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Review Essay 90

Chris Miller, *Chip War: The Fight for the World's Most Critical Technology*. London: Simon & Schuster, 2022. ISBN: 9781398504097 (hardcover, £20.00); 9781398504127 (paperback, £10.99).

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This review is being written on a computer, at the heart of which is an electronic gadget—a "chip"—made up of billions of transistors and other tiny components. Once the review is written, I will email it to the editor, meaning that it will pass through a chain of more powerful computers, perhaps bounce off a satellite, and appear on someone else's screen. You are (almost certainly) reading it on yet another computer, or a phone or tablet—all powered by their own chips. Obvious enough. But if you look around you, there are also chips in all sorts of non-obvious things: your car, thermostat, refrigerator, doorbell, credit card, children's toys, you name it. Like the old adage that we are never more than a few feet from a spider, these days we are rarely more than a few feet from at least one—and usually several—chips containing millions or billions of transistors.

Moreover, if you turn on the news you'll see yet more chips enabling the tanks and anti-tank missiles, drones, radars, and weaponized memes on the literal and digital battlefields of Ukraine. Planners in the Pentagon and their counterparts in Peking and Pyongyang are monitoring those battlefields too, trying to derive lessons from Ukraine for potential future conflicts in Taiwan and South Korea. If those conflicts erupt, they will be fought with—and, more importantly, fought over—the same chips that are in both your coffeemaker and the F-22 fighter jet. For it just so happens that most of the world's most advanced circuits—for both the military and civilian markets—are manufactured either in a country that is still technically at war with its neighbor, or in a country that the leaders (and most of the citizens) of its much larger neighbor believe is no country at all, but a renegade province to be brought back to the fold by force if necessary.

Chris Miller's *Chip War* attempts to explain how we got into that precarious and counter-intuitive situation. His explanation seems aimed partly at policymakers; after all, Miller teaches at Tufts University's Fletcher School of Law and Diplomacy, and is also Jeane Kirkpatrick Fellow at the American Enterprise Institute, a program that offers fellows "the opportunity to apply their scholarly interests to the public policy realm."[1] *Chip War* is thus written in direct language with skeletal endnotes and little explicit engagement with the historical literature on the topic—which is perhaps reasonable for addressing policymakers.[2] Each chapter

[1] Note that the AEI's description of the program also stipulates that it is only for "thinkers and future leaders who value freedom, a strong national defense, and American leadership in the world," Audrye Wong, Kyle Balzer, Sheena Chestnut Greitens, Chris Miller, and Jason Blessing, "Jeane Kirkpatrick Fellowship Program," *American Enterprise Institute*, 4 September, 2017, https://www.aei.org/special-features/jeane-kirkpatrick-fellowship-program/.

[2] Some important works that aren't cited include: Thomas J. Misa, "Military Needs, Commercial Realities, and the Development of the Transistor, 1948-1958," in *Military Enterprise and Technological Change*, ed. Merritt Roe Smith

reads like a *The Economist* article: an opening anecdote leading into a story combining history, technology, and geopolitics accompanied by light analysis with a center-right/free-market bent (an orientation reinforced by Niall Ferguson's cover blurb). Yet Miller isn't Malcolm Gladwell; he has written three academic monographs on Soviet history, the acknowledgements section of *Chip War* highlights the extensive archival research and interviews that have gone into it, and those skeletal endnotes do cite many of the best works in the semiconductor historiography.[3] So, with some caveats, this book does indeed make a contribution to that historiography.

Some of those caveats could be cleared up quickly if Miller had written—or will write—a couple peer-reviewed articles with more transparent sourcing. For instance, the book's foreword describes visits to archives on three continents; but my (admittedly rough) estimate is that less than 2% of the notes reference a primary source from an archival collection. A companion article would tell us whether Miller drew on a larger body of archival sources that are invisible in this book's reference list. On the other hand, Miller's interviews with policy and business actors are significantly more evident—a symptom (or cause?) of the fact that the book's contributions are notably stronger as the narrative approaches the present day. He's also drawn nicely on oral history interviews conducted by other scholars, especially ones associated with the Computer History Museum and the Institute of Electrical and Electronics Engineers History Center. Miller's reference list also displays real familiarity with certain corners of the semiconductor historiography; I was very happy to see reference to the work of my collaborator Hyungsub Choi, for instance.[4] One would certainly ask for more transparent sourcing if this were a journal article or book with a university press; but it isn't, and shouldn't be judged by that standard. Even so, if we read between the lines it is obvious that Miller has done the legwork to write a more rigorously-referenced contribution at some later date if he chose.

