BEFORE THE GARAGE:
THE INNOVATION SYSTEM THAT PRODUCED SILICON VALLEY

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Introduction

In late August 1938, William Hewlett informed David Packard that "I have been very busy." Hewlett had found a "small house" to rent in Palo Alto beginning in September. The house came with a garage that could be used as a shop, with a concrete floor and work table. [Hewlett to Packard, n.d. August, 1938. Packard papers, 1, 1, 2]. This was the legendary Addison Street garage, which is now accompanied by a historical marker identifying it as the "Birthplace of Silicon Valley." It was not, however, the birthplace of Hewlett-Packard's first product. At Stanford's electrical engineering laboratory in July 1938, Hewlett developed the variable frequency oscillator generator. It was at Stanford that the core H-P team (Hewlett, Packard, Ed Porter, and Barney Oliver) became friends in the early 1930s, and were mentored by engineering professor Frederick Terman. Hewlett already had demonstrated proof of concept in Portland, Oregon, at the August 1938 meeting of the Institute for Radio Engineers, before moving off campus. [Packard to Flehr, Aug. 14, 1941, Packard. 2, 2, 14] Hewlett and Packard would operate in the garage for only a year.

In June 1939, Packard wrote to his father (an attorney based in Pueblo, Colorado), requesting his help in licensing the foreign rights to the oscillator, as well as the U. S. patent for H-P's temperature control. [David Packard to Sperry Packard, June 29, 1939. 1, 1, 2] Sperry Packard's advice was: "What you need now in your work is legal advice

from some competent patent attorney in San Francisco, or if possible in Palo Alto." Two days later, San Francisco patent attorney Paul D. Flehr was working with H-P. [Flehr to Hewlett, August 1, 1939] Flehr would not only handle patent work but would also guide Hewlett and Packard to help in Washington, D.C.

Although Hewlett's oscillator was famously used by Walt Disney Productions for the sound systems used in theaters for the movie *Fantasia*, H-P relied heavily on government work before becoming primarily a commercial enterprise. By the summer of 1940, more than a year before the United States entered World War II, Hewlett-Packard was both a government contractor and subcontractor. Finding a motivated lead user in the U.S. Signal Corps, the company thrived during World War II. [Von Hippel, 1986] H-P's revenues grew from $34,000 in 1940 to $679,000 in 1947.

Years later, David Packard would emphasize how little money the company needed, and how it was able to finance growth from earnings. [Packard 1952 security analyst meeting talk]. This was true for most of the company's first fifteen years—with a couple of exceptions. By early 1941, Packard's parents had provided the fledgling firm with $1,500 of loans at 4% interest. [D. Packard to S. Packard, March 7, 1940; S. Packard to D. Packard, July 10, 1940; D. Packard to S. Packard, July 16, 1940; S. Packard to D. Packard, Feb. 15, 1941; Packard Papers, series 1, box 1, folder 2]. H-P's initial bank, the Palo Alto National Bank, was fine for a small business but not for a start-up on the make. In 1945, the Anglo California Bank (based in San Francisco) acquired the Palo Alto National Bank and turned it into a branch. California's branch banking system thereby provided Hewlett and Packard with access to the resources of a bank more than fifty times larger, although the branch was 40 miles south of San Francisco. The Anglo California

relationship, along with the resources of the Wells Fargo Bank, came in handy in securing a $300,000 loan—collateralized by government contracts—in 1945 [Provisions for Hewlett-Packard Co. 'T" Loan, March 30, 1945. Packard files, series 2, box 2, folder 39].

Diligent would-be tech entrepreneurs in the twenty-first century learn basic lessons regarding relationships with customers, sources of financing, and the protection of intellectual property [see, for instance, Audretsch, et al., 2011]. They also learn about the importance of location and the possible benefits of operating in the orbit of a university or research laboratory [Etzkowitz, 2008; Roberts and Eesley, 2011] Nevertheless, the concept of humble and unassisted beginnings, symbolized in the iconic garage, has had a tremendous impact on would-be entrepreneurs in Silicon Valley and elsewhere in the world. Foregrounding H-P's garage has obscured the fact that H-P's early story included all of the elements we associate with an ecosystem nourishing modern tech entrepreneurship—which were all present when H-P began. The garage fetish has also skewed our understanding of sequencing during the third industrial revolution.

