



Where's the Silicon?

Nir Kshetri, University of North Carolina at Greensboro

Jeffrey Voas, IEEE Fellow

The world is facing a silicon shortage. We look at some of the key facts and figures to gain some insights.

A Wendy's hamburger commercial asked, "Where's the beef?" We're asking, "Where's the silicon?" Recent news clips concerning a global silicon shortage intrigued us. It's a supply chain case study that comes with an interesting twist: is this problem natural or manufactured? We can't answer that, but here are a few tidbits:

1. Silicon is a metalloid,¹ and China is the largest producer.²
2. Silicon demand has been growing for microprocessors to support 5G, self-driving vehicles, artificial intelligence, and other uses. Pandemic lockdowns accelerated the demand for work-from-home products, and China has been accumulating integrated circuits (see Figure 1).
3. In the late 1980s,³ the prevalent business model among semiconductor designers changed to outsourced manufacturing. In the fabless model, a product vendor designs and sells hardware and semiconductor chips but relies on chip-making factories known as *foundries* to manufacture silicon wafers.
4. East Asia has emerged as the global epicenter of fabless. More specifically, Taiwan Semiconductor Manufacturing Company (TSMC) has been credited with pioneering the "foundry and fabless" model. According to TrendForce, TSMC and Samsung have foundry market shares of 55% and 18%, respectively.⁴ About three-quarters of the global semiconductor manufacturing capacity, as well as key suppliers of essential materials, are in Asia (Figure 2).
5. East Asia's dominance is clear in the manufacturing of semiconductor devices. Currently, 100% of the world's highly advanced logic semiconductor (smaller than 10 nm) manufacturing capacity is in two Asian economies: Taiwan, 92%, and South Korea, 8%.⁵ In 2020, Samsung and TSMC introduced 5-nm chips. A plan exists to produce 3-nm chips in 2022.^{6, 7}
6. A single semiconductor fabrication plant costs US\$10–20 billion.⁸ Public support is almost certainly required. One important lesson from Taiwan and South Korea was the role that governments played.⁵
7. The United States recently took legislative measures; a 2020 bill, the CHIPS for America Act (H.R. 7178), provides incentives to enable R&D in the semiconductor industry and secure supply chains.⁴

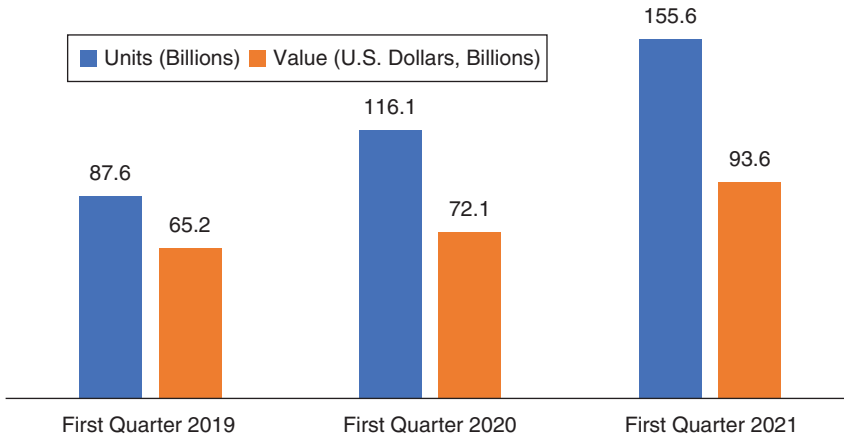


FIGURE 1. China's integrated circuit imports.

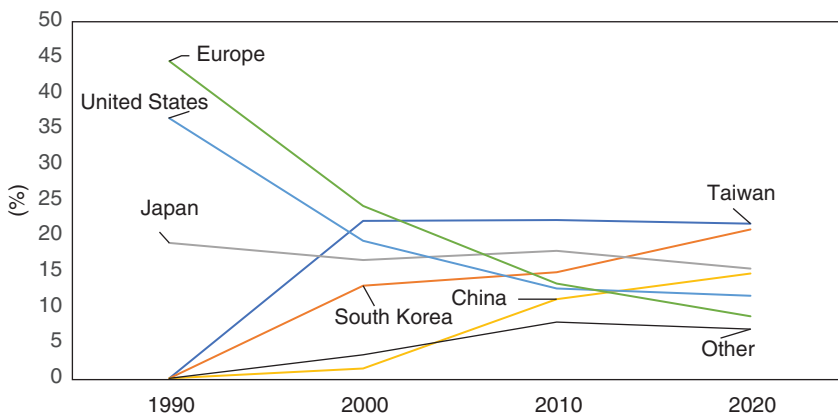


FIGURE 2. Major economies' share of the global semiconductor manufacturing capacity.

So that's some of what we found. We're still hoping to answer our original questions. Expect to read more about this in future *Computer* issues.

REFERENCES

1. S. Pappas, "Facts about silicon." Live-Science, Apr. 27, 2018, <https://www.livescience.com/28893-silicon.html#:~:text=Silicon%20is%20neither%20metal%20nor,both%20metals%20>

2. "Major countries in silicon production from 2010 to 2020 (in 1,000 metric tons)." Statista. <https://www.statista.com/statistics/268108/world-silicon-production-by-country/> (accessed on Apr. 26, 2021).
3. J. Ye, "China semiconductor imports surge to all-time high in March amid global chip shortage," South China Morning Post, Apr. 13, 2021. <https://www.scmp.com/tech/big-tech/article/3129383/china-semiconductor-imports-surge-all-time-high-march-amid-global> (accessed May 15, 2021).
4. A. Kharpal, "How Asia came to dominate chipmaking and what the

- U.S. wants to do about it," CNBC, Englewood Cliffs, NJ, Apr. 12, 2021. [Online]. Available: <https://www.cnbc.com/2021/04/12/us-semiconductor-policy-looks-to-cut-out-china-secure-supply-chain.html>
5. "SIA urges U.S. government action to strengthen America's semiconductor supply chain," Semiconductor Industry Association, Washington, D.C., Apr. 5, 2021. [Online]. Available: <https://www.semiconductors.org/sia-urges-u-s-government-action-to-strengthen-americas-semiconductor-supply-chain/>
6. R. Sharma, "Pound for pound, Taiwan is the most important place in the world." NY Times, Dec. 14, 2020. <https://www.nytimes.com/2020/12/14/opinion/taiwan-computer-chips.html> (accessed Feb. 15, 2021).
7. S. Kim, "South Korea and Taiwan's chip power rattles the U.S. and China," Bloomberg, Mar. 3, 2021. <https://www.bloomberg.com/news/articles/2021-03-03/chip-shortage-taiwan-south-korea-s-manufacturing-lead-worries-u-s-china> (accessed Mar. 15, 2021).
8. Y. To, "China chases semiconductor self-sufficiency," East Asia Forum, Feb. 22, 2021. <https://www.eastasiaforum.org/2021/02/22/china-chases-semiconductor-self-sufficiency/> (accessed Mar. 15, 2021).

DISCLAIMER
The authors are completely responsible for the content in this message. The opinions expressed are their own.

NIR KSHETRI is a professor of management in the Bryan School of Business and Economics, University of North Carolina at Greensboro, Greensboro, North Carolina, 27412, USA, and the "Computing's Economics" column editor at *Computer*. Contact him at nbkshetr@uncg.edu.

JEFFREY VOAS, Gaithersburg, Maryland, USA, is the editor in chief of *Computer*. He is a Fellow of IEEE. Contact him at j.voas@ieee.org.