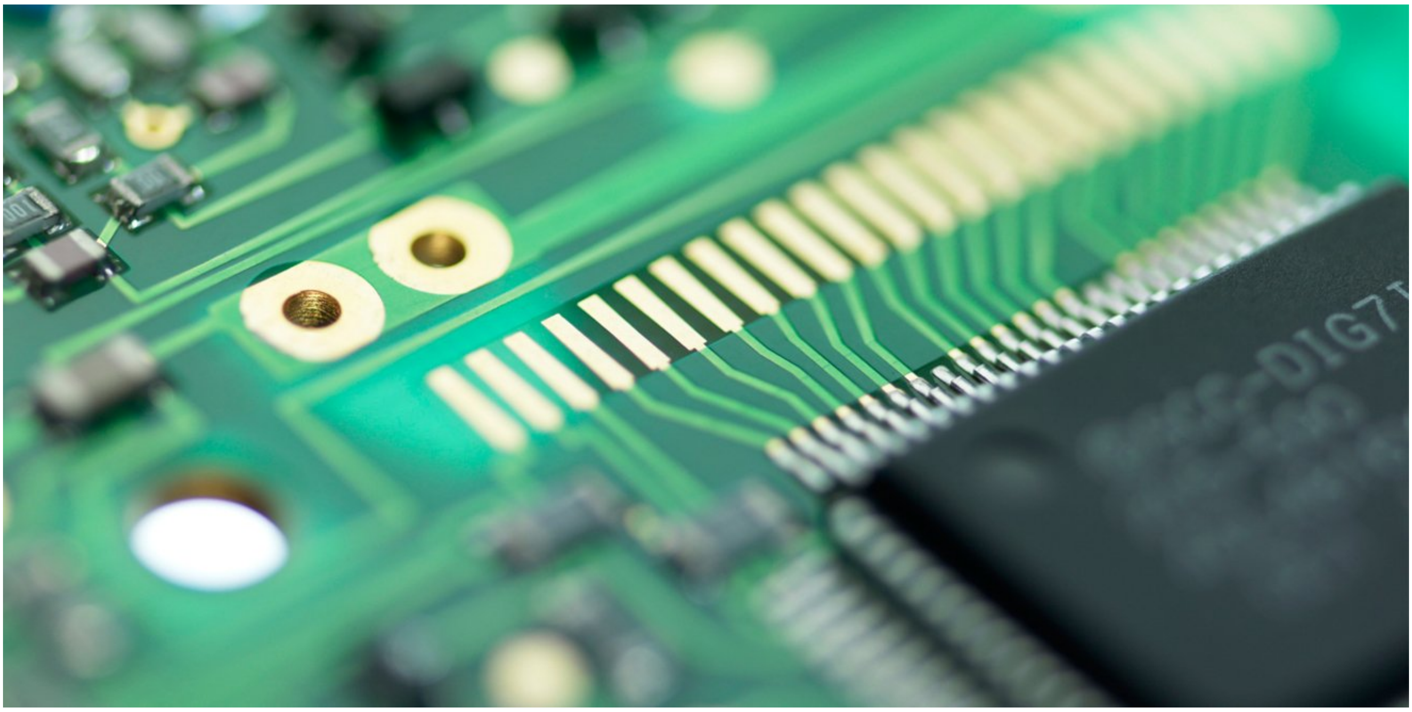


Chip Shortages: Driving Forces, Long-Term Implications

June 21, 2021

New and used cars are getting more expensive because of a global semiconductor (chip) shortage, but there's much more to the story.

While automotive shortages are certainly front and center right now, they didn't occur in a vacuum, and understanding why they are happening can shed light on our long-term investment expectations for semiconductors and related manufacturing equipment.

The punchline: There should be plenty of growth opportunities in the coming years, but there are also many risks.

Two Structural Drivers of Chip Shortages

Automotive chip shortages are a microcosm of broader secular trends—digitalization and deglobalization—that play a critical role in framing our long-term investment mosaic.

Digitalization involves transformational changes to business models and consumer connectivity. It is about technology-led innovation, and semiconductors are the critical building blocks.

When the pandemic spread globally in early 2020, forcing much of the world to work and learn remotely, digitalization trends accelerated—and chip demand exploded across a wide range of applications, from cloud computing to laptops and webcams.

Deglobalization—“decoupling,” to be more precise—refers to the desire for technological sovereignty among the world’s most powerful nations.

This topic warrants an entire blog post, but for now, I’ll focus on two contributing factors: China’s stated goal of semiconductor self-sufficiency and geopolitical issues between the United States and China.

As background, tensions between the two nations spiked in mid-2019 when the United States placed Huawei on its “entity list,” thereby limiting Huawei’s access to critical software and hardware needed to produce smartphones and 5G networking equipment.