Two edited volumes about Silicon Valley stress the importance of an ecosystem--of venture capitalists, lawyers, headhunters, executive search firms, accountants, and consultants--to the success of the Valley [Lee, 2000; Kenney, 2000]. A persistent question, as posed by John Seeley Brown, is the "chicken-or-egg problem": Did entrepreneurs appear first, or the ecosystem to assist them? [Kenney, 2000: xvi] Brown and Paul Duguid suggest that other regions "in the remnants of the industrial age" began with factor endowments such as raw materials, transportation nodes, or workers with particular skills [Lee, 2000: 19]. In *Understanding Silicon Valley*, Martin Kenney and

Urs von Burg posit that the Valley's defining feature is "Economy Two," an "institutional complex specialized at creating new firms." [Kenney, 2000: 222] Yet Kenney suggests that the garages came first: "In the 1950s there were start-ups, but not a discernible set of institutions to support them" [Kenney, 2000: 229].

A big question that the literature on Silicon Valley has sought to answer is: How did the Valley come to be? One of the implicit goals of various authors on the topic has been to go beyond an overly individualized explanation for regional high-tech success. Nevertheless, by describing external economies arriving after an initial spate of start-ups, scholars of the Valley imply that, although there may not have been a single founding act, a handful of entrepreneurs jump-started the region. Granted, thousands of entrepreneurial acts contributed to the development of the Valley. Yet various endowments helped make possible the region's ascent, including resources repurposed from previous industrial activity, and an infrastructure of support for high-tech enterprise—in the Valley, San Francisco, and Washington, D.C. I will show that Silicon Valley's manifold innovations grew out of an existing nurturing environment that provided the region's start-ups a strategic advantage.

What was the nature of the Valley's system for innovation and entrepreneurship before the local arrival of venture capitalists and high-tech law firms? In 1959, Soviet premier Nikita Khrushchev visited the United States and stopped at IBM's San Jose research facility, one of many outposts established in the Valley by eastern corporations. The following year, French president Charles De Gaulle made two stops in California: at Disneyland and Stanford Industrial Park (now called Stanford Research Park) [Findlay, 1992]. By the time of these state visits, Silicon Valley had more than 100 high-tech firms.

Yet 1959 was the founding year of the Valley's first venture capital firm, and preceded the establishment of the Valley's major high-tech law firms. I will show that the pre-1960 start-ups were supported by an innovation system that was much more dispersed, not contained by what would later become considered the region's boundaries.

Central aspects of Silicon Valley's innovation system, which scholars first wrote about in the 1980s and 1990s, have been sufficiently spatially concentrated as to convey an impression of the Valley is a self-sufficient entity. That spatial concentration and appearance of self-sufficiency has shaped the nature of questions that have been asked about the Valley, resulting in limited emphasis on the role of external factors in the region's development. The initial development of Silicon Valley, and its indigenous start-ups, relied on existing institutions: Bay Area universities, San Francisco-based banks and law firms, federal defense agencies (and favorable federal and state laws). This article builds on portrayals of America's pre-1960 system of national defense, education, and research [Nelson, 1993; Mowery, 1998]. I will portray what Zahra and Wright call the "heterogeneity of contexts" for the development of the world's foremost high-tech region [Zahra & Wright, 2011: 72].

This paper is titled "Before the Garage" because I will show the extent to which a far-flung ecosystem—from San Francisco to Washington, DC--was at work in the years before the creation of the Valley's first venture capital firm (1959) and the Valley's first tech law firm (1961). The tech garages preceded much of the modern ecosystem. Yet a different ecosystem of institutions made those garages possible. These institutions and multiple contexts enabled the garage-based start-ups to begin, to survive, to grow, and to

matter. In identifying the earlier ecosystem, I will show that both the *where* and the *when* of Silicon Valley need reassessment.

