BOOK REVIEW

Chip War: The Fight for the World's Most Critical Technology

Chris Miller

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"*Last year, the chip industry produced more transistors than the combined quantity of all goods produced by all other companies, in all other industries, in all human history. Nothing else comes close.*" (Miller, 2022, p.19)

Semiconductors are the bedrock of the modern global economy, supporting a wide range of products from appliances and cars to smartphones, computers, and advanced missile systems. Yet, recent supply chain disruptions due to COVID-19 and the ongoing political tensions between the United States (U.S.) and China have exposed the fragility of the industry, casting doubt on its future. Against this backdrop, Chris Miller's *Chip War: The Fight for the World's Most Critical Technology* provides an extensive and insightful account of semiconductors, exploring the historical, technological, economic, and geopolitical forces that have shaped this industry. The focus throughout the book lies on the ongoing battle for dominance in chip manufacturing, a dispute with major consequences for global power balance as well as for many downstream industries like electronics, defence, or automobiles.

The story begins in 1947 with the invention of the transistor in the U.S. by researchers at Bell Labs, followed in 1957 by the founding of Silicon Valley's first semiconductor company (Fairchild Semiconductor International Inc.) by a group of engineers dubbed the "traitorous eight." This group included three larger-than-life characters who play a central role in Miller's story: William Shockley (1965 Nobel Prize for semiconductors), Gordon Moore (the proponent of Moore's law[1] and co-founder of Intel) and Bob Noyce (the inventor of the microchip, co-founder of Intel, and the unofficial "Mayor of Silicon Valley"). Within the next decade, the technology of placing an increasing number of transistors on a piece of silicon to make an "integrated circuit" or "chip" would become a reality, spinning off a booming industry in the San Francisco Bay area.

Sensing the commercial and strategic potential of the new technology, international competitors started to emerge. Notably, the Soviet Union saw chips as an integral part of the Cold War race and responded immediately by building a domestic computer industry through reverse engineering of

[1] An empirical relationship linked to gains from experience in production of microchips. Originally (1965), Moore's prediction was that the number of transistors in a dense integrated circuit will double every year for at least a decade. In 1975, he revised this prediction, namely that the number of transistors will double about every two years, which is consistent with historical evolution of the industry up until the present. In the early 1960s four transistors could be fitted onto a chip; in turn, today's technology allows for around 5.3 billion.

integrated circuits developed by Texas Instruments. Their "copying" strategy involved tapping into spy networks including American engineers (including Alfred Sarant and Joel Barr), and also building Zelenograd, a Soviet replica of Silicon Valley. Nevertheless, despite these efforts, the Soviets were never able to catch-up with the U.S. Their inability to develop in-house new technologies, huge challenges in terms of mass production of chips, and the rapid technology advancements of U.S.-based firms, have all sealed their fate as perpetual laggards in both chip production and technology. A legacy that, according to Miller, is still visible today when comparing U.S. and Russia in terms of high-tech military equipment deployed for instance on international battlefields.

In the 1980s it was Japan's turn to challenge the U.S. for supremacy in semiconductors. Led by visionary businessmen like Akio Morita and Masaru Ibuka (the co-founders of Sony), Japan found a better alternative to the Soviet approach by licensing U.S. technology and specializing in mass production of consumer products. Market expansion, product quality, and global leadership in less advanced market segments (i.e., discrete transistors) soon followed, in parallel with the rise of Japanese tech giants (Hitachi, Toshiba, NEC, and Fujitsu) through significant governmental support and large R&D investments.[2] In response to this threat, the U.S. government employed the perennial "the enemy of my enemy is my friend" strategy, and propped up the rise of the South Korean chip industry through trade measures (by limiting Japan's access to the U.S. market) and technology transfers to Korean firms (through joint-ventures and licensing). Subsequently, by the early 1990s, Samsung had morphed successfully from a fish and vegetable wholesaler to the world's leading memory chip maker.

