



# A GUIDE TO THE SEMICONDUCTOR INDUSTRY

*April 2021*

American engineers invented the transistor, perfected the integrated circuit, and built the world-leading firms that powered the computing revolution. But America no longer leads in the semiconductor industry, thanks to decades of complacent economic policy summarized in an infamous remark by the chair of George H. W. Bush's Council of Economic Advisors: "Potato chips, computer chips, what's the difference?"

Quite a lot, it turns out.

While U.S. policymakers held tight to the belief that it doesn't matter who makes what where and trusted "comparative advantage" to leave each country specializing where it could naturally excel, foreign governments placed big bets on the value of dominating the digital future. The Reagan administration fended off Japan's challenge in the 1980s, but no such defender of the national interest stood ready to take action as Taiwan and South Korea surged forward in the past two decades.

Combined, those countries now manufacture more advanced chips than the United States and account for more of the industry's value-add. Their national champions, Taiwan Semiconductor Manufacturing Company (TSMC) and Samsung, have surpassed Intel in manufacturing prowess. China continues to invest aggressively in its effort to overtake them.

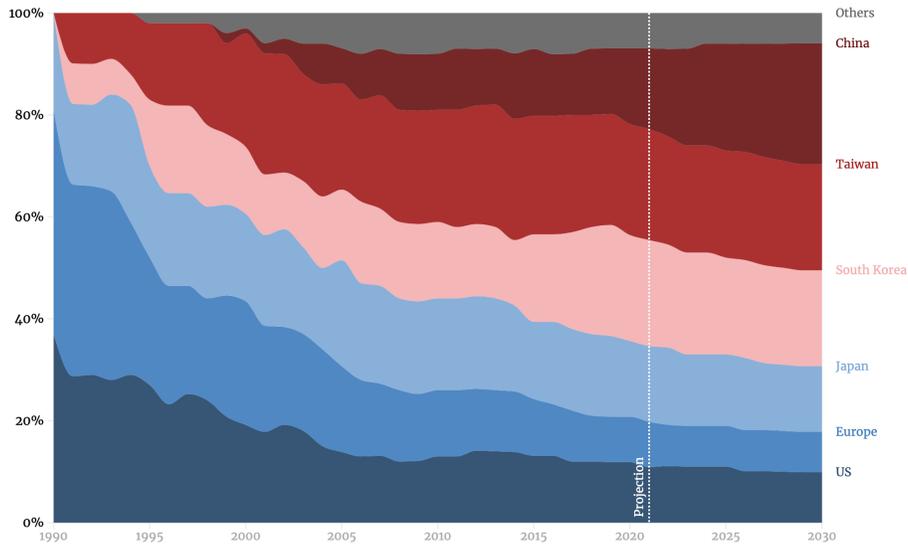
In 2018, Congress created the National Security Commission on Artificial Intelligence "to consider the methods and means necessary to advance the development of artificial intelligence, machine learning, and associated technologies to comprehensively address the national security and defense needs of the United States." The commission's final report, issued in March 2021, put the matter succinctly: "After decades leading the microelectronics industry, the United States is now almost entirely reliant on foreign sources for production of the cutting-edge semiconductors that power all the AI algorithms critical for defense systems and everything else. Put simply: the U.S. supply chain for advanced chips is at risk without concerted government action."

## AMERICA'S CHIP SLIP

The U.S. share of chip-making capacity has fallen by two-thirds since 1990 and is still falling.

The U.S. has lost its leadership position in semiconductor manufacturing

*Share of global capacity*



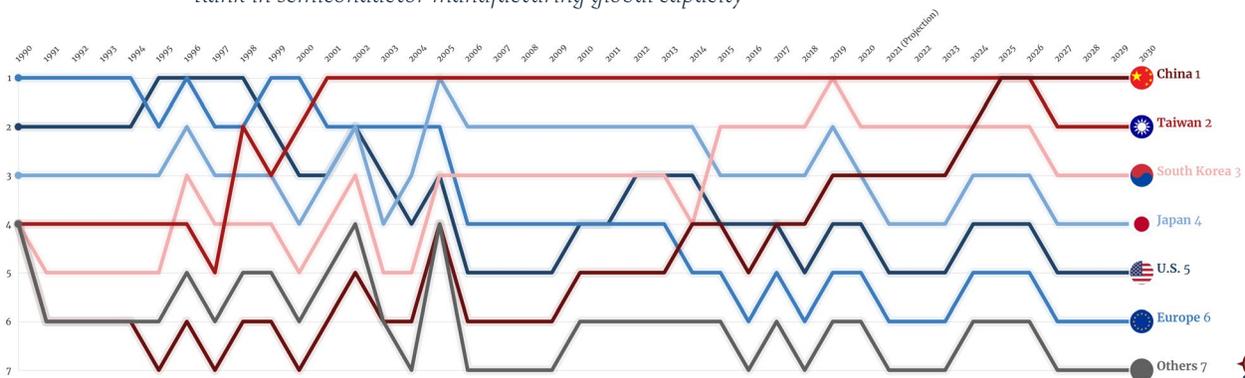
Source: VLSI Research Projection; SEMI second-quarter 2020 update; BCG analysis · Note: All values shown in 8" equivalents; excludes capacity below 5 kwpm or less than 8"