A State-Centered District

Accounts of Silicon Valley enterprise tend to emphasize supply more than demand, focusing on purveyors of tech such as Steve Jobs and Robert Noyce [Schmookler, 1966; Isaacson, 2011; Berlin, 2005] Yet regardless of how groundbreaking its technology, a start-up truly becomes a going concern only when it has customers. What were the sources of demand before the region became known as Silicon Valley? In the half century before consumers began to snap up video games and other consumer electronics, demand in the Valley came primarily from the U.S. Navy, the U.S. Army, and the U.S. Air Force. By the 1950s, California became the leading state in the union for defense contracting, and Santa Clara County ranked third within the state—behind only Los Angeles and San Diego [Clayton, 1962].

Why there? It would take a skilled debater to convincingly make the case that San Mateo County or Santa Clara County had a geographically strategic position regarding American national security. Perhaps that is why the preponderance of government activity in Silicon Valley is credited to initiatives by representatives of Stanford University during the decades following World War II. Pulling back the lens a bit from the Valley reveals a story longer in the making.

Dating from 1850, when California attained statehood, the San Francisco Bay Area was blessed with geographic endowments related to both national security and aspirations of a young country. San Francisco was the key West Coast port city in a

nation that periodically embraced imperial ambitions. To some, San Francisco's harbor was the primary attraction of California as a potential American acquisition—especially beginning in the 1840s, when American trade to China first loomed as a possibility. Senator Daniel Webster, for instance, considered San Francisco twenty times more valuable than Texas (another acquisition candidate). [Merk, 1963: 52] When Americans were not considering annexing parts of Canada or Mexico, westward the course of empire took its way. Once the United States reached the shores of the Pacific Ocean, the San Francisco area became a key American strategic region.

A combination of geographic endowment and national identity, then, made the San Francisco Bay Area a "state-centered district," which Ann Markusen defines as one where "a major government tenant anchors the regional economy." Instead of one major anchor, however, this district had several smaller ones. By 1868, the San Francisco Bay Area had a total of six forts, naval bases, and arsenals (a number that would increase to ten by within forty years), and the area became a magnet for defense contractors [Brechin, 2001: 125]. During the Spanish-American War, Admiral George Dewey's flagship was the *Olympia,* which was built at San Francisco's Union Iron Works [Brechin: 151]. Much of the ebb and flow of the area's technological activity would relate to the exigencies of national defense. During World War II, San Francisco had more government offices than any city but Washington, D.C--a sign of the Bay Area's continuing strategic importance [Reiner, 1989: 201].

The Valley's initial high-tech role was to fulfill the needs of global telecommunications, communications made necessary by the creation of America's overseas empire in the wake of the 1898 Spanish-American War. [Douglas, 1989: 102]

As the twentieth century progressed, America's overseas presence expanded, although not in a traditional colonial sense. American expansion evolved from "manifest destiny" (limited to the western hemisphere, and accompanied by the promise of statehood) to a network of military installations that helped protect American overseas interests, including access to markets. [Merk, 1963: 259; Bacevich, 2004: 25] America's new empire needed communications technology, and the area that would become Silicon Valley got in on the ground floor.

The U.S. military's twentieth-century needs included cutting-edge capabilities in telecommunications (especially radio and radar), instrumentation and electrical components that would enhance systems capabilities. [Flamm, 1988: 66] How could they entice industry to meet those needs? One way the government could assure a sufficient stable of contractors during a national emergency was through legal protection. Firms engaged in high-tech commercial business were ever vigilant about potential patent infringement suits filed by larger companies. In the 1930s, the San Carlos-based Dalmo Manufacturing Company declared bankruptcy after losing one such suit, and then emerged as a defense contractor. [Sturgeon, 2000: 42-43] In its new incarnation, the Dalmo Victor Company was on firmer ground because at the behest of Assistant Secretary of the Navy Franklin D. Roosevelt in 1918, Congress decreed that patent infringement suits related to government contract activity would be directed against the government rather than against the individual firm. [Welch, 1968: 39-42]

Besides some legal protection, what did individual companies receive in exchange for meeting the military's needs? Time. Scholars of entrepreneurship have found that half of all start-ups fail during their first five years, and that for various reasons (such as

learning curve), casualty rates drop considerably during subsequent years. [Shane, 2010] The collective challenge faced during the first five years, known as the "liability of newness," is one reason for the popularity of start-up incubators. [Stinchcombe, 1965] The idea is that if it has support during a particularly vulnerable period, the fledgling company will later be able to stand on its own. During the period 1909-1959, defense contracts helped sustain Silicon Valley start-ups during their early years.

