

Review Essay

Troublemakers: Silicon Valley's Coming of Age. By Leslie Berlin. New York: Simon & Schuster, 2017. xvi + 494 pp. Photographs, bibliography, notes, index. Cloth, \$30.00. ISBN: 978-1-4516-5150-8.

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Leslie Berlin's book *Troublemakers* is an engaging and insightful people-first exploration of the roots of Silicon Valley, from the late 1960s to the early 1980s. Berlin portrays seven individuals who played important roles at critical junctures in the development of technologies we now take for granted: the Internet; personal, connected computing and communications devices; genetic engineering; software as a service (SAAS); streaming video; massively multiplayer online games; and democratized access to the world's information. They helped lay the foundation for the economic powerhouse called Silicon Valley.

Berlin begins her book by introducing Bob Taylor, a persistent fellow working at the Advanced Research Products Agency (ARPA), an elite technology-focused organization within the Department of Defense. In the fall of 1966, Taylor was working on a computer network that might enable geographically dispersed grant recipients to communicate more effectively, leveraging their impact. Taylor did not "invent" the idea of connecting people and computers. Visionaries like J. C. R. Licklider saw the potential and described the benefits of an "intergalactic network." But, Taylor had capital to support the effort because he had convinced his boss to allocate \$500,000 to get the work done.

That one person could support multiple researchers and universities with a common objective was important. Access to financial, human, and intellectual capital is a dominant force underlying all of Berlin's stories and is an essential factor in Silicon Valley then and now.

Rather than going through Berlin's book and protagonists chronologically, I will focus on some of the ideas, behaviors, and contextual factors that unite the stories and tie the past to the present. I will also offer some reasons as to why Silicon Valley became the global epicenter for technology entrepreneurship rather than a city like Boston, the other likely locus for this activity.

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In the late 1970s, my colleague Howard Stevenson introduced the idea that entrepreneurship is the pursuit of opportunity beyond the resources controlled. It is a way of managing rather than an economic function (risk bearing or innovation), a personality trait (creativity or vision), or a company stage (start-up). Berlin's book offers a deep look at entrepreneurial management in action. Her protagonists constantly search for opportunity, whether for personal computing or recombinant DNA. They get access to resources—people, money, advice, suppliers, and distribution networks—that enable them to test their ideas. If a test yields encouraging results, they get access to more resources to design and run the next test. If a test reveals that their hypothesis is false, then the team abandons the project or changes direction.

The process of identifying potential opportunities, gathering resources, and structuring experiments can take place in any kind of organization. In this regard, Taylor at ARPA and Neils Reimers at Stanford are important entrepreneurial actors in the early days of the Valley. Reimers was the associate director of contract administration—not exactly a career-defining post. He identified an opportunity to help Stanford commercialize research. Most universities, Stanford included, did little to identify research that could be licensed to existing or new enterprises.

Reimers convinced his boss to let him explore the possibilities with Stanford faculty and with companies that might benefit. As Berlin recounts, Reimers seized the opportunity; he proved that faculty members, the university, and organizations could and would collaborate to bring the research to market to benefit society.

Reimers, like Taylor, was not an operating executive or a venture capitalist. He was a connector, with a talent for sales and marketing, and he helped create a perpetual stream of opportunities for generations to come.

Berlin's emphasis on Taylor and Reimers makes sense. To build and sustain a dynamic ecosystem like Silicon Valley, a few ingredients are essential. The first and most obvious is human capital. The second is ideas—intellectual capital—that might form the basis at some point for successful enterprises. Taylor and Reimers were associated with two of the biggest ideas of the past century: the Internet and biotechnology.

Taylor also played a role in the third big idea around personal computing. After working at ARPA, he worked at a new computer graphics center at the University of Utah. He then went to Xerox's famed Palo Alto Research Center (PARC), where he and his team championed the idea of a personal computer. As everyone knows, researchers at PARC were pioneers in areas like graphical user interfaces and even the omnipresent mouse. As many know, Xerox never capitalized on the many opportunities identified in the lab.

