The Future Of Chips Is Overcapacity

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Chips are in short supply right now, but on a longer time horizon we're headed for overcapacity

Chips are hard to come by right now. The present shortage will be deep and long-lasting (see **The Broader Risk Of Semiconductor Shortages**). But on a longer time horizon, semiconductors are heading for the opposite problem: persistent excess capacity. Three trends point in that direction. First, the severity of the current shortage is prompting stunning levels of investment in new supply. Second, the US, China and other big chip producing regions are pursuing self-sufficiency in integrated circuits on national security grounds. Third, semiconductors are close to running up against physical limits which will make technological improvements far harder, and turn chips into more of a commoditized product.

A decade from now, semiconductor supply may look similar to steel today, with production in every major region

Because of their centrality in the tech ecosystem, and their salience in the growing strategic rivalry between the US and China, chips are often described with increasingly extravagant metaphors: they are the "lifeblood" of the digital technologies, the "new oil" of the global economy, or more humbly the indispensable "rice" without which (at least according to one South Korean politician) we would all figuratively starve. A better analogy might be steel. Every major region feels the need to support a steel industry for national security and economic security reasons. As a result, steel suffers from chronic overcapacity because non-economic supply won't go away. A decade from now, semiconductors might look the same.

It's not just the current crisis…

The current semiconductor shortage is causing most major chip firms to announce massive investments in new capacity, and these plans are being egged on by government pressure. Taiwan Semiconductor Manufacturing Company says it will spend up to US$28bn on capex in 2021, and US$100bn over the next three years. Intel announced in March that it would invest US$20bn for two new fabs in Arizona. The last of the global big three, Samsung, announced on May 13 that it would raise its investment target by 30%, to spend an expected US$151bn through 2030 in non-memory technologies. Smaller companies like SK Hynix, Chinese memory producer YMTC and STMicroelectronics also plan to increase capex in 2021.

Chips and politics are getting increasingly intertwined

These capex plans are driven partly by the need to respond to the current shortages, partly by a long-standing trend for market share to accrue to the companies that invest the most, and partly by politics. Cabinet-level leaders in the US and Europe have asked TSMC to prioritize chips for the politically powerful automotive sector. In April, President Joe Biden and Commerce Secretary Gina Raimondo convened a CEO summit to discuss ways to alleviate the chips shortage. Raimondo is following that up with another meeting for tech companies in May.

… it's national security

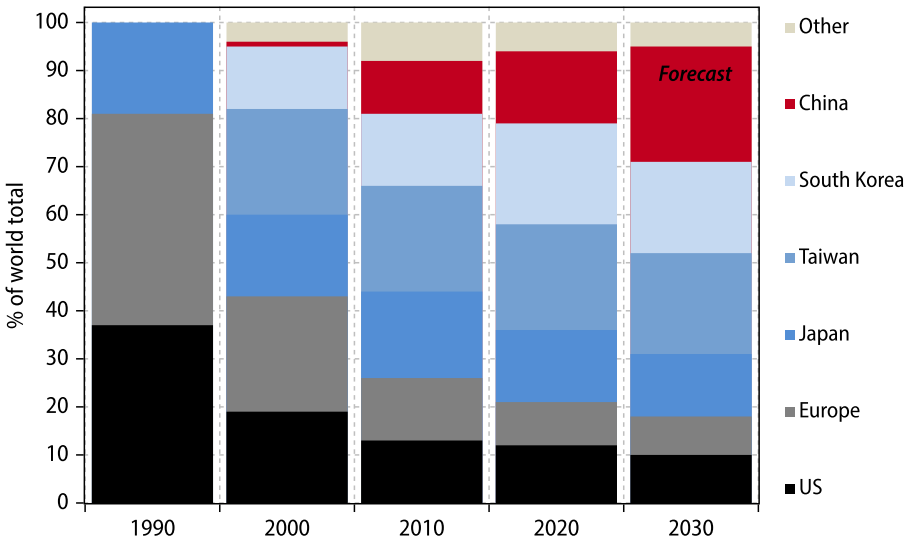
Political pressure reflects not just governments' desire to relieve the immediate shortage, but also their drive for greater self-sufficiency in products that they see as vital to national security. Semiconductors are crucial components for a widening range of products, and the chip value chain is unusually complex. Governments fear depending too much on imports, and so are trying to create more secure semiconductor supply chains. Over the long run, this will lead to significant redundant capacity.

China's massive spending on fabs hasn't put it in the lead, but it has laid the foundations to compete effectively

The trailblazer in this latest cycle of semiconductor industrial policy is China. Beijing ramped up its efforts to master semiconductors beginning in 2014, with more coordinated policies and massive financial support, including at least US$50bn in central government support for new fabs, as well as significant investments by local governments. So far, Chinese chip firms have not attained technology leadership in any major segment, but have built the foundations to compete effectively (see **The Quest For Semiconductor Sovereignty**).

China could have the biggest chip-making capacity by 2030

Share of global IC manufacturing capacity by location



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China is poised to become the world's biggest chip producer by volume

These efforts have gained urgency after US export controls revealed the potentially catastrophic dependency of China tech firms on imports of US chips and semiconductor equipment. American technology restrictions stopped memory-chip startup Fujian Jinhua in its tracks, are forcing Huawei's operations into collapse and could crimp the operations of SMIC, China's leading foundry. As a result, Chinese technology firms are aligned with their government's desire for chip self-sufficiency (see **This Time Is Different For Industrial Policy**).