Some scholars have argued that individual firms have difficulty making the transition from government contracting to commercial business, and emphasize the challenge of transferring a particular product from a government market to a civilian one. [DeGrasse, 1984: 86] Such an argument ignores what successful entrepreneurs build is organizations, and that during a firm's vulnerable early years, government contracting provides resources—and time—to build important skill sets. [Prahalad & Hamel, 1990] Key companies in the Valley's history may have wanted to aim their products or services at businesses or consumers, but they used government contracts to sustain them as they assembled competitive capabilities.

The original business model for the Federal Telegraph Company (FTC) in 1909 involved a commercial business that would compete in the United States with Western Union through one of the original promises of wireless telegraphy: a cheaper service made possible through cost reduction. [Douglas, 1989: 26] When that model did not provide a clear path to profitability, the company was saved by defense business. Representatives of the Mare Island Naval Shipyard kept tabs on developments at FTC, and in 1913 the company received its first Navy contract. Blessed with government work,

Silicon Valley's first major high-tech firm became a going concern. Within six years, FTC did more than $2 million of business with the U.S. Navy alone [Adams, 2017].

Thus began a pattern of relationships between Valley firms and the government, the federal government represented what Kenney calls a "price insensitive lead customer." [Kenney, 2000: 5] Such was also the case for key entrants in electronics equipment (Hewlett-Packard, 1938); recording equipment (Ampex, 1944); power tubes (Varian Associates, 1948); and semiconductors (Fairchild Semiconductor, 1957).

Indeed, the U.S. government managed the diffusion of technology in what would become Silicon Valley's signature industry of semiconductors. A team headed by William Shockley at the Bell Telephone Laboratories of AT&T (a regulated monopoly) invented the transistor in late 1947. Not long afterward, the Justice Department sued AT&T, attempting to pry loose its captive manufacturer (Western Electric). In the early 1950s, with the suit still unresolved. Bell Labs disseminated its new transistor technology via a $25,000 licensing fee to twenty-five American firms. Then Western Electric showed them how to manufacture the devices. [Riordan and Hoddeson, 1997: 195-197; Tilton, 1971: 73-77] Shockley himself brought semiconductors to the Valley in 1955 with the establishment of Shockley Semiconductor Laboratories. Shockley Semiconductor did not leave much of a mark, but its 1957 spin-off, Fairchild Semiconductor, did with the invention of the integrated circuit. 19 More than 90% of Fairchild's sales during its first two years were defense-related [Lécuyer, 2007: 337].

A growing literature has described how events in Washington have influenced what happened in Silicon Valley. Ann Markusen delineates a number of possible government roles with respect to individual industries: "as rule maker, as producer and

consumer of goods and services, and as underwriter of innovation." [Markusen, 1996: 295] Scholarship on the Valley demonstrates the relevance of each of those roles. Leslie shows the federal government's role underwriting the Valley's innovation. [Leslie, 1993] Lécuyer does as well, and shows how the military, as consumer, "influenced the development of electronics component technologies." [Lécuyer, 2007: 2] O'Mara shows the government's role as rule maker (nationally) with respect to dispersion of defense industry and (locally) with respect to land use [O'Mara, 2005]. The federal government was also a rule maker shaping the Valley's key industries of radio and semiconductors, and the state government an arbiter regarding the growth of branch banking and the training of the high-tech work force. Another form of influence involves the Electro Dynamics Corporation, which acquired Charles Litton's manufacturing business in 1953, and then changed the parent firm's name to Litton Industries in recognition of the Litton brand's value to an all-important customer: the U.S. Navy. [Sturgeon, 2000: 34]

Scholarly exploration of Washington's role in Silicon Valley developments has been primarily limited to the early Cold War period, as indicated by titles such as *Cities of Knowledge: Cold War Science and the Search for the Next Silicon Valley*; *Creating the Cold War University: The Transformation of Stanford*; and *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford*. [O'Mara, 2005; Lowen, 1997; Leslie, 1993] These books show that the period 1945-1960 was crucial in deepening key academic/industrial/governmental relationships Etzkowitz emphasizes, and in attracting talent and resources to the Valley [Etzkowitz, 2008]. Yet a concentration on the Cold War implies that such relationships and desires were distinctive to that period.