That is another theme in Berlin's book: big, profitable companies have difficulty developing new products and markets. Whether in personal computing, recombinant DNA, software, or gaming, the same opportunity that was seized by Apple, Genentech, ASK, ROLM, and Atari was not exploited by Xerox, Digital Equipment, AT&T, Merck, or any of the existing players.¹ Why not? As Berlin describes the political and economic machinations inside companies like Xerox, we begin to see how differently the people behave and how strong the pressure is to protect or optimize existing resources. It is also clear that potential personal wealth creation is far greater in new ventures than in existing companies, which lures people out of established enterprises.

The large companies in the region did, however, play a critical role in the creation of the iconic Silicon Valley companies of the current era. Throughout *Troublemakers*, Berlin describes the career paths of her subjects. Fred Alcorn, Ted Dabney, and Nolan Bushnell worked together at Ampex before joining forces at Atari. Mike Markkula, Mike Scott, and Gene Carter spent time at Fairchild Semiconductor before joining Apple. Fawn Alvarez also worked at Ampex before joining ROLM. Sandra Kurtzig worked at General Electric before founding ASK.

At each stop people acquired skills, discovered "best and worst" management practices, made connections, and saw opportunities. Many stayed in their organizations and many left to launch new ventures. Of course, in many ways, the most important sequence of departures in the history of Silicon Valley occurred when the "traitorous eight" left Shockley to form Fairchild Semiconductor in 1956, followed in 1968 by the formation of Intel. William Shockley's managerial ineptitude and erratic behavior likely accelerated the development of silicon-based technologies and companies. Sherman Fairchild's unwillingness to share significant equity or reinvest in the semiconductor division played a role as well, when Gordon Moore and Robert Noyce left to start Intel and Jerry Saunders left to start Advanced Micro Devices.

Troublemakers is a story about flows of human, financial, and intellectual capital between academic institutions, existing companies, new ventures, and supporting organizations (e.g., law firms, venture capital firms, and marketing/PR firms). That fluidity is essential to change and growth.

Consider the creation of Apple, currently the most valuable company in the world. Steve Wozniak, arguably a technical genius, worked at

¹ As I will explore later, some companies, such as Intel and Hewlett Packard, did participate successfully in the newer businesses, which may explain some of the enduring strength of the region. Obviously, IBM also launched its personal-computer business (based in Boca Raton, Florida) and did well for many years before the product effectively became a commodity. In biotechnology, companies like Hoffmann-La Roche (minority stake in Genentech) and Eli Lilly (Hybritech) acquired pioneering biotech companies and participated in that way.

Hewlett Packard (HP). In his spare time, he developed a simple computer that could be attached to a TV and keyboard. Wozniak wanted to share his design with fellow enthusiasts, but Steve Jobs convinced him to sell the device.

Jobs epitomized the concept of entrepreneurial action. He saw the opportunity. He acquired the resources necessary to run the first commercial experiment at Apple—selling motherboards (called the Apple I) to the Byte Shop. Jobs was a proverbial one-man band on the business side, preselling the “computers,” acquiring parts, assembling the devices, and raising capital through trade credit, a small loan, and savings (think HP calculator and VW bus). Also, the owner of the Byte Shop agreed to pay cash on delivery of the assembled units rather than wait until he collected from customers; that float made it financially feasible for Jobs, Wozniak, and Ron Wayne (the third partner) to get going. Wayne—in one of many examples of bad luck, bad timing, or poor decision-making—left the partnership because he was concerned about the personal liability associated with the loan and trade credit.

To run the second major experiment of introducing a more functional personal computer, Jobs and Wozniak needed significantly more capital. Jobs went on the road to attract investors or a company that might acquire Apple. Not surprisingly, he found it difficult to develop options until Don Valentine, a venture capitalist, suggested he meet with Markkula, a recently retired executive from Intel. Markkula eventually committed to join Jobs and Wozniak. He provided equity capital and a loan guarantee and received the same equity percentage ownership as the two Steves.

