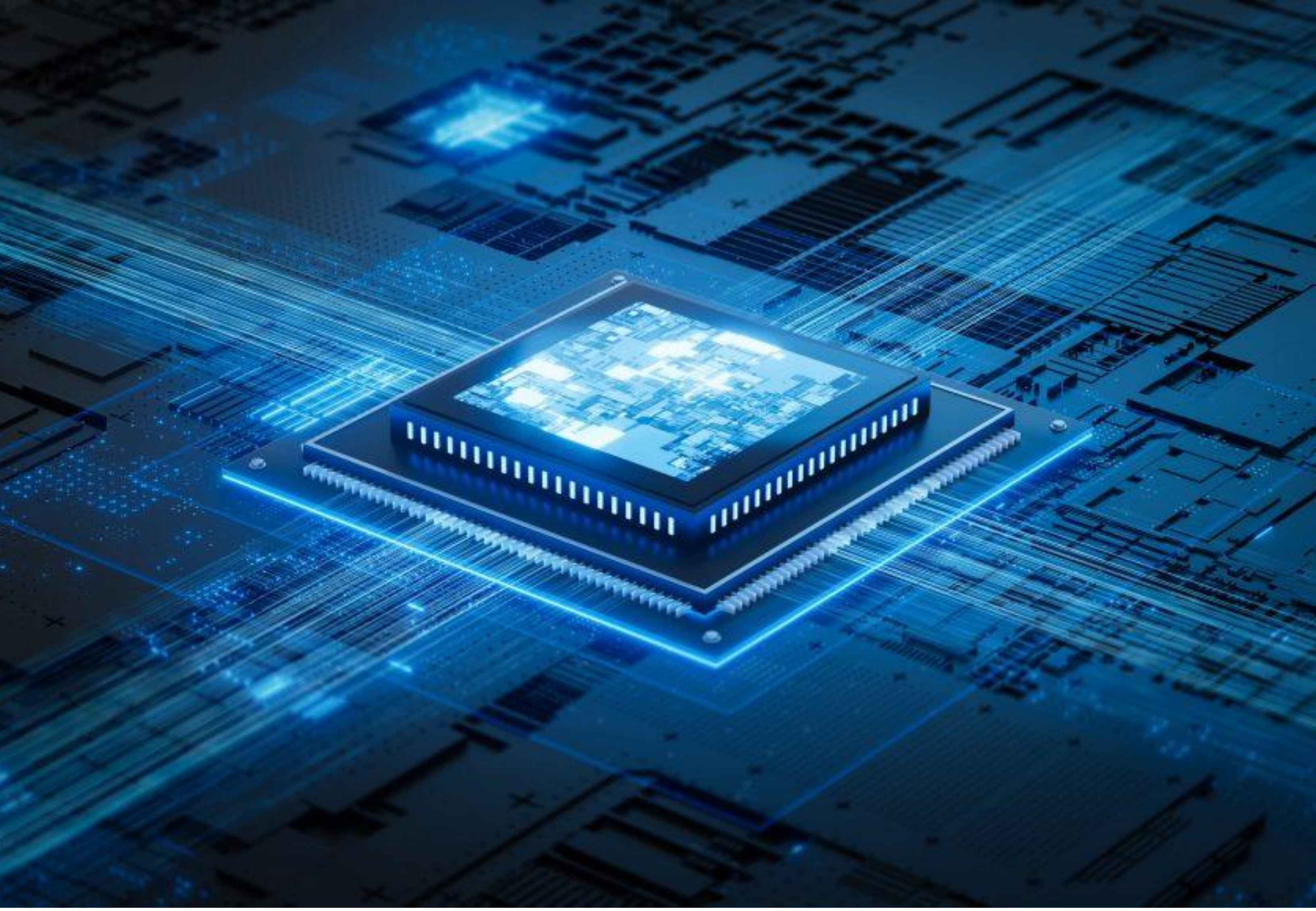

AMERICAN SEMICONDUCTORS

A STRATEGIC ANALYSIS: How chip firms compete on a global stage

By Keegan Conley

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Author’s Connection to the Topic

This subject matter combines three areas I enjoy learning about: business, technology, and geopolitics. Business is the engine that allows us to enjoy the goods and services that ensure our wants and needs are met. The fashion retailers you shop at, the hospitals you receive necessary treatment from, and the logistics companies that process and transport products all play an important role in allowing us to function in a modern society. Understanding their function, and related disciplines like finance, marketing/strategy, and economies would render anyone well-rounded and capable as they face real-life challenges.