Elsewhere, Europe's strategic failure to acknowledge the importance of chips is depicted largely as a consequence of political myopia. This is punctuated by a quirky anecdote from 1962 when French president de Gaulle reportedly sniffed at the sight of a new transistor radio, a gift from Japan's prime minister, Hayato Ikeda. The apathy for semiconductors in Europe has persisted until 2018, when existing chip technologies were plateauing in terms of their ability to further miniaturize transistors. Enter ASML: a Dutch company which, after several decades of R&D and largely funded by Intel, perfected the Extreme Ultraviolet Lithography (EUVL) technology that allows production of even smaller chips. Given its unique position, ASML became effectively a monopoly (turnover of €18.6 billion in 2021) for manufacturing of photolithographic machines required to produce today's most sophisticated chips, and dwarfing its main competitors (Japanese behemoths Canon and Nikon) who were denied access to the intellectual property (IP) behind this new technology. Nevertheless, this rapid ascendance came also with strong allegiances to Washington's political and commercial interests. To date, ASML remains subject to significant pressures from the U.S. via the Dutch government, which have effectively instated an export ban of EUVL machines to China (*The Wire China*, 2021; *The Register*, 2023) to curb its growing influence in the chips arena.

[2] The fall of GCA Corp. (overtaken by Nikon in 1993) was a clear indication of Japanese superiority in terms of certain segments of chip production technology.

China is certainly one of the main actors of the book. While Miller suggests that the U.S. initially perceived Xi Jinping as a proponent of democratic reforms and a potential Western ally, his actions – i.e., authoritarian measures to restrict information access and focus on developing Chinese counterparts to Silicon Valley's giants- have quickly dispelled this view. Xi's strategy to reduce the country's reliance on foreign technologies included, in addition to heavy governmental investments and involvement, some more controversial actions to stimulate technology transfer via mandatory joint ventures, infringement on certain IP, and veiled attempts to acquire Western firms and technologies related to chips. These cumulative endeavours triggered some harsh American responses in the form of policies laid out by the U.S. Trump (2018)[3] and Biden (2023)[4] administrations, which targeted technology exports, chip manufacturing, and commitments from allied countries to stop supplying cutting-edge chips to Chinese tech companies or collaborating with them on their development. While these measures appear to have curbed Chinese advancements in this area, their long-term effectiveness remains unclear, particularly given the sheer size of its needs (for instance, China spends now more on imports of semiconductors than on oil) and the rapid technological and geopolitical shifts happening in this space.[5]

Taiwan receives its fair share of coverage, proportional to its crucial role in the industry. A central figure behind its tale is Morris Chang, the founder of the Taiwan Semiconductor Manufacturing Company (TSMC) in 1987, after being passed over as CEO at Texas Instruments. Educated at MIT and Stanford, Mr. Chang developed Taiwan's un-inimitable chip fabrication plants ("fabs"), focusing on efficient production for the world's biggest chip designers, particularly Apple (which surprisingly, was refused by Intel in a strategic blunder). The success of the Taiwanese fab model came also with massive governmental support and impressive technological leaps,[6] allowing TSMC to surpass its U.S. counterparts. Moreover, as the size of chips shrank from year to year, their production costs skyrocketed, shifting most leading chipmakers towards the "fabless" option where they outsource manufacturing rather than making them internally. This resulted in an unprecedented geographic concentration in terms of chip production worldwide and in particular for high-end spectrum of the chips market.

The book concludes by examining the intensifying rivalry between the U.S. and China, fuelled by the desire to dominate emerging technological areas such as artificial intelligence (AI) or the sixth-generation wireless technology (6G). According to Miller, China's IP infringements and forceful technology transfers have ultimately led Washington to impose tighter export controls first on the chips themselves, and then, on the tooling used to manufacture the most sophisticated chips. Nevertheless, he

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[3] Trade measures. Section 301, Chinese Products (Tax Foundation, 2022).

[4] CHIPS Act. https://www.commerce.gov/news/press-releases/2023/02/biden-harris-administration-launches-first-chips-america-funding.

[5] According to Miller, China's current market share in chip production remains small (about 15 percent) despite massive public investments, behind Japan (17%) or Taiwan (41%).

[6] For instance, the "Grand Alliance"- an R&D consortium led by TSMC.

suggests that these bans, unlike those laid on the Soviets sixty years ago, are likely to fail their mandate, and at best, they might only delay China's progress. Unlike the Soviet Union, China is much more integrated into the global economy, better supported through governmental funds, and better equipped with highly skilled, U.S.-educated, Chinese nationals who can help it develop such technologies in-house. This integration can provide partnerships and alternative access to key technologies and manufacturing tools in addition to the expertise developed domestically. Finally, geo-politics loom large over the industry. Taiwan remains part of China's reunification ambitions and at the same time, a major choke point in the industry that is responsible for about 37% of the global manufacturing of chips. This accentuates the perception of fragility for the industry, one that was well-exposed by the events of the recent pandemic.