From the beginning, the success of high-tech firms in the region required not only know-how but also know-who—and Washington, D.C., belongs on any map of Silicon Valley. Rather than an anomaly, the Cold War sustained a long tradition of defense work (and business/government relations) in the region. Throughout the Valley's first half century (1909-1959), the region's high-tech activity was premised on such relationships.

Silicon Valley as Two Places

One of the cultural aspects of the Valley is an emphasis on the future rather than on the past—a constant focus on the horizon. In such a culture, the past can become an earlier version of the present rather than the foreign country it truly is, replete with contingency and paths not taken. In that sort of environment, the timing of observation can be very important, shaping not just interpretations of the past but definitions of what is observed.

Prior to 1980, there had been sporadic publications about the Valley, such as the book *Electronics in the West: The First Fifty Years*, [Morgan, 1967] a *Fortune* article titled "California's Great Breeding Ground for Industry," [Bylinsky, 1974] and an article for the IEEE called "The Origins of the Electronics Industry on the Pacific Coast" [Norberg, 1976]. Media attention to the region spiked in the mid-1980s; the number of references to Silicon Valley in the *Reader's Guide to Periodical Literature* for 1984 and 1985 each more than doubled those of any earlier year. The 1980s also brought a spate of books about Silicon Valley: Hanson, *The New Alchemists*; Rogers and Larsen, *Silicon Valley Fever*; and Malone, *The Big Score* [Hanson, 1982; Rogers and Larsen, 1984; Malone, 1985]. At the time, the geographic center of the region's high-tech activity was in Santa Clara (specifically, the headquarters of Advanced Micro Devices) [Madrigal,

2013]. The 1980s Valley, captured in amber by three compelling books, gave the appearance of an utterly self-contained region. Malone asserts: “More than any industry in history, it is a self-contained, living city” [Malone, 1985: 8]. Rogers and Larsen agree: “Almost all of Silicon Valley lies in Santa Clara County.” [Rogers and Larsen, 1984: 28] In the 1980s, Silicon Valley was, for all intents and purposes, Santa Clara County plus a small portion of southern San Mateo County.

Yet the mid-1980s was a distinctive time in the Valley’s history. Firms in semiconductors and other industries were increasingly dispersing their manufacturing around the globe. Most of the enterprise involved commercial and consumer products (by way of contrast to the period ending in 1960). Most of the region’s high-tech employees worked for firms headquartered in the Valley. By 1985, much of the region’s venture capital and legal capabilities were close at hand, but had been based in the Valley for little over a decade. Once there, venture capital firms adopted what Josh Lerner terms a “parochial view,” which means “wishing only to invest in firms within a few miles of their office.” [Lerner, 2009: 28] The self-contained, start-up-dominated portrayal from the 1980s would shape accounts of earlier developments in the Valley.

One of the most striking allusions in the literature on Silicon Valley is to the “Valley of Heart’s Delight,” the pre-1950 Santa Clara County of orchards and farmland. Saxenian notes that as late as 1940, Santa Clara County had about 100,000 acres of orchards, and “accounted for one-third of California’s annual crop of plums, cherries, pears, and apricots.” [Saxenian, 1985: 20] In just a few decades, Santa Clara County went from predominately orchards and farm workers to industrial parks and high-tech employees. Little wonder that many have penned stories with titles such as “From the

Valley of Heart's Delight to Silicon Valley," or "From Orchards to Hard Drives," or "From 'Garden of the World' to Silicon Valley." [Alpers, 2010; Findlay, 1992: 143] Malone writes, "What had been the Valley of Heart's Delight had been bulldozed and paved out of existence." [Malone, 1985: 428] Rogers and Larsen note that Silicon Valley "in 1950 was the prune capital of America. . . Today the fruit trees have disappeared." [Rogers and Larsen, 1984: 28] O'Mara writes, "Over the second half of the twentieth century, this region evolved from a primarily agricultural landscape far away from the centers of industry and capital to 'Silicon Valley'. . . 'the ultimate post-industrial city.'" [O'Mara, 2005: 97] That truth, combined with the accepted wisdom about the region's boundaries, would lead to a major historical misconception.