Berlin appropriately focuses on Markkula and his engagement with Apple. Markkula was a talented and disciplined executive who brought capital, credibility, competence, and contacts to Apple. When Apple went to raise venture capital in the fall of 1977, Markkula went to people who knew him well. Hank Smith from Venrock, who had been Markkula’s officemate at Fairchild and a consultant to Intel, agreed to invest. Arthur Rock, who had helped establish Fairchild Semiconductor and then led the financing of Intel, also invested and joined the board. Rock has stated that he was skeptical about Jobs and Wozniak but invested because of his faith in Markkula.

Venture capitalists like Rock, Valentine, Smith, and Tom Perkins play a critical role in almost all the stories in *Troublemakers*. These individuals and their firms were prepared to back new ventures that had a high likelihood of failure.

Berlin describes in detail how a young venture capitalist—Bob Swanson from Kleiner Perkins—helped create Genentech based on pioneering research by Herb Boyer (UCSF) and Stan Cohen (Stanford).

Reimers worked closely with Swanson to gain intellectual property protection and buy-in from the scientists and universities.

The Genentech story is complicated. Many were concerned about genetic engineering, the consequences of filing for a broad patent on a biological process, and the role of professors in new company formation. Also, Swanson was not in a strong position at Kleiner Perkins; Tom Perkins had informed him that he would have to find employment elsewhere.

In the end, Perkins did invest in Genentech, Swanson became the CEO, recombinant DNA worked and did not destroy humanity, patients benefited from a new source of insulin, and faculty members and universities encouraged commercialization of research. The biotechnology revolution began. Many new companies were formed to take advantage of the new technology.

I believe that two of the greatest inventions of the twentieth century were the high-potential start-up and venture capital. Obviously, both have existed in some form forever—think Queen Isabella and Christopher Columbus, or the early days of whaling. But, until the mid-1970s, there were few professional venture capital firms or even wealthy angels eager to back enterprising entrepreneurs. In 1975, to illustrate, the total amount of venture capital raised by independent venture firms was under \$50 million. The same year, new companies raised less than \$50 million in initial public offerings.

Without access to external financing, it is challenging or impossible to start a company that can scale quickly. That was true at Apple, Atari, Genentech, ROLM, ASK, and most of the myriad companies that were formed to pursue new opportunities in technology-based businesses. Indeed, if aspiring entrepreneurs did not believe they could get access to financial resources, they might never take the plunge. Or, if they could not create and capture wealth in an initial public offering or a strategic sale, they might not be willing to bear the risk of failure.

Venture capital firms like Kleiner Perkins and Sequoia raise capital from investors and then identify promising ventures to back. They stage the commitment of capital to each start-up. They invest enough money to run an important test that indicates if the team and idea make sense. Conditional on success, they invest more capital to scale. They provide credibility and access to new hires, suppliers, customers, and other investors. If a venture has challenges, they intervene in management or stop funding.

Eugene Kleiner (ex-Fairchild Semiconductor) and Perkins (ex-HP) raised their first fund in 1972 with \$7.5 million in total commitments. Kleiner Perkins invested in seventeen companies. Of those, seven failed completely, two resulted in a loss, and two—Tandem and Genentech—were smashing successes, with returns on capital invested of over one

hundred times. Each company had gone public. That is the nature of venture capital: a few big winners more than offset losses on the rest of the portfolio. For the first five years of the first fund, the compound rate of return was 100 percent per year.

As Kleiner Perkins and other firms achieved success, more capital flowed into the industry, a process that was accelerated by changes in pension fund regulation (ERISA) and a decline in the rate of taxation on long-term capital gains in the late 1970s. By 1980, over \$2 billion per year was invested in professionally managed venture capital firms. In 1980, and for every year thereafter, more than fifty new firms were formed to invest in high-potential ventures. Most of these firms concentrated on companies in Northern California; many located in a single place: 3000 Sand Hill Road in Menlo Park.

The IPO market turned from moribund to ebullient as companies like Apple and Genentech went public. Genentech's IPO in 1980 was particularly important—the IPO was priced at \$35 but the first trade was at \$89. Kleiner Perkins, which invested only \$200,000, held shares worth \$65 million, as did Swanson and Boyer. After Apple's 1980 IPO, Jobs, Wozniak, and Markkula each held shares worth over \$100 million.