The U.S. once led the world in manufacturing capacity. Today, Taiwan, South Korea, China, and Japan hold the top four spots, accounting for three-quarters of capacity.

The U.S. has fallen from first to fifth; China will soon take the top spot

*Rank in semiconductor manufacturing global capacity*



Source: VLSI Research Projection; SEMI second-quarter 2020 update; BCG analysis · Note: All values shown in 8" equivalents; excludes capacity below 5 kwpm or less than 8"

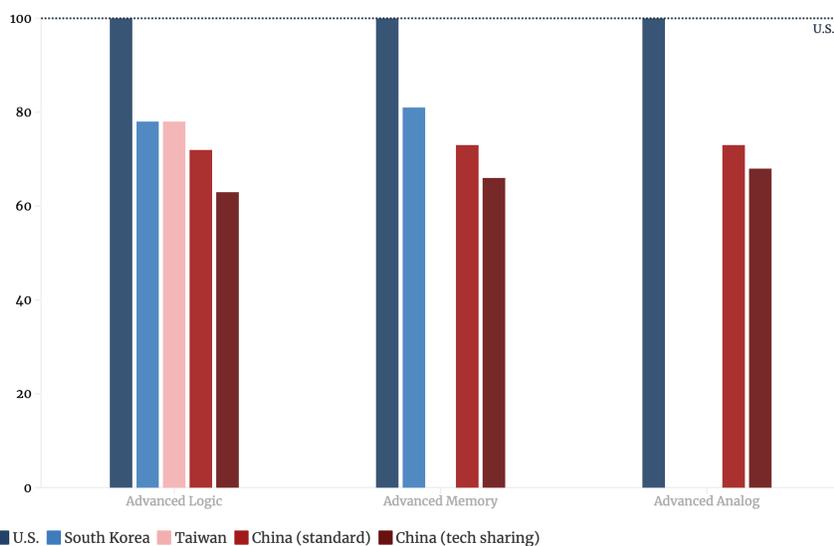


Leadership hasn't moved across the Pacific because Asian nations are naturally better places to make semiconductors or because their economies have generated remarkable innovation. Leadership has moved because governments in Taiwan, South Korea, and China have adopted policies to aggressively subsidize the construction and operation of fabrication plants.

Today, an advanced foundry costs 30–60% more to build in the United States, with the vast majority of that difference explained by government support. Meanwhile, China provides extra subsidies to foreign firms that agree to share their technology with local partners.

### Chip manufacturing costs 30-60% more in America

10-year total cost of ownership for fabrication plant, indexed to U.S.=100



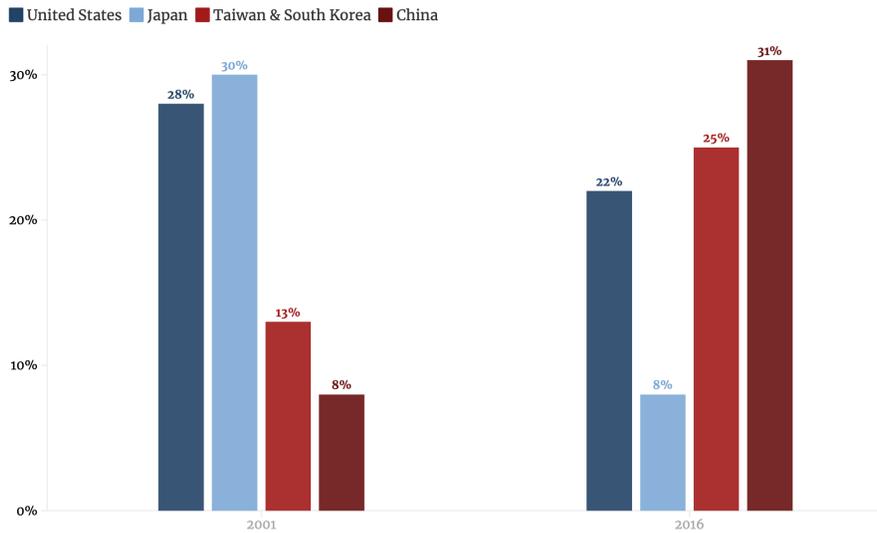
■ U.S. ■ South Korea ■ Taiwan ■ China (standard) ■ China (tech sharing)