In the realm of supply chain, technology is commonly said to be the “enabler”. This is true, and technological advancements in the last 50 years have rapidly advanced our collective standard of living and quality of life. At the most fundamental level, this shift is supported by ever-improving computer hardware and processing power. Think of the wide-ranging implications: processing items at the grocery check-out aisle, data analysis to optimize business performance, automotive technology, social media to connect with people near and far, and much more all have modern computing power to thank.

Geopolitics is interesting because it is actually the study of a few distinct subjects: philosophy, psychology, history, and more generally, how societies function. The relative economic and military power of different nations, their capabilities, their laws and legislation, their culture, and their values all feed into complicated, strategic decisions about how a state can best serve the needs and interests of their people – or the politicians and vested interests that hold the real power. Because of the concentration of semiconductor production in one small subset of the world, major geopolitical moves are being made that influence society’s perception of what global conflicts or events will occur in the coming years, and I find that trying to understand the dynamics of all of it is fascinating. In aggregate, I can’t think of a more intellectually stimulating area to analyze.

Who am I sharing this with?

The three best people that I can think of to share this with include:

1) **Ge Yan**: I am currently taking his Technology Infrastructure course (S305) which largely covers how networks function among the “five layers”. The class also goes deep into the different types of networks (LAN, BN, WAN) and explores design considerations. He already has some familiarity with the political importance of semiconductors, and he is an executive director supporting IU’s major IT initiatives.
2) **Frank Akaiwa**: This is a former professor of mine who teaches Digital Business Technologies (S302), which covers the idea behind Gartner’s “hype cycle” in detail to understand the practicality of various existing and emerging technologies in a business context. I suspect he may be interested in learning how firms choose to locate the production of their most advanced chips.
3) **Foster Swanson**: This is a good friend of mine who I often work with in my supply chain courses. He is also the president of the Business Operations Consulting workshop and has signed with EY for a full-time role in tech consulting.

Overview

Semiconductors represent one of the world's single most valuable inventions in the modern day. They are directly used in many of the goods consumers use every day: vehicles, electronics, appliances, and more. They also facilitate many of the services enjoyed in modern economies, ranging from travel applications to social media to data analytics to the grocery store aisle. Ensuring continued access to these chips and the infrastructure that enables their production is therefore essential to any nation or state's economic security. Strategic principles such as incentives, leverage, barriers to entry, politics, resources, and capabilities must be understood in a detailed context to appreciate the many challenges all parties face in trying to gain and maintain their own form of competitive advantage.

The following analysis will first explore the current political, economic, and technological environment in which the broad, ever-growing semiconductor industry operates. Notably, recent significant subsidy investments from the U.S. – after decades of divestment – has rapidly shifted thinking around future production decisions for many major firms, which boosts U.S. economic performance but presents new issues. The research then looks at how the industry's concentrated nature poses challenges for new market entrants and specifies in what ways countries employ leverage via physical and immaterial resources to try to incentivize local investment.

Finally, the analysis examines some of the ways firms can create value for customers to differentiate themselves in an otherwise brutal market utilizing supply chain or operational efficiencies and/or innovative design and manufacturing techniques. In combination with intellectual property rights, firms can successfully secure their role as rare and inimitable value creators. As a whole, the analysis focuses on the ways in which government, society, and self-interested firms interact with each other to create or prevent mutually advantageous outcomes.

STEEP

Political/Legal

The U.S. Government's ardent investment in the semiconductor industry is a consequence of shifting attitudes towards globalization in favor of **protectionism**. Just 8% of semiconductor manufacturing capacity is conducted in the United States[1], with the vast majority of global production being completed in Southeast Asia, and in particular, TSMC, who's foundries output two-thirds of the world's supply[2].