The spillover? China’s biggest chip buyers, not just limited to Huawei, began stockpiling inventory amid fear of expanding restrictions and difficulty finding adequate substitutes. For chips and tech hardware, this is leading to increasingly bifurcated and localized supply chains.

An Idiosyncratic Driver: Failed Inventory Management

Another reason for chip shortages is perhaps the most obvious, yet largely overshadowed by politics: failed inventory management.

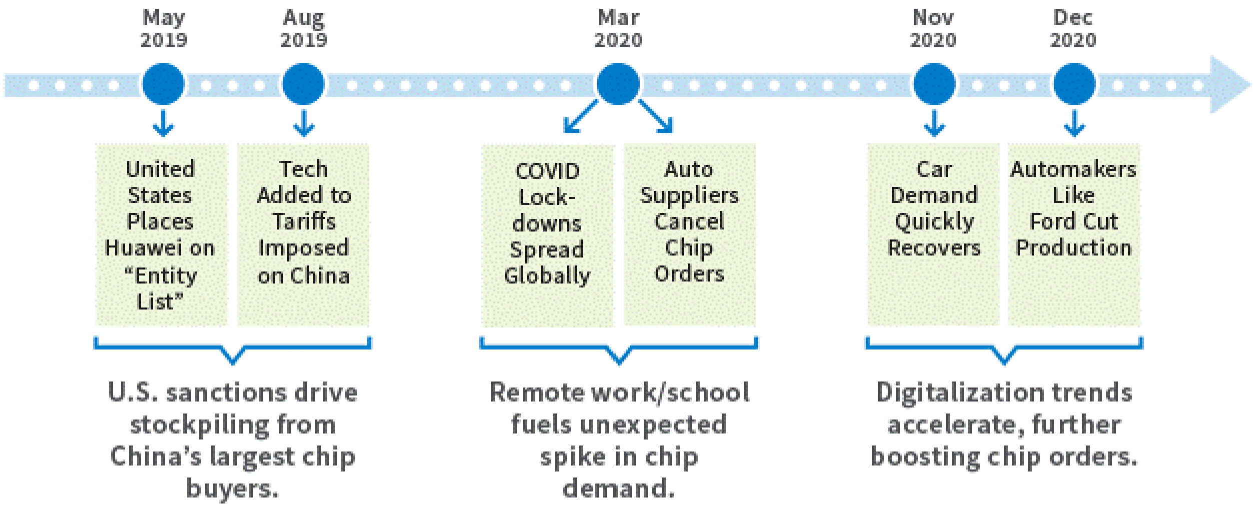
As car demand plummeted in the early stages of the pandemic, auto suppliers drastically reduced existing orders for semiconductors. When the market recovered just a few months later, they attempted a U-turn on those order cuts, but it was too late: chip producers already reallocated capacity to higher-volume customers in other end-markets.

Supply constraints or not, it’s unrealistic for semiconductor suppliers to accommodate significant volume increases for car components on short notice. Lead times are notoriously long (several months) because of extensive testing and quality control protocols, and this is unlikely to change given consumer safety concerns and regulatory requirements.

In the end, we believe shortages will ease later this year before being fully resolved in 2022, but we should not ignore the longer-term implications.

Connecting the Dots on Chip Shortages

A Perfect Storm of Demand and Automotive Supply-Chain Mistakes



Source: William Blair, as of June 2021.

A Convenient Catalyst for Change

These three factors—digitalization, deglobalization, and failed inventory management—are driving key changes. Just as remote work/school accelerated the pace of digitalization, chip shortages have accelerated U.S. government initiatives to stabilize the balance of tech power with Asia and reinvigorate the American semiconductor industry.

To understand why, consider changes in the geographic distribution of chip manufacturing over the past 20 years. The United States had close to 25% of global capacity in 2000, but today it's just north of 10%; meanwhile, Europe has gone from 17% to 7%.

Even more concerning are the supposed national security risks associated with the leading-edge capacity needed for the most advanced technologies. More than 90% is located in Taiwan, a tiny island off the coast of China. The problem: Despite Taiwan's independence and separate government, China has long claimed ownership and does not recognize it as a separate country.

With Taiwan caught in the middle of an increasingly hostile political environment, both the United States and Europe are urgently developing new policies and government incentives to bring capacity investments closer to home.

Following the election last November, we thought there might be a cooling of Chinese restrictions established during the Trump era. But as it turns out, not much has changed under the Biden administration. In fact, there is some evidence of "success" in slowing the pace of China's rapidly improving domestic semiconductor industry.

Consider Huawei as one example. Recently, for the first time in more than five years, the company lost its position as the world's third-largest smartphone maker behind Samsung and Apple. Huawei isn't even in the top five anymore.