Source: BCG and Semiconductor Industry Association · Note: Additional incentives are available to multinational corporations that enter technology sharing arrangements in China



Semiconductors aren't sneakers. Whereas just 4% of the sneaker industry's value-add is in manufacturing, in semiconductors that figure is 45%. Thus, as manufacturing left America, the economic loss totaled tens of billions of dollars. South Korea and Taiwan now account for more of the industry's economic activity, and China for the most.

Valuable manufacturing has shifted from the U.S. to Asia  
*Share of value added in global semiconductor industry, 2001 and 2016*

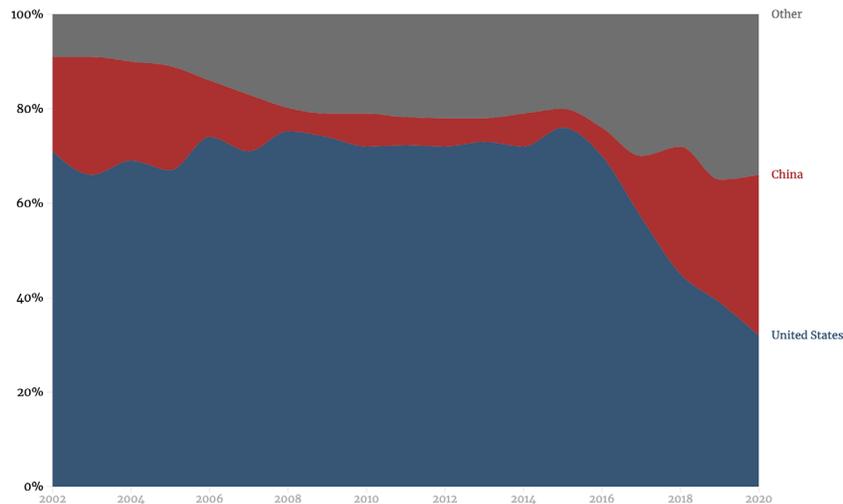


Source: National Science Board · Note: Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs.



Semiconductor manufacturing also matters because cutting-edge innovation in the manufacturing process is tied closely to progress in design and application. Thus, as manufacturing migrates, the whole investment ecosystem goes with it. While America once dominated the industry’s venture capital scene, China now holds the lead. “Silicon Valley” may need to change its name to AppLand.

Venture capital has followed manufacturing out of the U.S.  
*Share of publicly disclosed VC deal value in semiconductor industry, trailing 5-year average*



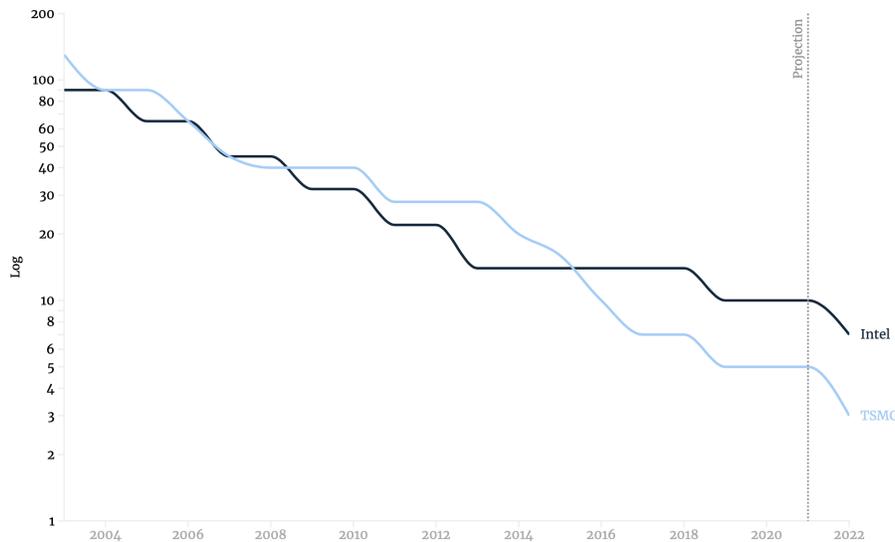
Source: Crunchbase



U.S. chipmaker Intel’s loss of technological leadership presents an especially stark illustration of America falling behind. For five decades, Intel defined the cutting edge of chip production, traditionally measured by how small a manufacturer can make its transistors. But in the 2010s, Intel got stuck at 14 nanometers (nms) while TSMC passed and then lapped it.

