Semiconductor Geopolitics - Past, Present, and Future

Book review of 'When the Chips are Down: A Deep Dive into a Global Crisis' by Pranay Kotasthane and Abhiram Manchi

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During the COVID-19 pandemic, the world witnessed a widespread chip shortage. Coming out of the COVID pandemic, the automotive industry was hit badly, resulting in widespread public awareness of the supply chains for integrated circuits (ICs).

Artificial intelligence (AI) applications as well as big data are driving the demand for more processing capabilities provided by newer and more efficient chips. Microprocessors underpin a whole range of economic activities as well as technologies, making chips and access to chips 'meta-critical'. However, some of these developments are being overshadowed by the trade war between the US and China. Policy actions are being used to try to delay and deny access to crucial semiconductor technology. This is the geopolitics of semiconductors.

Accessible literature on this complex subject is sparse. Chris Miller's 2022 book, 'Chip War', remains one of the better entries in this small canon. 'Chip War' is a thrilling, yet long read. In contrast, 'When the Chips are Down: A deep dive into a global crisis' provides concise and comprehensive coverage of the geopolitics of semiconductors. In less than two hundred pages, the authors run through a summary of the past decades of chip development and provide a framework to examine the complex inter-dependencies in the world of semiconductor geopolitics. It is also the first book that deals with this subject comprehensively from an Indian lens, while placing it simultaneously in the global context.

The authors employ jargon-free prose to make highly technical topics approachable to a wide audience. The '101' of Chips cover semiconductor design, fabrication, manufacturing, and the roles of people, processes, and materials. While semiconductors started off as innovation drivers for military applications, consumer and industrial applications are the current growth engines. The role of the globalised supply chain, with its various players engaged in specialised roles, resulting in high performance and cost-efficient products, is well covered in this section of the book.

The book uses the prism of 'creative insecurity' to explain American policy actions related to the semiconductor industry. The American Cold War policy birthed the semiconductor industry. The

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authors start with the invention of the transistor at Bell Labs in 1947 and take readers through the bursts of innovation that allowed the US to leverage semiconductor technology to build its military might and establish space leadership over the USSR. Later, rapid product quality improvements resulted in Japan gaining a massive lead in logic chip memories. The resulting 'creative insecurity' led to a chip war with Japan, where the US employed 100% tariffs on Japanese products, and was able to restrict Japanese products in the global market. This led to an expanded role of South Korea in the market, eventually resulting in it gaining a dominant market share. China's economic growth has been increasingly viewed as a challenge to American economic and geopolitical dominance. In 2022, this resulted in the US CHIPS Act, which looks to funnel $52 billion into manufacturing incentives and R&D, a scale similar to the Manhattan Project that created the atomic bomb.

The book chronicles various events and developments that made some East Asian states major players in the chip ecosystem. Taiwan, China, Japan, South Korea, Singapore, and Malaysia have all established their positions in the value chain. In a short time, Vietnam has become a competitor in the labour-intensive 'outsourced semiconductor assembly and test' (OSAT) business. The book provides a useful pattern to understand the cycle in these developments, which starts with a nation-state building competitive manufacturing capabilities in semiconductors using some form of technology transfer from the US, excelling in global exports over a period of time by building a local ecosystem, ending with moving into design, resulting in moving up the value chain.

US, Taiwan, Netherlands, UK, South Korea, and Japan are now the key technology providers, encompassing design and design tools, memory chips, fabrication technology, manufacturing, memory chips, and sensors. The book describes the comparative and absolute competitive advantages of these countries in key areas, and how their position in the chip ecosystem have changed over the past half century. This is an essential background for anyone looking to project events into the future.

The book adequately covers the global scenario, with countries looking to build and maintain a lead in their positions in the semiconductor supply chain. In recent times, China, South Korea, EU, Japan, and India have allocated large budgets, subsidies, or both towards their semiconductor goals. American efforts to contain Chinese progress by limiting technology access to advanced semiconductors has been work in progress. Various bilateral and multilateral initiatives such as Chip 4 (Taiwan, the US, South Korea, and Japan), the Quad (India, Australia, the US, and Japan), the US-EU Technology and Trade Council, and iCET (India and the US) have turned their attention towards supply chain diversity and resilience.

The chapter on happenings in the Indian semiconductor ecosystem, aptly titled 'India is an Enigma', details the reasons for the country's underwhelming performance in this sector. It details the efforts made towards establishing chip manufacturing in India, starting with the setting up of a CMOS fabrication ship unit at the Semiconductor Complex Limited (SCL). SCL has played an important role in India's space programme. With its niche focus, however, the chips it created could not be used to create consumer or industrial products, whether for the domestic or the export market. Relying solely on government budgets, and without substantial revenue, SCL could not keep up the

pace required to remain relevant. Subsequent attempts made to start a manufacturing ecosystem have turned out to be non-starters so far. The impact of the recent policies such PLI, SPECS, and PLI 2.0 are yet to accrue, at least at a chip level.