A thriving venture capital market, a receptive public market for new companies, and eager entrepreneurs transformed the economy across Silicon Valley. The level of opportunity was extraordinary, and many new ventures emerged, often pursuing the same basic market. This had been true in semiconductors as firms like Intel, Advanced Micro Devices, and National Semiconductor launched, but the pace of entry became frenetic.

To illustrate, between 1977 and 1984, professional venture capital firms backed forty-three new manufacturers of Winchester Disk Drives. Each entrepreneurial team imagined that if they could get just 10 percent of the market, they would be successful. Unfortunately, by 1983, there were over one hundred firms (including existing companies) that competed for the same customers. But, even when individual firms failed, the entrepreneurs and employees were able to find new, good jobs as long as they had not caused the failure or engaged in bad behavior.

If entrepreneurship is the pursuit of opportunity beyond the resources currently controlled, you can see how and why a region like Silicon Valley became a global force. William Shockley's fateful move to California, and the ensuing progress in semiconductor technology, created massive opportunity for entrepreneurial actors for decades to come. Cohen and Boyer launched a revolution when they developed tools for producing human therapies using genetic engineering.

To exploit opportunities, entrepreneurial actors need resources. They need talented individuals to form effective teams, from entry-level workers to senior managers. They need willing suppliers and early

customers. They need design firms and contract manufacturers. They need capital. They need advice and guidance from investors, advisors, and service providers. They need mechanisms to convert ideas into wealth, as when a company goes public or gets acquired.

For a region to thrive, there must also be tolerance for failure. Entrepreneurship is risky business. In the 1980s, the failure rate for venture capital-backed companies was almost 40 percent. If the personal, legal, social, and financial consequences of companies failing were too harsh, few would start companies or join them. Similarly, if there are strictly enforced barriers to changing jobs, then flows of human capital are constrained. In California, as case law has evolved, non-compete clauses are essentially not enforceable.

As Berlin illustrates, having great universities is essential. Stanford plays a particularly important role in the development of Silicon Valley. Though not covered in *Troublemakers*, Fred Termin, the dean of Stanford's engineering department, encouraged students to start companies or get jobs at emerging growth companies, beginning with HP. Stanford produced thousands of engineering students, including many with terminal master's degrees. They populated the technology companies in the region and constituted a strong network.

Stanford also had a superb research faculty that developed many ideas that were commercialized. Reimers and the licensing office played a key role, as did the Stanford endowment that invested in local venture capital firms. Stanford also connected with the military-industrial complex, which funded important projects like Arpanet. Stanford even played a positive role as a real estate owner that supported new companies and venture capital firms.

Silicon Valley had essentially all the ingredients required to start and sustain a vibrant, technology-based ecosystem. As Berlin describes, a few people played a disproportionately important role in getting the entrepreneurial ecosystem up and running. In addition to her main protagonists, there were other key actors. Regis McKenna, who left National Semiconductor to found a communications firm, did magical marketing work for Intel, Apple, and Genentech. Larry Sonsini became the go-to lawyer for new ventures and venture capitalists in the Valley. Bill Hambrecht formed an investment bank that brought Apple, Genentech, and many other high-tech companies public.

Once in gear, the entrepreneurial ecosystem system builds on itself. Human, financial, and intellectual capital flows to pursue opportunities, which, in turn, creates new opportunities, as in genetic engineering and personal computing. There are likely network effects in regions like Silicon Valley in which the "value" of the region increases exponentially as other elements grow arithmetically.

But, why didn't Boston also become a Silicon Valley-like cauldron of new technologies? After all, General Georges Doriot launched the professional venture capital industry in 1946 in Boston by creating American Research & Development. Greylock, now one of the iconic venture capital firms, started in Boston in 1965 as a limited partnership of limited duration, a legal form that has dominated the industry ever since.

Boston also had two of the world's most prestigious and productive universities, Harvard and MIT. It had important defense contractors like Raytheon and Lincoln Labs. The minicomputer revolution started in Boston with companies like Digital Equipment, Wang, Data General, and Prime. The modern spreadsheet was created in Boston (Visicalc), followed by the even more successful Lotus 123.