Readers should be aware, though, that *Chip War* is written from a particular perspective and thus has particular blind spots. To offer one small illustration: at one point Miller writes that "John Bardeen and Walter Brattain invented the first transistor, but it was their Bell Labs colleagues Mohamed Atalla and Dawon Kahng who devised a transistor structure that could be mass-produced" (346). On the one hand, kudos to Miller for not crediting the odious Bill Shockley as a co-inventor of the transistor (Bell Labs ensured that Shockley shared a Nobel Prize with Bardeen and Brattain, but in fact they worked independently of—or even in opposition to—his oversight).[5] On the other hand, Miller's praise for Atalla and Kahng is a bit like saying that Carl Benz built the first modern car, but it was really the designers of the Ford Mustang who devised a

(Cambridge, MA: MIT Press, 1987): 253-287; Stuart W. Leslie, "Blue Collar Science: Bringing the Transistor to Life in the Lehigh Valley," *Historical Studies in the Physical and Biological Sciences* 32.1 (2001): 71-113; Daniel Holbrook, Wesley M. Cohen, David A. Hounshell, and Steven Klepper, "The Nature, Sources, and Consequences of Firm Differences in the Early History of the Semiconductor Industry," *Strategic Management Journal* 21.10-11 (2000): 1017-1041; Ethan Mollick, "Establishing Moore's Law," *IEEE Annals of the History of Computing* 28.3 (2006): 62-75; Lisa Nakamura, "Indigenous Circuits: Navajo Women and the Racialization of Early Electronic Manufacture," *American Quarterly* 66.4 (2014): 919-941.

[3] Among the classic works that are cited are: Margaret Pugh O'Mara, *Cities of Knowledge: Cold War Science and the Search for the Next Silicon Valley* (Princeton: Princeton University Press, 2004); Christophe Lécuyer and David C. Brock, *Makers of the Microchip: A Documentary History of Fairchild Semiconductor* (Cambridge, MA: MIT Press, 2010); AnnaLee Saxenian, *Regional Advantage: Culture and Competition in Silicon Valley and Route 128* (Cambridge, MA: Harvard University Press, 1994); Arnold Thackray, David C. Brock, and Rachel Jones, *Moore's Law: The Life of Gordon Moore* (New York: Basic Books, 2015); T. R. Reid, *The Chip: How Two Americans Invented the Microchip and Launched a Revolution* (New York: Random House, 2001).

[4] Specifically, Hyungsub Choi, "Manufacturing Knowledge in Transit: Technical Practice, Organizational Change, and the Rise of the Semiconductor Industry in the United States and Japan." Ph.D. dissertation, Johns Hopkins University, 2007.

[5] As Miller notes, the most thorough studies of Shockley are Joel N. Shurkin, *Broken Genius: The Rise and Fall of William Shockley, Creator of the Electronic Age* (New York: Macmillan, 2006) and Michael Riordan and Lillian Hoddeson, *Crystal Fire: The Birth of the Information Age* (New York: WW Norton, 1997). An enlightening window on Shockley's thinking can also be found in David C. Brock, "From Automation to Silicon Valley: The Automation Movement of the 1950s, Arnold Beckman, and William Shockley," *History and Technology* 28.4 (2012): 375-401.

car that could be mass-produced. As Ross Bassett has shown in meticulous detail, the transition from Bardeen and Brattain's invention (the point-contact transistor) to Atalla and Kahng's version (the metal-oxide-semiconductor field-effect transistor or MOSFET) was slow and uncertain, with an entirely different technology, bipolar junction transistors, having been mass-produced in enormous quantities long before MOSFETs became predominant.[6] Moreover, the companies—especially IBM—whose labs pioneered MOSFETs long viewed them as commercially unimportant; Bassett shows that at first the cheaper-to-manufacture MOSFETs were only appealing to start-ups like Intel that did not have IBM's vast cash reserves. Yet Miller barely cites Bassett (in passing and on a mostly unrelated point) and the narrative does not engage with his work—which in a sense is fine. Books that aim to shift policy or impact public debate don't need to reference every academic work on the topic. But the treatment of the development of MOSFETs is illustrative of a more general choice to tell the history of semiconductor manufacturing from the perspective of the "winners," the people and organizations that made the "right" technological and business choices, and to ignore or slight those who went down (what turned out to be) technological or business dead ends.

The main exceptions to that focus on the winners are the chapters on the Soviet microelectronics industry, which Miller depicts as thoroughly wrongheaded and hence perpetually behind that of the West. These chapters add some color and eccentricity to the narrative—which would be wonderful in a different book that more consistently prized color and eccentricity, but they sit somewhat uncomfortably in a book that is otherwise dedicated to the single-minded vision of the victors. Moreover, Miller paints a significantly more dismal picture of Soviet computing than other recent works.[7] This fits with his main argument for US policymakers today that great powers that are content to remain also-rans in semiconductor manufacturing will eventually be consigned to the dustbin of history. But I would be interested to read a discussion by Miller—again, in a journal article or monograph from a university press—that presents a more nuanced study of Soviet microelectronics that engages with the recent historiography.