If the Silicon Valley saga were entirely a Santa Clara County story, then what happened there would have been nothing less than an economic miracle. In a few decades, the region went from orchards to chips, from agrarian to post-industrial—and with a competitive advantage to boot. Saxenian suggests, "Unhampered by the constraints imposed by pre-existing industrial traditions, the region's founders created a distinctive technological community." [Saxenian, 1994: 12] Who could fault distant observers for seeing in the region a macro version of the Horatio Alger myth?

Yet the establishment of Silicon Valley was no rags to riches story. Such an interpretation of the local history ignores the extent to which prior to the 1970s the role earlier industrial activity played in the region's development, as well as San Francisco's role in the Valley's activities. Prior to the 1970s, a majority of the high-tech employees of the Valley worked for satellite operations of companies based elsewhere in the United States. [Adams, 2011a] Such "domestic direct investment" was crucial in establishing a

critical mass of tech talent in the Valley. This was true for major employers in microwave electronics (Sylvania), aerospace (Lockheed and Westinghouse), and computers (IBM), years before Xerox PARC became a font of ideas for the personal computer. Thus, the resources to construct new facilities and to train much of the region's skilled work force came from outside the area. In that respect, the Valley was a beneficiary of America's postwar industrial might.

In the mid-1950s, Potter published *People of Plenty*, which used America's superior wealth to explain the American character. [Potter, 1965] Woodward countered that an entire region, the South, did not fit Potter's thesis. [Woodward, 1968] Subsequent events have shown the value—even to poor regions—of locating in the world's wealthiest country. A particularly compelling case is Research Triangle, which developed in what had been one of the nation's poorest states (North Carolina), and has shown that a strong higher education core, the capacity to attract industry, and access to financial resources could ameliorate regional economic liabilities. [Link, 1995]

Silicon Valley began in a much stronger position than Research Triangle, benefitting from its location in one of America's wealthiest states. For the Valley's indigenous firms, much of the capital investment was repurposed from the bounty of the region's legacy industries, such as railroads, mining, oil, agriculture, and shipping, bolstered by a 20th century takeoff in manufacturing [Rhode, 2001]. In that sense, the Valley's location provided a strategic advantage even before semiconductors arrived.

Pulling the lens back a bit reveals a different map of this high-tech region during its early years. Silicon Valley was really *two* places. During the period ending in 1959, key aspects of the innovation system, such as sources of capital and legal expertise,

originated in San Francisco. A general division of labor between the Valley (manufacturing and R&D) and San Francisco (finance and law) existed for half a century. The nexus of high-tech activity gradually headed south, attracted by developments at and around Stanford University, but still tethered to San Francisco's financial resources and legal expertise [Adams, et al, forthcoming]. Many high-tech firms founded prior to 1950 clustered south of San Francisco, but north of Santa Clara Valley. This was the case for high-tech entrants such as Litton Engineering Laboratories (and Litton Industries), Eitel-McCullough, Varian Associates, Dalmo Victor, and Ampex.

One of the distinctive aspects of Silicon Valley is that it contains the world's foremost venture capital community. Yet the Valley had more than 100 high-tech firms by 1959, the year Draper, Gaither, and Associates, the Valley's first VC firm, was established. [Saxenian, 1994: 208; Kenney and Florida, 2000: 106] Where had the capital come from for the earlier start-ups? From the same financial center that had previously bankrolled extractive, shipping, and manufacturing industry. Companies such as the Federal Telegraph Company, Litton Industries, Hewlett-Packard, Ampex, and Varian Associates worked with the Crocker National Bank, the Anglo California National Bank, the American Trust Company, and the Wells Fargo Bank—all based in San Francisco. Even government contractors needed capital.