The authors rightly note (p. 136) that "By 2010, India was ahead of China in the complexity of chip designs handled, and in filing patents. However, not much IP belongs to Indian companies." India has 20% of the world's hardware design engineers for ICs. Most of this talent, however, is locked up in Global Competency Centers (GCCs). Much like the Indian IT industry, they largely offer design services. To effectively leverage this talent, a product ecosystem needs to be created in India. This can only be achieved by giving a big push to R&D in this sector. Given the IC design engineering background of the authors, a more detailed mapping of the sector, from the chip ecosystem to the downstream applications, would have significantly added to the value of the book.

The book persuasively argues for a twenty-year roadmap, instead of 'twenty-one-year plans'. They propose various actions including increased R&D investment to spur higher private R&D spending, setting up a trailing-edge chip fabrication unit, building a plurilateral semiconductor system with low tariffs, all backed with a robust infrastructure plan. Inexplicably, and generally against the grain of their past findings, they suggest a revival of SCL through fresh capital infusion to ensure that defence equipment is obtained from trusted sources. Yet, for efficiency, it would be better to have a private fab inside the country to achieve a similar goal. To kick-off new efforts, the book recommends starting a trailing-edge fab using fifteen-year-old manufacturing technology, based on a 40 nano-meter manufacturing process. They could have advocated for a decade old, yet highly useful technology based on a finer 28 nano-meter process. The newer process is more efficient, with broader application areas. This would have been in line with future needs and broader strategic autonomy goals. The broad policy canvas proposed by the authors looks like a missed opportunity to push a more detailed, actionable agenda.

The impact of Open-Source technologies is one of the threads that run through the book. The most prevalent example of such technology is RISC-V - a royalty free, open standard CPU Instruction Set Architecture (ISA). In late 2019, the RISC-V foundation moved its headquarters from the US to Switzerland. This was done to address concerns over potential US trade curbs raised by members including Huawei, Alibaba, NXP Semiconductors, and Qualcomm. This has turned out to be the right move, and the book rightly notes that the US cannot do much to prevent access to a public ISA. Nonetheless, US lawmakers are trying.

While the book does note that open-source hardware is a nascent field, it over-estimates the role of open-source hardware in geopolitics. The potential impact of open-source hardware can be huge; however, open-source hardware is today where open source software was twenty years ago. Unlike software developers, hardware developers (and the ecosystem) are known to be extremely protective of crucial aspects of their designs to retain their competitive edge. Given the costs and expertise involved, a high-performance open-source chip design that matches commercial-grade competitors is some time away.

The last chapter, 'Peering into the Future', is the highlight of the book. The realities now are different from the past. The authors address the 'meta-critical' aspects of semiconductors by looking at it through three lenses: semiconductor geopolitics, semiconductor geoeconomics, and semiconductor technology. Known technology trends are well captured in the book, including the role played by important drivers such as fabrication, packaging, and applications. Semiconductors are a capital-intensive business; specific chips require a high market volume to be viable. Geoeconomics is the market underpinning these considerations, including growing application areas, unit economics, as well as dependence on major consumer markets such as China. The book argues that geopolitics will need to live with the realities of geoeconomics in the medium term, and that non-linear technology breakthroughs arising out of investments may alter the status quo.

As a framework for formulating actions, the authors have come up with a useful framework, 'siliconcraft', that encompasses various possible tools of semiconductor statecraft. A neat table in the book helpfully shows how various strategic objectives could be met by applying specific instruments, while demonstrating the unintended repercussions. While international partnerships are an important part of siliconcraft, businesses of cooperating countries compete in a growing market. The authors could have shed some light on relevant details of current partnerships and expected impact on the relative power of nation-states.

All said, it is hard to disagree with their overall conclusions – that the billions of dollars that will be spent in the new initiatives will likely only result in a slightly diversified supply chain, and that the on-going round of semiconductor geopolitics will end with a realisation that 'semiconductor interdependence is a boon not a bane'.

Indian Prime Minister Narendra Modi recently said that the 'Semiconductor Mission should have started 30 years ago'[i]. This is a tacit admission that building a robust ecosystem is a long game. Overall, this book is an essential read for policy makers in India; it could infuse a sense of urgency as well as help drive an action plan for the next twenty years. Beyond government support, India's future in chips is highly dependent on building an ecosystem that will cater to both India and the world. 'India's Chip Designers', to whom this book is dedicated, must read this to understand and make the best of the massive potential opportunities in building this ecosystem.

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[i]https://www.indiatoday.in/business/story/prime-minister-narendra-modi-exclusive-india-semiconductor-mission-delay-30-years-artificial-intelligence-job-creation-2481981-2023-12-29