In biotechnology, scientists like Phil Sharp (MIT), George Whitesides (MIT), and Walter Gilbert (Harvard) did pathbreaking work in biology and genetics. However, in contrast to Genentech in San Francisco, Sharp and Gilbert joined the initial scientific advisory board of Biogen, a start-up that launched in Europe in 1978 rather than in Cambridge, Massachusetts. Also, the Harvard faculty voiced concern over conflicts of interest and discouraged Harvard from starting companies to commercialize the new technology. Gilbert took a leave from Harvard to become CEO of Biogen, which set up facilities in Cambridge in 1982. In late 1984, the Biogen board replaced Gilbert as CEO. The company ultimately achieved commercial success when it introduced genetically engineered interferon in 1986, but that was well after Genentech and other California-based companies had introduced products.

At MIT, Sharp expressed interest in developing a genetically engineered bovine growth hormone for Biogen. However, MIT enforced a rule that scientists could not receive research funding from a company in which they owned shares. Sharp abandoned his lab project in order to retain his ownership in Biogen.

No one can pinpoint exactly why Boston, or other regions, failed to take off at the same rate as Silicon Valley. In biotechnology, the nexus of universities, scientists, venture capitalists, and companies developed more slowly, and later, in Boston than in Northern California. MIT and Harvard, as well as the City of Cambridge, constrained what faculty members and researchers could do in the emerging field. In Silicon Valley, Stanford and UCSF placed fewer restrictions on activities and participated in the creation of value, effectively crafting a more permeable and productive boundary between academe and industry.

In personal computing, Boston entrepreneurs effectively missed a technology wave. Boston-based companies like Digital Equipment dominated the minicomputer industry. Success in one technology, however,

often creates obstacles to catching the next wave. The companies that succeeded in minicomputers uniformly failed to compete effectively in the personal-computer industry. That failure also impacted the rate at which new software and other related technology companies were formed in the region.

In contrast, at Apple, Wozniak and Jobs were developing a personal computer, not one that would be used in business. They had no existing products or profits to protect. Though business analysts often speak of the “liability of newness” (Arthur L. Stinchcombe, “Social Structure and Organizations,” 1965), the ability to create a new company to develop an inchoate market is a powerful asset. As Apple experienced explosive growth, many entrepreneurs started to write software for the Apple II. The introduction of the IBM PC (and subsequent clones) accelerated entry into the personal-computer software business.

Massive technological shifts such as personal computing, genetic engineering, and the World Wide Web typically take root in one region. Success attracts imitation and innovation. The proliferation of ventures attracts human and financial capital, which leads to more competition and innovation. These economic and social processes swept Silicon Valley forward. Human capital flowed out of places like Boston to pursue opportunity. Boston-based firms like Northbridge and Matrix lost momentum. Firms like Charles River Partners and Greylock shifted much of their operation to Silicon Valley. As a result of less competition among venture capital firms in Boston, terms for deals became less entrepreneur-friendly relative to West Coast options.

A final possible determinant of the relative performance of Silicon Valley relates to the nature of successful companies there. The three foundational examples are HP, Intel, and Apple. From HP’s founding in 1939 to the 1990s, it prospered in electronics, measurement, personal computers, and printers. Intel, which launched in 1968, made one of the great strategic decisions of all time—shifting emphasis to microprocessors from memory chips in 1984—that enabled the company to thrive to the present. Apple did extremely well from 1977 to 1996, even after Jobs was ousted in 1983. The company lost money in 1996 and 1997 but survived with a cash infusion of \$150 million by Microsoft and the return of Jobs as CEO after Apple bought NeXT. Beginning in 2005, revenues and profits grew rapidly, making Apple one of the largest and most profitable companies in the world.

That these companies remained independent and economically healthy was important for many reasons. They helped anchor the region and provide a growing workforce. Many entrepreneurs began their careers at one of these companies—prominent examples include Wozniak (Apple) at HP, Markkula (Apple) at Intel, and Bill Campbell

(Intuit), and Donna Dubinsky (Palm) at Apple. The founders of each company encouraged the next generation of entrepreneurs.