The US is reacting to chip fabrication moving outside of US influence

The US is acting urgently too. Biden has given multiple press conferences on chips, and Raimondo declared that the lack of domestic semiconductor production poses both national security and economic security risks. US fears boil down to two interrelated concerns. First, over the past three

decades chip fabrication has steadily moved from the US to East Asia. This was not a problem when the Asian chip producers were located in South Korea and Taiwan, but seems dangerous now that China is poised to become the world's biggest chip maker by volume if not by value. Second, if the US loses semiconductor leadership, then it might not be able to lead in new technology fields or be able to make the most advanced military goods.

Washington is pushing big chip companies to make more in the US...

As a result, Washington is leaning hard on big chip companies (including Intel, TSMC and Samsung) to increase their US manufacturing. In 2020 Congress passed the CHIPS Act, authorizing federal funds for semiconductor production and research. Congress has not yet appropriated the funds, but it will probably come out to US$50bn in support over ten years (see **Biden's Tech War**).

...and Taiwan's economy minister insists that TSMC's most advanced fabs remain on the island

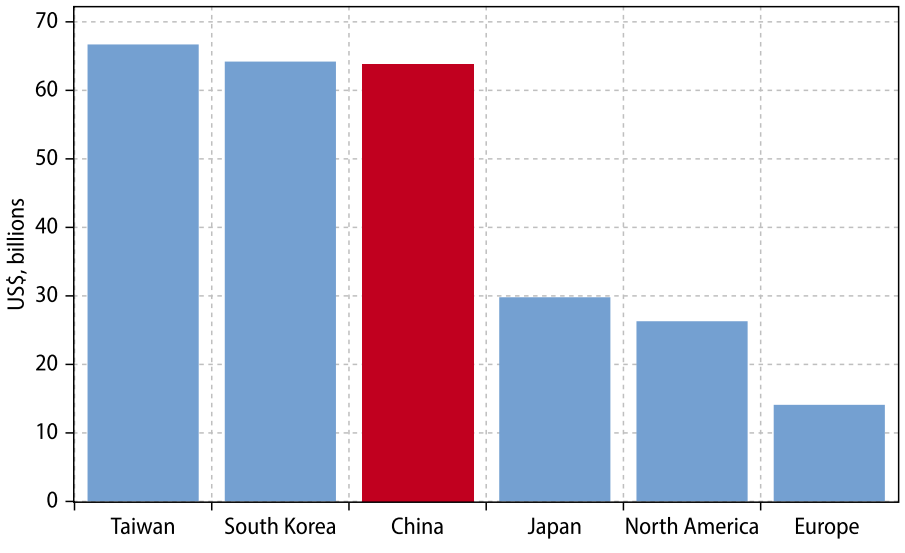
Other major chip producers are not standing still. Taiwan's economy minister has insisted that TSMC's most advanced fabs should stay on the island. And in March, the European Union announced that it intends to spend up to US$150bn to double its share of the production of advanced chips to 20% by 2030.

Europe is least likely to successfully compete against established chip makers

Not all of these efforts will bear fruit. Most semiconductor segments have high barriers to entry, and incumbents enjoy strong competitive advantages. Of the various industrial policy efforts, Europe's is the least likely to succeed. Its share of global chip production has plummeted from 44% in 1990 to 10% today, and it is competitive mainly in a few niche industrial applications as well as in semiconductor production equipment, where the Netherlands' ASML produces the world's most advanced lithography tool. Regaining lost ground is an enormous challenge. Europe is competing against established chipmakers while it lacks the behemoth end-user firms (such as Amazon, Google, Huawei or Alibaba) who can be the early customers for unproven products.

China is spending big on semiconductor equipment for new fabs

Forecast spending on semiconductor equipment spending, 2019-2022



China's spending will probably grant it large positions in memory and analog chips

World Fab Forecast, SEMI, Gavekal Dragonomics/Macrobond

It's likelier that the US, Taiwan and South Korea will be able to extend their advantages. And China is almost certain to vastly increase its production capacity, even if it does not achieve its ostensible goals of complete self-sufficiency and global technological leadership. The state is able to mobilize large-scale funding and to sustain it over many years, keeping marginally profitable companies afloat. Two decades after its founding, SMIC still relies on government support: in 2019 it received US$300mn in government grants, more than its net profit for the year. In the coming decade, Chinese companies will probably achieve large positions in memory and analog chips, as well as other relatively simpler and high-volume devices.

A maturing technology

Chip technology may soon reach a plateau...

The final factor driving the semiconductor industry into excess capacity is the physical limit on technological advance. Moore's Law—the tendency for transistor density to double every 24 months—could soon come to an end. TSMC, the world's most advanced chip firm, now produces chips at the 7-nanometer process node. Once it gets down to 2 nanometers, further progress will be highly technically challenging, since this would require manipulating materials on an atomic scale at which quantum effects become increasingly intrusive. In part for this reason, the International Technology Roadmap for Semiconductors—the global industry's consensus technical forecast—decided in 2016 that it can no longer attempt to map out targets beyond 2030.

...and demand for the most advanced chips is not growing

More prosaically, the center of gravity for semiconductor demand is shifting in a lower-tech direction. Demand for the products that require the most advanced chips—smartphones and computers—is not growing. Demand is growing fastest for lower-end chips (such as those that go into automobiles and internet-enabled devices). This is good news for Chinese producers. Chinese firms have shown the ability to master various mature technologies like shipbuilding, LCD screens and solar panels. When they succeed, they produce in enormous volumes and erase profits for everyone, including themselves. The semiconductor value chain would thus shift in favor of chip designers.

Massive new capacity is being bought just as semiconductors are becoming commoditized

Thus the chip industry is set once again to replay the boom and bust cycles that have plagued its past. Massive new capacity investments are occurring just at the point when semiconductors are starting a transition from technological wonder to commoditized product. Political pressure for national self-sufficiency ensures that much of this capacity will endure even if it is not profitable. The silver lining is that what is bad news for chip companies is good news for their customers. It would mean that shortages of the current sort won't take place again.