The Long View

The events and trends highlighted above inform our view of both the long-term growth opportunity and the trajectory of that growth.

To simplify our analysis, we disaggregate the semiconductor industry into two segments: companies that design and sell chips, and those that supply the equipment needed to manufacture chips.

We expect the total semiconductor revenue pool to more than double by 2030, but the path won't be linear. For equipment in particular, we think the majority of next decade's growth will occur over the next five to seven years.

As the table below shows, total chip revenue was approximately $300 billion in 2010. By 2020 that number was $465 billion. But we expect faster growth ahead, with global chip sales reaching $1 trillion by 2030.

Meanwhile, total semiconductor equipment revenue was approximately $32 billion in 2010. By 2020 that number was $65 billion. We anticipate roughly $150 billion in sales by 2030, a 10-year compound annual growth rate (CAGR) near 10%.

Revenue Expectations

$1 Trillion (for Chips) and $150 Billion (for Equipment) Expected by 2030

	2010	2015	2020	2025(E)	2030(E)
Semiconductors	**$300 Billion**	**$335 Billion**	**$465 Billion**	**$650 Billion**	**$1 Trillion**
5-Year CAGR		2%	7%	7%	9%
Manufacturing Equipment	**$32 Billion**	**$35 Billion**	**$65 Billion**	**$120 Billion**	**$150 Billion**
5-Year CAGR		2%	13%	13%	5%

Source: William Blair, as of June 2021. Manufacturing equipment refers to front-end manufacturing equipment; total capital expenditures will be higher.

The Path to $1 Trillion and $150 Billion

Why is it not farfetched to expect more than a doubling of semiconductor and manufacturing equipment revenue in the next 10 years? We see four key growth drivers.

Digitalization

We've already discussed how technology-led innovation is driving transformational changes to business models and consumer connectivity. But what exactly does that mean?

To start, the world is moving toward "ubiquitous connectivity," with a rising number of connected devices supported by the continuing migration to 5G wireless technology.

We're also referring to "digital lifestyle" consumer trends, with rapid growth in e-commerce in addition to more and richer content consumed over the internet.

Lastly, businesses of all sizes are quickly realizing the critical role technology plays in both differentiation and mere survival. Digital transformations involve technologies like cloud computing and software-as-a-service, which rely on physical cloud infrastructure and high-performance computing enabled by—you guessed it—semiconductors.

Deglobalization

In addition to sustained growth from China amid semiconductor self-sufficiency objectives, the desire for technological sovereignty (supported by increased government funding) will likely drive capacity expansion in both the United States and Europe. As a result, we expect a continuation of above-average equipment volumes.

Broadening Demand and Content Gains

The composition of chip buyers is becoming more diverse, leading to strength across the spectrum—from advanced chips enabling 5G networks and cloud-based artificial intelligence to more mature technologies (such as sensors found in smart thermostats).

Looking at end-markets, automotive and industrial are poised to outgrow most others, with 10-year growth rates in the low double digits.

This can be partly attributed to a smaller revenue base today, but it’s also a function of rising semiconductor dollar content per unit (device).

As an example, the total cost of semiconductors in an average car increased from $300 in 2015 to more than $450 in 2020. We see significant upside going forward alongside rapid adoption of electric vehicles.

Outside of cars, dollar content growth is most apparent in smartphones and data center servers, where the desire for improving performance and functionality requires more complex chip designs.

Leading-Edge

This is related to the drivers discussed above but focused on the suppliers of manufacturing equipment.

Large buyers of high-end chips, including your favorite smartphone brand, constantly seek performance enhancements such as faster processing speeds. For sophisticated customers, this requires highly complex, leading-edge manufacturing techniques.

As background, leading-edge technology refers to a type of manufacturing process that can produce the smallest and best-performing (fastest, most power-efficient) chips.

Demand for performance improvements via leading-edge technology isn’t a new phenomenon. The difference now compared to even a few years ago is that pricing premiums for leading-edge manufacturing equipment are larger today than ever before. In fact, some machines cost more than $150 million.

Rising price tags underpin elevated capital intensity and, we believe, sustained double-digit revenue growth in semiconductor equipment.

Evolving Economics

We see plenty of growth opportunities within both chips and equipment over the coming years, but there are also plenty of risks.