As it is, the rest of the book outlines one technological and business triumph after another: from the invention of the transistor at Bell Labs in 1947, to that of the integrated circuit at Texas Instruments and Fairchild Semiconductor in 1958–1959, to the founding of Intel in 1968 and that company's marketing of the first microprocessor in 1971, to Japanese firms' takeover of the memory chip market in the 1970s and 1980s, and finally to the emergence of South Korea and Taiwan as the world's semiconductor manufacturing superpowers in the 1990s. That storyline is not exactly wrong; Miller's narrative hits the main notes. But one could argue that it carries the melody but doesn't supply the harmony, especially in the early chapters. There, I would have expected to read much more about IBM, the vertically-integrated conglomerate that made its own chips to supply its near-monopolistic share of the mainframe market.[8] Or RCA, the company that did more to transfer semiconductor technology to Japan than any other.[9] Or Philips, the #2 or #3 global semiconductor manufacturer for much of the 1970s and 1980s, and a key player in facilitating Taiwan's current dominance.[10] Or Texas Instruments, which Miller only spotlights briefly when it made the "right" choices in the 1950s, but which drops from view once it made the "wrong" choice not to move into consumer products in the 1960s. The narrative gives no indication that Texas Instruments remained an

[6] Ross Knox Bassett, *To the Digital Age: Research Labs, Start-up Companies, and the Rise of MOS Technology* (Baltimore: Johns Hopkins University Press, 2002).

[7] E.g., Benjamin Peters, *How Not to Network a Nation: The Uneasy History of the Soviet Internet* (Cambridge, MA: MIT Press, 2016); Ksenia Tatarchenko, "A House with a Window on the West:" The Akademgorodok Computer Center (1958-1993)." Ph.D. dissertation, Princeton University, 2013; Zahar Koretsky, Ragna Zeiss, and Harro van Lente, "Exploring the Dynamics of Technological Decline through the History of a Soviet Computer 'Ural' (1955-1990)," *Science, Technology & Human Values* (OnlineFirst): https://journals.sagepub.com/doi/abs/10.1177/01622439221130139.

[8] James Cortada, *IBM: The Rise and Fall and Reinvention of a Global Icon* (Cambridge, MA: MIT Press, 2019).

[9] Hyungsub Choi, "Technology Importation, Corporate Strategies, and the Rise of the Japanese Semiconductor Industry in the 1950s," *Comparative Technology Transfer and Society* 6.2 (2008): 103-126.

[10] Cyrus C. M. Mody, *The Squares: US Physical and Engineering Scientists in the Long 1970s* (Cambridge, MA: MIT Press, 2022): chapter 6; Mila Davids, "Local Meets Global: Resilience in Dutch and Taiwanese High-Tech Regions," *Business History* (2021): https://doi.org/10.1080/00076791.2021.1944111.

important semiconductor manufacturer right to the present, or that its consumer products—yes, even its calculators!—were both widely beloved and revolutionary.

Instead, in the first half of the book all roads lead to Intel and its co-founders, Robert Noyce, Gordon Moore, and Andy Grove. Miller relies especially on Grove's autobiography and on Leslie Berlin's biography of Noyce (Berlin is thanked prominently in the acknowledgements).[11] Hence, Miller's argument is dismissive of those who did not see the future in the same way as Grove and Noyce. For instance, Miller refers to Sherman Fairchild—the man who bankrolled Noyce and Moore's first company, Fairchild Semiconductor, but who so alienated them that they left to found Intel—as a "trust fund heir" (30) who thought that stock options were "a form of 'creeping socialism.'" (32). In fact, Sherman Fairchild was hardly a failson wastrel; Wikipedia lists more than seventy firms that he founded.[12] And we know from Christophe Lécuyer's work that Fairchild wasn't wrong about stock options; the company responsible for enshrining them in Silicon Valley culture, Varian Associates, was explicitly run along the lines of the socialist commune where its founders grew up.[13]

At times, Miller's dismissal of semiconductor history's losers gets tangled up in uncritical stereotypes. For instance, he recounts that

> French president Charles de Gaulle was formalistic and ceremonious, a tradition-minded military man who saw himself as the incarnation of French *grandeur*… Japan was nothing but an "economic power," de Gaulle declared, huffing to an aide after the meeting that [prime minister of Japan Hayato] Ikeda behaved like a "transistor salesman." Transistor salesman was a position of far more influence than Charles de Gaulle could ever have imagined (45, 50).