In Boston, companies like Digital Equipment, Bay Networks, and Lotus Development were acquired by others (Compaq, Nortel, and IBM, respectively). Afterward these same companies lost momentum and never really spawned start-ups the way HP, Intel, and Apple did, nor did they train a generation of general managers.

In the end, because Boston did not have many iconic technology companies, Boston entrepreneurs also missed out on the early days of the Internet. Companies like Netscape based operations in Silicon Valley. Amazon, which based headquarters in Seattle to be near a book wholesaler and to avoid state sales taxes, raised money in Silicon Valley and Seattle.

Later, companies like Yahoo and Google, with strong connections to Stanford, also set up operations and raised capital in the Valley. And, of course, Mark Zuckerberg famously left Harvard College to establish Facebook in Silicon Valley.² Bill Gates had decamped from Harvard College in 1975 to exploit opportunities in the personal-computer space. He ended up back in Seattle, his home town.

The situation in Boston has changed in the past decade. Biotech is flourishing, and Boston is arguably the global epicenter of life sciences. Large companies like Novartis chose to set up operations in Boston. Harvard and MIT contributed to a boom in start-ups by supporting the process. Also, both Harvard and MIT graduated thousands of smart young people, many of whom opted to pursue local opportunities in areas like robotics, regenerative medicine, and immunotherapy.

Berlin has done a terrific job in *Troublemakers* of focusing on some of the key players in the early days of Silicon Valley. She documents many of the pivotal moments, as when Atari chose not to buy Apple or when the recombinant DNA patent was filed and issued and formed the basis for some extraordinary companies.

Silicon Valley gained extraordinary momentum in the early days. Opportunity and resources were abundant. Success beget success. Now, the Valley thrives even though California is a high-tax, high-cost place to do business. Competition for talent is vigorous. Many immigrants opted to head to Silicon Valley, a flow encouraged by programs like the H1-B visa program. By some accounts, almost half of Silicon

² When Zuckerberg returned to Harvard in 2017 to deliver the commencement speech at graduation, he visited the Harvard i-Lab, a center launched in 2011 to promote entrepreneurial activities across Harvard. Zuckerberg commented that he might not have left Boston had the i-Lab been in place. Perhaps that would have dramatically changed the trajectory of Boston in social networking and other new opportunity spaces.

Valley founders are foreign born. Over half of all STEM workers there are foreign born.

Though much of the attention is focused on Silicon Valley, entrepreneurship is thriving across the world in countries like Argentina, China, Estonia, and India. Entrepreneurs in these countries have benefited from democratization of access to resources. A programmer in Estonia can use the Internet to learn programming techniques and get access to extraordinarily powerful software tools (e.g., open source software). They can gain access to global markets.

Today, ideas, people, markets, and money can come from anywhere. If you look at companies like Alibaba, Skype, FlipKart, and Mercado Libre, you understand that no country has a permanent edge in start-ups. Many more places will thrive in the way that Silicon Valley did in the 1970s and beyond. Opportunity and resources can be found nearly anywhere these days.

Though immigrants have thrived in Silicon Valley, the same cannot be said for women and people of color. That was certainly true in the period Berlin describes in *Troublemakers*, but is equally true today. Of two hundred so-called unicorns (private companies with market caps in excess of \$1 billion), only three have female CEOs. Minorities and women are rare in the ranks of venture capital. Imagine what Silicon Valley might have become had it been a true meritocracy and a place of opportunity for all.

Silicon Valley is a remarkable region, with a strong culture of entrepreneurship. It remains dynamic, with new areas of opportunity in areas like autonomous vehicles, virtual reality, cloud computing, the sharing economy, big data, online education, and artificial intelligence. The locus of new activity has shifted somewhat from the southern reaches of the peninsula (e.g., San Jose) to San Francisco, but the entire region is prospering.

Though almost every major city in the world has studied and tried to replicate elements of the Silicon Valley ecosystem, there is no simple recipe. As depicted so ably by Berlin, unique factors combined to jump-start Silicon Valley. Berlin's book offers a powerful way to understand the forces at work in the creation of winning ecosystems of entrepreneurial action. She has written an important book.

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