Given the role of chip technology in supporting all major U.S. industries, and the crucial role of advanced technology in U.S. military interests and power projection, the historical pattern of outsourcing to the lowest-cost regions is perceived as a significant national security threat in U.S. **political circles**. That sentiment led to the CHIPS and Science Act, a $52 billion **regulatory investment** that gives leading semiconductor companies a major **incentive** to produce in the U.S[3].

Economic

More than 90 projects across 28 states have been announced, totaling nearly $450 billion in private investments, creating 58,000+ new jobs, and leading to a 203% increase in U.S. fab capacity between 2022 and 2032, by far the largest of any global region in that timeframe[4]. The most significant investments have gone to Intel ($8.5B), TSMC ($6.6B), Samsung ($6.4B), Micron ($6.14B), and GlobalFoundries ($1.5B), notably spurring the development of a $20 billion fab in Ohio by Intel and a $100 billion plant in New York by Micron[5].

The global market for semiconductors is set to reach $1 trillion by 2030, driven primarily by the wireless communication and computing, automotive, and industrial sectors[6]. The industry is the second-most profitable in the world, accounting for the second-highest amount of R&D spending, which **creates many highly skilled jobs**. But importantly, there are challenges around **labor and material shortages** and **volatile prices** for raw materials[6] that may influence further encroachments into U.S. territory.

Technology

American firms outsourced assembly, testing, and packaging (ATP) in the 1960s, and wafer fabrication in the 1980s, the latter of which enables firms to be responsible for design without having to physically produce them[7]. Foundry services have enabled companies that typically relied on off-the-shelf semiconductor chips to join the supply chain and design chips for their specific applications, while offloading the need for more labor-intensive and lower-value-added services[7]. That made American firms malleable to the **pace of change**, and as the **technology has matured**, manufacturing complexity and costs have risen exponentially, resulting in a dependency on economies of scale to manage costs.

[1] Elkus, Richard. "A Strategy for The United States to Regain Its Position in Semiconductor Manufacturing." *CSIS*, 13 Feb. 2024, www.csis.org/analysis/strategy-united-states-regain-its-position-semiconductor-manufacturing.
[2] Slotta, Daniel. "Taiwan Semiconductor Manufacturing Company - Statistics & Facts." *Statista*, 24 May 2024, www.statista.com/topics/7097/taiwan-semiconductor-manufacturing-company/#topicOverview.
[3] "Two Years Later: Funding from CHIPS and Science Act Creating Quality Jobs, Growing Local Economies, and Bringing Semiconductor Manufacturing Back to America." *U.S. Department of Commerce*, 9 Aug. 2024, www.commerce.gov/news/blog/2024/08/two-years-later-funding-chips-and-science-act-creating-quality-jobs-growing-local.
[4] *State of the U.S. Semiconductor Industry*, Semiconductor Industry Association, 2024, www.semiconductors.org/wp-content/uploads/2024/10/SIA_2024_State-of-Industry-Report.pdf.
[5] Roth, Emma. "Micron's Investing up to $100 Billion to Bring the Country's 'Largest Semiconductor' Facility to New York." *The Verge*, 4 Oct. 2022, www.theverge.com/2022/10/4/23386906/micron-new-york-chip-factory-investment-syracuse-chips-act.
[6] "The CHIPS and Science Act: Here's What's in It." *McKinsey & Company*, 16 May 2024, www.mckinsey.com/industries/public-sector/our-insights/the-chips-and-science-act-heres-whats-in-it.
[7] *Semiconductors and the Semiconductor Industry*, Congressional Research Service, 19 Apr. 2023, crsreports.congress.gov/product/pdf/r/r47508.