Today, TSMC’s foundries are at the cutting edge and continue to push the boundary forward while Intel struggles to catch up. The situation is so dire that Intel has considered outsourcing some of its own production to TSMC.

TSMC has overtaken Intel at the cutting edge of manufacturing  
*Foundry production capabilities, in nanometers*



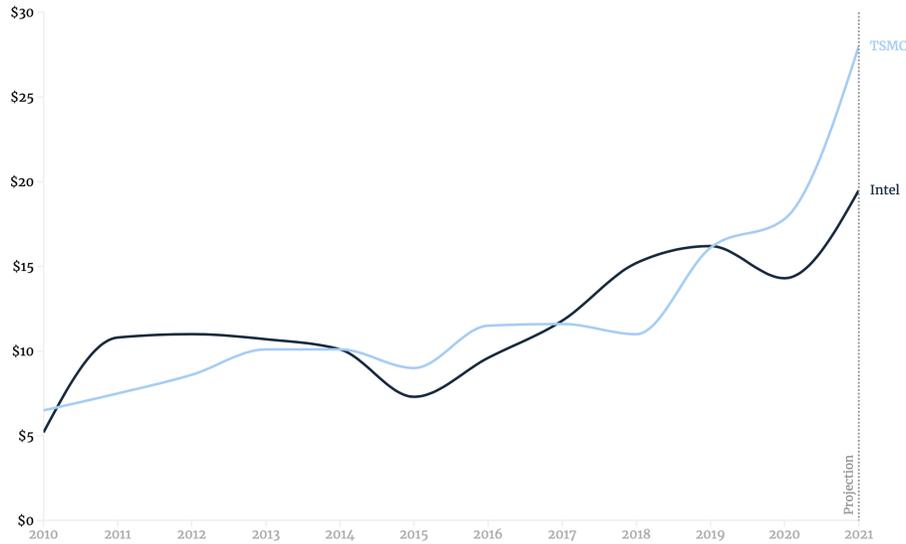
Source: Intel & TSMC annual reports and public statements • Note: Smaller chip - production capabilities yield more powerful chips



TSMC has had the benefit of aggressive support from the Taiwanese government, but a key driver of its success has also been its commitment to capital investment. While Intel has historically been the more profitable company, TSMC began out-investing it in the mid-2010s and has made major commitments to higher investment levels going forward.

### TSMC is out-investing Intel

Capital expenditures, billions of dollars



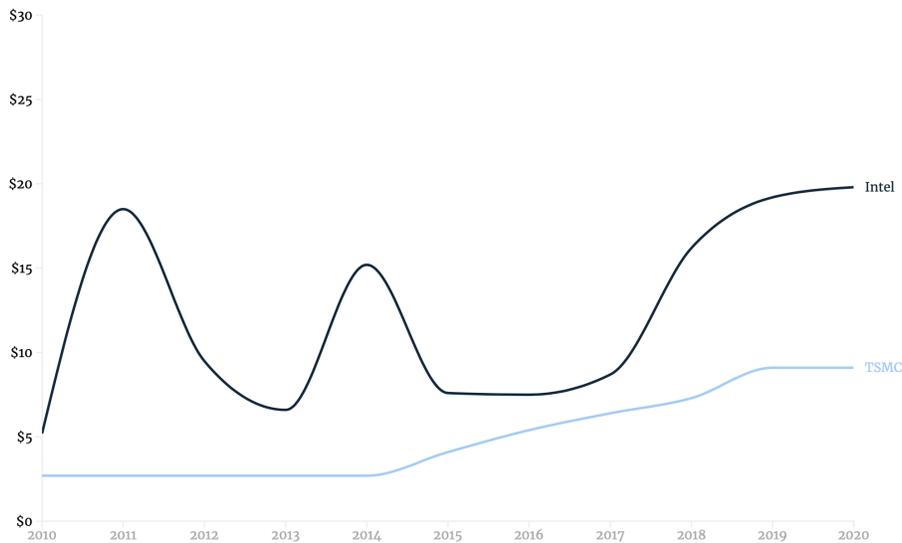
Source: Intel & TSMC annual reports and public statements



Intel, meanwhile, has shown particular aptitude in returning cash to shareholders. It has consistently spent more than TSMC on dividends and buybacks even while getting out-invested. As its technical capabilities and market share fell further behind in recent years, it doubled down on payouts.