Left undiscussed in all of this is the ultra-Gaullist mid-1960s *Plan Calcul*, which aimed to make the French and European computer industries more competitive with IBM.[14] But that initiative is generally seen as a failure, and hence can be excluded from Miller's account. Later European national, multinational, and EU-led initiatives such as ESPRIT (European Strategic Program for Research in Information Technologies), MEGA, JESSI (Joint European Submicron Silicon Initiative), and Eureka also go unmentioned; again, those projects are mostly remembered as failing to boost European firms into competition with US and Asian rivals. Yet I do think that some mention of those initiatives might have helped explain the otherwise rather surprising appearance of Dutch, British, and German firms here and there in Miller's narrative. [I have to admit that this gap in the story is hardly unique to this book; indeed, its global overview allows readers to infer the existence of that gap in ways that other semiconductor histories have not.]

All that said, once Miller gets to the US semiconductor industry's stumbles in the face of rising competition from Japan in the 1970s and 1980s, and the eventual emergence of South Korean and Taiwanese firms as market leaders along with China's successful insertion into the global semiconductor value chain in the 1990s and 2000s the book starts to take off. He has obviously read the contemporary business press carefully—something historians of technology do not do often enough—and so his explanations of the business logic behind various decisions and outcomes are generally convincing. I especially noted, for instance, his attention to the role of government-backed easy money behind the sudden boost in Japanese semiconductor firms'

[11] Leslie Berlin, *The Man behind the Microchip: Robert Noyce and the Invention of Silicon Valley* (New York: Oxford University Press, 2005); Andrew S. Grove, *Only the Paranoid Survive: How to Exploit the Crisis Points That Challenge Every Company* (New York: Crown, 1999).

[12] See https://en.wikipedia.org/wiki/List_of_Sherman_Fairchild_companies.

[13] Christophe Lécuyer, *Making Silicon Valley: Innovation and the Growth of High Tech, 1930-1970* (Cambridge, MA: MIT Press, 2006).

[14] Pierre-E. Mounier-Kuhn, "Le Plan Calcul, Bull et l'industrie des composants: les contradictions d'une stratégie," *Revue Historique* 292.1 (1994): 123-153.

competitiveness in the '70s and '80s (and the tapering of that competitiveness when the monetary taps were turned off).

The book also highlights actors who are well-known in industry circles but are largely absent from the historiography: for instance, while most US semiconductor history orients to the East or West Coast, Miller devotes ample space to Micron, the Idaho-based memory chip manufacturer. And he grasps that the history of semiconductor manufacturing cannot be told solely in terms of business or technology or domestic governance, but must include elements of diplomacy and geopolitics, which again is something that most semiconductor history does not deal with very well. That aspect of the book particularly shines through in Miller's depiction of the Taiwanese regime's drive to establish a globally-important chip industry. I would, perhaps, have preferred that Taiwan and South Korea be given more equal space in this account; and also that Miller had more fully placed the growth of both countries' semiconductor industries in the context of their simultaneous democratization. But I recognize that the policy points that Miller stresses– particularly with respect to China—are better served by a focus on Taiwan and the booming Chinese electronics industry just across the Taiwan Strait.

In the end, this is a book that aims to insert the history of semiconductor manufacturing into the grand story of great power competition. For Miller, microelectronics innovation goes a long way toward explaining why the Soviet Union lost the Cold War; the timing of various advances in chip design explains why the US military ceded the battlefield in Vietnam but went on to two easy victories against Iraq (though Miller does not note that over-reliance on technology might also explain the consistent failure of US counterinsurgency strategy); and the Spenglerian (Fergusonian?) decline of US imperial ambition and sharp-elbowed business acumen explains how more determined Asian regimes have made the world's most contested strait the center of the world's most important industry.[15] Throughout, Miller places great weight on a "chips are the new oil" analogy: the countries that controlled fossil fuel production had all the geopolitical leverage in the twentieth century, while the countries that control chip production will gain that same leverage in the twenty-first.[16] It's an argument worth listening to; but also an argument that requires choices regarding narrative and evidence that won't necessarily resonate with an H-Diplo audience of scholars.

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[15] Oswald Spengler, *The Decline of the West:* volume 1, *Form and Actuality*, trans. Charles Francis Atkinson (London: George Allen and Unwin, 1926 [1918]) and volume 2, *Perspectives of World-History*, trans Charles Francis Atkinson (London: George Allen and Unwin, 1928 [1922]). Rather closer in thinking and style are Niall Ferguson, *Colossus: The Rise and Fall of the American Empire* (New York: Penguin, 2005) and *Civilization: The West and the Rest* (New York: Penguin, 2011).

[16] An alternative reading is that "oil is the new oil," in that semiconductor manufacturing is in part merely an extension of the hegemony of fossil fuels. Zero Cool, "Oil Is the New Data," *Logic* 9 (2019): 15-30; Cyrus C.M. Mody, "Spillovers from Oil Firms to U.S. Computing and Semiconductor Manufacturing: Smudging State-Industry Distinction and Retelling Conventional Narratives," *Enterprise & Society* 24.3 (2023): 676-701.