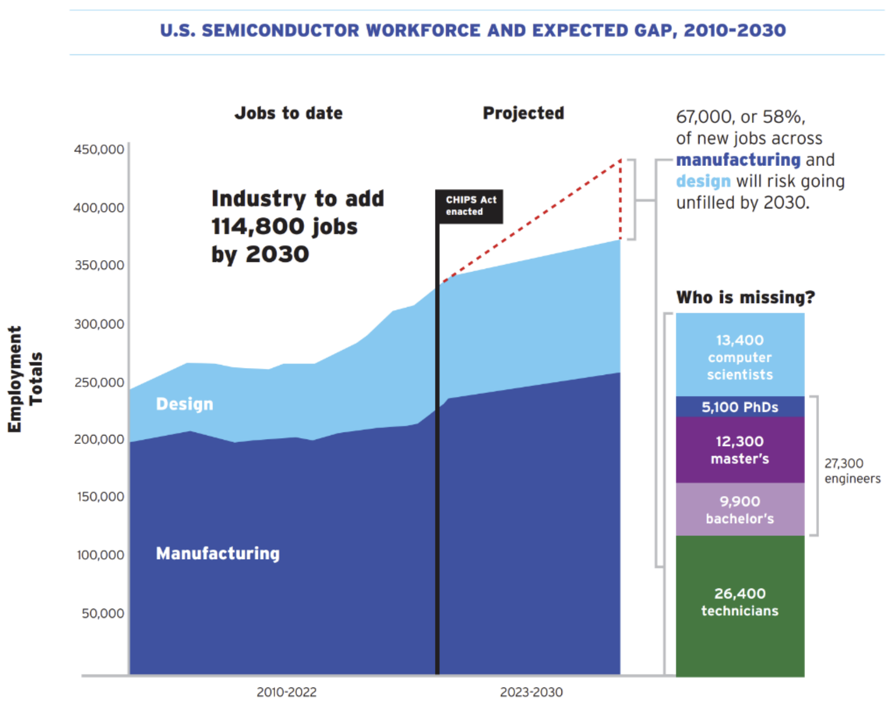
Porter's Five Forces

Buyer/Supplier Power

The industry's entire global supply chain consists of only a few thousand companies, so buyers have limited options and suppliers have some **leverage**. They can use large-scale purchasing power to achieve economies of scale, which enables them to **negotiate favorable terms** and pricing[8]. But the nature of the semiconductor firm matters: large fabless firms that compete on design, like Apple and IBM, will deal with different purchasing dynamics and end-use cases than integrated device manufacturers like Intel and Micron or foundries like Samsung and TSMC[9]. Part of their supplier power comes from the **extremely high barriers to entry**, as state-of-the-art facilities costing billions of dollars, highly skilled engineers and technicians, and significant regulatory compliance challenges all limit the number of entrants[8]. Also, suppliers often maintain decades-long agreements, making it difficult for even the most technologically sophisticated small firms to grasp an edge[8].

Substitutes

U.S. firms and politicians must remain vigilant of two largely uncontrollable realities. The first is that China, the United States' biggest trading partner and primary global adversary, maintains 60 percent of the world's rare earth mining production and around 90 percent of all processing and refining[10]. They have exercised the leverage that gives them before by restricting the flow of materials crucial to high-performance chips including gallium, germanium, and graphite, and there are many chip materials for which the U.S. has zero domestic production, making it **vulnerable to supplying countries**[10].



Source: Semiconductor Industry Association [4]

The second is that only two major firms currently are producing or have plans to produce the most advanced chips, including 3nm, 2nm, and sub-2nm technology, and **there is room to create incentives for them to prioritize the U.S.** over other lucrative locations like Japan and Germany. That may require addressing not only monetary concerns, but also supply chain stability, cultural differences, and a workforce educated around subjects like IC manufacturing and materials science[11]. These chips will play a vital role in the burgeoning use of AI, machine learning, consumer products, and military applications, all of which represent major focus points for influential nations.