### Intel sends more cash back to shareholders

Shareholder payouts, billions of dollars



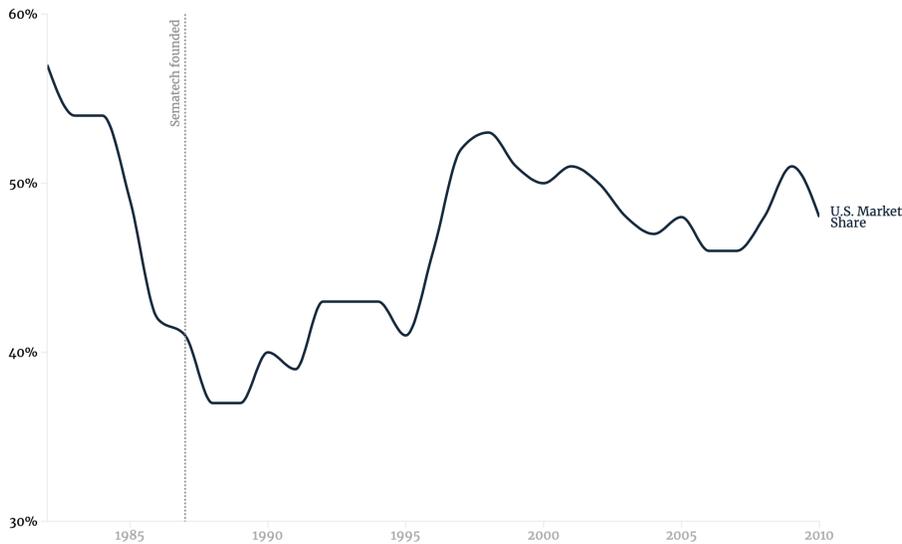
Source: Intel & TSMC annual reports



There remains reason for optimism, though. America encountered a similar challenge in the 1980s when market share of U.S. firms plunged in the face of Japanese competition. The Reagan administration fought back through trade policy, and the federal government partnered with industry on a research consortium called Sematech that funded research and development projects for use industry-wide. According to the National Academy of Sciences, “Sematech is widely credited within the U.S. industry with some role in stimulating a resurgence among U.S. semiconductor producers in the 1990s.”

American market share recovered and today remains strong, thanks to leadership in design and marketing. With renewed focus and investment, manufacturing leadership could return as well.

### America successfully defended its market position before *U.S. share of global chip sales*



Source: Semiconductor Information Agency



American firms have made clear that they will gladly move their manufacturing capabilities abroad, but policymakers have begun to take seriously the idea that those capabilities need to recover at home. Last year, the Senate voted 96–4 to incorporate an aggressive investment framework into the National Defense Authorization Act, including production incentives, research and development funding, and creation of the National Semiconductor Technology Center, which could play the role of a next-generation Sematech.

Encouragingly, Intel appointed a celebrated engineer, Pat Gelsinger, to be its new CEO in 2021. Gelsinger immediately announced plans to invest \$20 billion in rebuilding Intel’s foundry business to compete directly with TSMC. The coming years will determine whether, with support from public policy, the American industry can regain its lead. ■



### **Our Mission**

To restore an economic consensus that emphasizes the importance of family, community, and industry to the nation's liberty and prosperity:

**REORIENTING POLITICAL FOCUS** from growth for its own sake to widely shared economic development that sustains vital social institutions.

**SETTING A COURSE** for a country in which families can achieve self-sufficiency, contribute productively to their communities, and prepare the next generation for the same.

**HELPING POLICYMAKERS NAVIGATE** the limitations that markets and government each face in promoting the general welfare and the nation's security.

### **Our Activities**

**AFFILIATION.** Providing opportunities for people who share its mission to build relationships, collaborate, and communicate their views to the broader political community.

**DELIBERATION.** Supporting research and discussion that advances understanding of economic and social conditions and tradeoffs through study of history, analysis of data, elaboration of theory, and development of policy proposals.

**ENGAGEMENT.** Initiating and facilitating public debate to challenge existing orthodoxy, confront the best arguments of its defenders, and force scrutiny of unexamined assumptions and unconsidered consequences.

### **Our Principles**

American Compass strives to embody the principles and practices of a healthy democratic polity, combining intellectual combat with personal civility.

We welcome converts to our vision and value disagreement amongst our members.

We work toward a version of American politics that remains inevitably partisan and contentious but operates from a common commitment to reinforcing the foundations of a healthy society.

*American Compass is a 501(c)(3) nonprofit organization.*