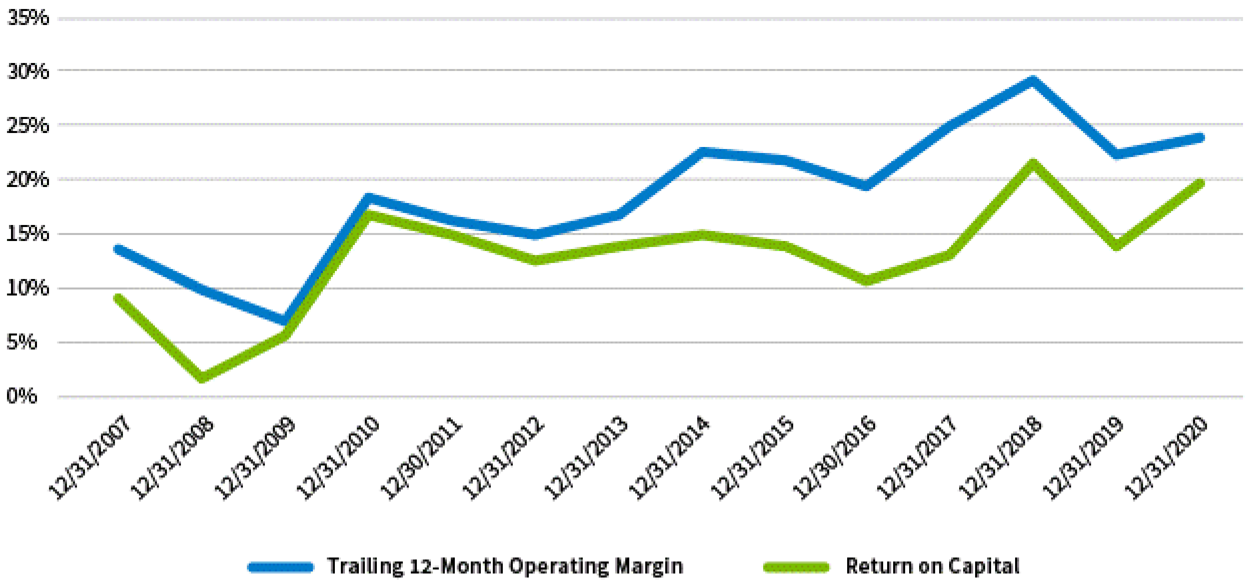
The current state of affairs—with chip-making capacity geographically centralized and consolidated among a handful of outsourced manufacturers (called foundries)—is easy to rationalize from a financial perspective.

It’s the most efficient allocation of resources, especially at the leading edge, where the most complex chip designs are becoming prohibitively expensive to produce, requiring billions in upfront capital.

Operating profit margins and returns on capital have improved alongside the shift toward outsourced manufacturing (again, foundries) and the explosive rise of “fabless” business models, which are companies exclusively focused on chip design. The chart below illustrates.

Semiconductor Industry Margins and Returns

Profitability Has Improved With More Outsourced Manufacturing

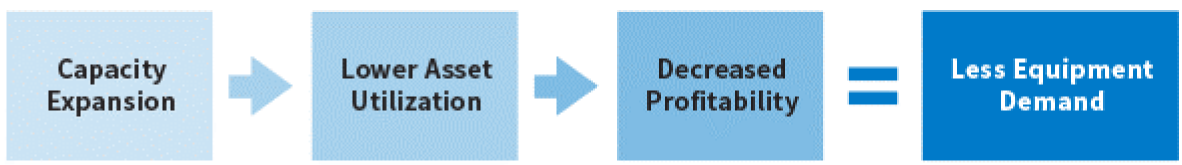


Source: Bloomberg, as of June 2021. Aggregate data is from the MSCI ACWI Semiconductor & Semiconductor Equipment Index.

Still, capacity expansion plans driven by deglobalization and increased government intervention could lead to lower asset utilization for chip manufacturers, putting downward pressure on profit margins and returns on capital. With less money for foundries to reinvest in research and development and capital expenditures, we may see a slowdown in technological innovation and more subdued growth for equipment suppliers.

Semiconductor Foundry Economics: 2025 and Beyond

Capacity Expansion Is a Longer-Term Risk for Equipment Suppliers



Source: William Blair, as of June 2021.

Potential Disruption

There's also at least one emerging technology with the potential to be highly disruptive: quantum computing. At some point, leading-edge semiconductors (the tiniest and best performing) will reach a physical limit—chips can't get much smaller.

Computers using quantum physics instead of traditional semiconductor architectures have performance capabilities and processing power that's far greater than classical computers.

While it probably won't become mainstream for at least another five years, quantum computing has the potential to transform everything from technology to healthcare.

No Signs of Slowdown

The semiconductor party is showing no signs of slowing down. But with mounting risks and rapid innovation, it's getting more challenging to maintain any degree of confidence in decade-plus forecasting horizons. So, our 2030 estimates will inevitably be wrong.

But that's OK—we think the bigger-picture direction of travel is more important than striving for precision. Intellectual curiosity and an open mind are critical to identifying the best long-term investments in any domain—semiconductors or elsewhere.

Greg Scolaro, CFA, is a research analyst on the Global Equity team.

Disclosure:

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