[8] Curtis, William. "Semiconductor & Circuit Manufacturing in the US." *IBISWorld*, Nov. 2024, https://my.ibisworld.com/us/en/industry/33441a/competitive-forces
[9] Blank, Steve. "The Semiconductor Ecosystem" 25 Jan. 2022, https://steveblank.com/2022/01/25/the-semiconductor-ecosystem/
[10] Berg, Ryan C. et al. "Mineral Demands for Resilient Semiconductor Supply Chains." *CSIS*, 15 May 2024, https://www.csis.org/analysis/mineral-demands-resilient-semiconductor-supply-chains
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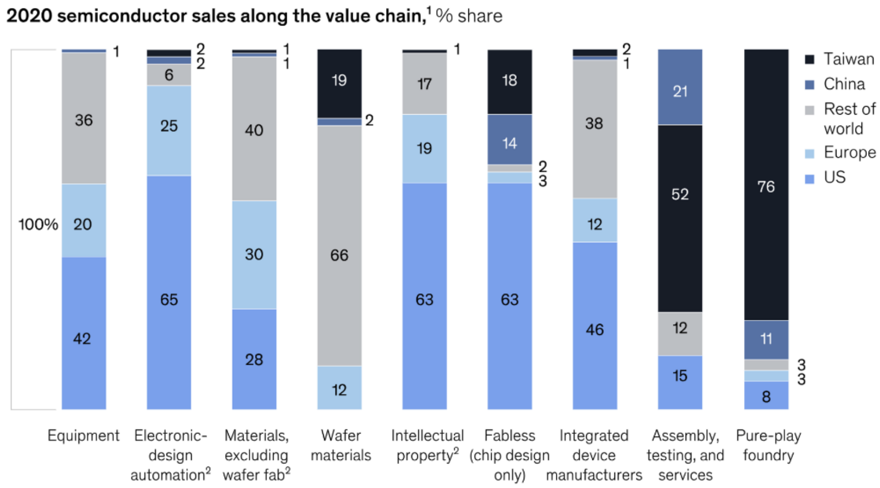
VRIO

Rarity

In the semiconductor industry, no local market has all **capabilities** necessary for end-to-end design and manufacturing, rendering the entire value chain highly interdependent[12]. The nature of a firm's focus also varies: on an HHI market concentration index, foundries are found to be highly concentrated, while wafers are moderately concentrated and those that make equipment or are fabless are much less concentrated[12]. **Driving competitive advantage** is therefore less about location and more about operational efficiencies and innovation.



Source: Gartner; Omdia; McKinsey analysis

Value

One way that firms can **increase their perceived value by customers** is by offering the best chips of an in-demand node size. While customers expect high performance, smallest is not always best, and some companies will take larger chips because it meets their performance needs and contains necessary features[12]. For example, automobiles today often use 40-65nm chips (first engineered in the mid-2000s) and mostly need computing power for modern safety technology. They can also innovate with novel materials such as silicon carbide and gallium nitride, which are more capable, efficient, and eco-friendly, likely satisfying ESG-aligned companies.

Concentrated expertise allows companies to **share resources** such as power supply, leading to **lower costs that get passed on** to consumers. It helps mitigate employment issues because it attracts talent that tends to gravitate towards clusters of expertise. Specialized chips (commonly called ASICs) that are customized for specific purposes such as AI and cloud computing offer a potential point of **differentiation**. And where markets exhibit mismatched supply and demand, manufacturers could dedicate more capacity for the highest-demand nodes to provide short-term relief, which would simultaneously increase supply chain resiliency and independence[12].

Inimitability

While achieving economies of scale is essential to succeeding in this industry, it is the **close protection of intellectual property** that most insulates firms from competition. Philosophically, governments incentivize innovation by giving companies the legal right to enjoy exclusive financial benefits from their work. Yet a majority of semiconductor firms struggle with patent infringement and counterfeiting[13], both of which threaten their bottom line through subsequent legal scrutiny and loss of revenue. Firms are therefore more likely to locate in nations that uphold the legal doctrine and government systems necessary to protect them against the effects of having their **capabilities** mimicked.

[12] Burkacky, Ondrej. et al. "Strategies to Lead in the Semiconductor World." *McKinsey & Company*, 15 Apr. 2022, www.mckinsey.com/industries/semiconductors/our-insights/strategies-to-lead-in-the-semiconductor-world.
[13] IP Challenges for the Semiconductor Equipment and Materials Industry, Semiconductor Equipment and Materials International, June 2012, www.semi.org/sites/semi.org/files/docs/2012_IP_White_Paper_V2_SupAdd.pdf.

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