entities both within and outside the enterprise—to be more resilient to future business disruptions.[32]

Semi companies should also bolster their collaboration with extended supply network partners so that they can better implement integrated AI, edge computing, 5G communications, and Internet of Things (IoT) solutions. Their transformation should represent the end markets they are expanding into and the capabilities that will best enable their growth and expansion. Deploying these technologies internally can help unleash capabilities, such as greater visibility of data across the corporate and supply network, timely and real-time intelligence, and automating key processes. All can be essential to executing their transformation initiatives. Enhancing customer experience is also a critical element as chip companies strive to acquire new customers in new markets.

The STS noted that starting in 2022, half of chip companies might plan to offer everything-as-a-service (XaaS) based solutions, representing a shift from the traditional one-time product sales model. As companies ponder this path, they should also consider how new offerings could change the way they go to market, what product engineering and design changes would be required, and how revenue models need to change.[33]

### Strategic questions to consider:

- Does the transformation strategy consider all the various entities including technology, workforce, business functions including strategic business units, channel and distribution partners, and end-market customers?
- As part of the transformation road map, what business partnerships, alliances, and novel talent and design capabilities do companies need to consider or develop?
- How do companies need to change their business and operating models to monetize more of the value their IP, chips, and solutions provide (e.g., silicon as a service)?

# Signposts for the future

In 2022, the semiconductor industry will experience continued strong growth, even as it takes steps to address chip shortages, manage lead times with suppliers and end customers, build manufacturing capacity locally or nearshore, hire specialized engineering and design talent, and bolster its supply networks using advanced digital solutions.

For fab equipment makers, integrated device manufacturers, fabless chip design companies, foundries, and chip distribution partners alike, the trends and developments will affect and influence their strategies and business moves.

## For 2022 and beyond, we recommend semiconductor industry executives be mindful of the following signposts:

- Lead times for chips: 12 weeks is about average, so moving toward that level is a key goal before the end of the year.[34]
- Inventory levels for end customers and distributors: As a result of the shortage, some customers may be hoarding or at least over-ordering. Once the shortage resolves, they could start working down excess inventories, leading to abruptly decreased demand.
- Money and pressure from governments: There is currently strong financial and political support for localization at both the national and regional levels of government, but semi companies should be on the alert for flagging support, as well as canceled or abandoned incentives.
- Wage inflation: The ongoing talent war continues to see companies struggle to fill positions. Compensation has not risen materially; however, as the competition for talent intensifies, that could change.
- Capital expenditure levels: Current run rates are over $100 billion annually, and as the industry shifts into balance, stakeholders may start arguing for a reduction.
- Unforeseeable global and regional disruptions: Significant global/regional political, trade, or conflict events or environmental issues (typhoons, earthquakes, droughts) could cause supply chain shocks and disruption and yet again radically alter chip companies' strategies and business models.





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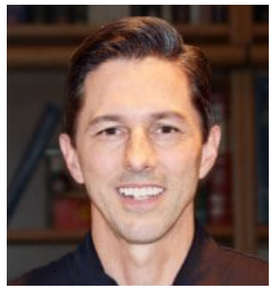

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