In addition to a plethora of historical insights on one of the world's most global and strategic industries, *Chip Wars* provides also some fruitful avenues for international business (IB) research. The most obvious one is a better understanding of globalization, both in terms of explicating its status quo and potential evolution. Global economic integration has been slowing down for some time now (The Economist, 2019), and has even reverted via significant 'decoupling' initiatives (Witt, 2019; Witt et al., 2023), especially in certain strategic industries such as semiconductors. While IB scholars have recently started to engage in this conversation, most of this work remains descriptive or conceptual in nature; moreover, most contributions remain confined to the prominent China-U.S. economic and technological battle for global supremacy (Luo & Van Assche, 2023). Yet, the world remains inherently gray, and the promise of globalization (in terms of growth and development) remains palpable for many firms, industries, and nations around the world[7]. Thus, examining how techno-geopolitical uncertainty influences the degree of integration (or decoupling) between countries as well as the drivers and consequences of firms' reconfiguration strategies is an intriguing research avenue (Hu, Tian, Wu & Wang, 2021), particularly in the current "wicked" (Rašković, 2022) landscape of international business characterized by increased heterogeneity, conflicting pressures, and multiple, diverse stakeholders (Moore, Brandl, & Dau, 2021; Krammer, 2022; Devinney, Hartwell, Oetzel, & Vaaler, 2023).

Furthermore, the book provides numerous historical accounts of governmental interventions that can greatly inform some of our current policy debates. Specifically, it persuasively condemns nationalistic reactions as a political response toward semiconductors and other industries[8], suggesting that historically self-sufficiency policies[9] never delivered, and in fact, may have even caused

[7] One such prominent example emerging from the book is Taiwan, the current epicentre of this global rivalry, highly dependent on both China (for sales) and the USA (for production technology and military support).

[8] China imposed export controls on the overseas sales of gallium and germanium, elements that are essential to the production of semiconductors (CNN, 2023).

[9] Following the recent CHIPS act and given the generous subsidies offered by the US government both Samsung and TSMC have agreed to build fabs (factories) on American soil. However, both still concentrate their main activities in their home countries (i.e., South Korea and Taiwan).

unnecessary crises and economic turmoil.[10] Such arguments resonate with recent academic findings in economics and international business (Colantone & Stanig, 2019; Luo, 2022) and most importantly, does so with supportive historical evidence. Moreover, they align with scholarship that suggests that global supply chains are more resilient than commonly perceived (Thakur-Weigold & Miroudot, 2023; Krammer, Nuruzzaman, & Mukherjee, 2023), and as such, globalization can still serve the greater good despite its recent setbacks (Witt, 2019; Witt et al., 2023). Ultimately, more research is needed to understand and quantify the consequences of populist and national-security-based resiliency policies vis-à-vis the status quo, i.e., a globalized, yet inter-dependent, global economy (Ghauri, Strange, & Cooke, 2021).

Finally, the book clearly shows that it is imperative for scholars and policy makers to be mindful of history (e.g., prior trade wars, autarkic policy agendas), and avoid repeating past mistakes when dealing with current socio-economic challenges (Jones & Khanna, 2006). Mirroring its recent frictions with China, the U.S. had trade disputes with Japan in 1980s, a period in which Japanese companies were on the verge of securing global dominance in several industries, including semiconductors. Creative destruction (Schumpeter, 1942) is real and cannot be fended off through economic policies designed to safeguard domestic companies at all costs. Historically, trade wars have failed to preserve U.S. supremacy in various domains of interest but unequivocally have taken a toll on U.S. consumers and society as a whole. And this latest episode is no different, with clear and negative effects of Trump Administration tariffs on GDP, income, and employment in the U.S. (Tax Foundation, 2022) and a limited impact on Chinese exporters (Jiao et al., 2022). Even other alternatives, like the CHIP4 initiative - an alliance between U.S., Taiwan, Japan and South Korea – are still subject to various concerns such incentive alignment, communication, trust, or shortages (*The Economist*, 2022b). IB scholarship should therefore strive to identify and balance these complex trade-offs, with a final aim of informing and advising policymakers on the best course of action.

Word count: 2,266

[10] For the U.S. chip industry these measures triggered a supply glut which caused price decreases that resulted in losses of about $1.5 trillion (*The Economist*, 2022a).

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