Thanks to being in California, Silicon Valley firms did not need to make the trip to San Francisco often. Instead, they could do most of their banking business in their headquarters town, but also have access to far more funds when needed. This is because of another key benefit of location in California was branch banking. California's Banking Act of 1909 enabled urban banks to either create branches within the same city or elsewhere,

or to acquire established banks and to deploy them as branches. Within two decades of passage of the Act, California became the nation's epicenter of branch banking. A 1932 report from the Federal Reserve Board indicated that "California is the only State in the Union in which modern intern-community branch banking has had a considerable development." [Goldenweiser, 1932: 1] This mattered to at least two other Valley firms besides H-P that had major "liquidity events" (acquisitions or initial public offerings) in the 1950s: Litton Industries, and Varian Associates. In 1952, when Litton Industries was a $600,000 firm with only 57 employees, it needed a $700,000 loan from American Trust to execute a $2 million fixed-price contract from the Air Force, collateralized by the contract. The loan was made possible by a new law (as was H-P's 1945 "T" loan). As of 1941, firms doing defense work could use their contracts as collateral for loans, and that is what H-P did [Nash, 1985: 34]. Discussions began at the local bank branch, but concluded twenty miles north at the American Trust San Francisco offices [Moore & Woenne, 1973: 22-23].

Varian Associates was, along with Hewlett-Packard, one of the two largest indigenous firms in the Valley in the 1950s. Only two years after its 1948 founding, Varian had annual sales just shy of $500,000, and employed just over 100 people. The company's financing was primarily through bank loans of about $120,000 from the Palo Alto branch of the Anglo California Bank. [Special Meeting Nov. 6, 1950, 73/65c, carton 1, folder 1] That changed in a hurry. Less than one year later the company needed working capital of about $2.7 million, and needed to expand its production facilities.

In September of 1951, Varian resolved these interrelated issues. The company agreed to a 99-year lease in the Stanford Industrial Park. The building they planned to construct would act as collateral for a $1.52 million loan from the Reconstruction Finance

Corporation loan. Meanwhile, the company's bank loans (secured by receivables and government contracts) with Anglo California had increased to more than $500,000, and the company's revolving credit agreement, guaranteed by the U.S. Air Force, grew to $600,000 by October. In short, the company had financing of more than $2.5 million guaranteed or collaterized by the U.S. government. It's a good thing they did: by the following April, executives expected sales to rise to $640,000 *a month*, with associated working capital needs of $2.7 million. [Executive Committee Meeting, April 1, 1952. 73/65c, box 1, folder 3] Having the relationship with a large San Francisco bank still mattered, however: when the RFC ceased operations in 1954, Anglo California took over Varian's RFC loan. [Statement of financial condition for 12/31/54]

California's branch banking helped accelerate one of the features of the digital revolution in the United States: the suburbanization of tech. In the new knowledge economy, in which know-how of employees mattered most, their desire to live in suburbs helped drive industrial location. It was an advantage for Silicon Valley that it was located on a peninsula where the distance from the San Francisco on the north and San Jose on the south, was just shy of fifty miles. California's system of branch banking helped shrink the gap, emboldening firms to locate closer to Stanford University, and then to other firms, without distancing themselves from a quick and familiar source of loans.

Law followed a different path to a similar outcome. From 1909 to 1959, both capital and legal expertise for the Peninsula's tech firms came from San Francisco. California's highly mechanized farming operations and application of scientific methods to extractive industry involved much technical innovation [Nash, 1972]. Such innovation, encouraged by high transportation costs--which hindered competition from the Midwest--

reinforced what Olmstead and Rhode call “cumulative and reinforcing character of the invention and diffusion process” [Olmstead and Rhode, 1988: 87]. This attracted skilled mechanics to California, and resulted in a greater number of patents per capita than all but one of the states in the union during the first two decades of the twentieth century [Carlton & Coclanis, 1995: 322-323]. That was a boon to patent attorneys. When local electronics firms sought protection for their intellectual property or guidance on how to avoid infringing on the patents of others, San Francisco-based attorneys were ready to help. From the 1920s until the 1960s, high-tech firms on the peninsula used leading patent attorneys, such as Paul D. Flehr and Donald Lippincott, based in San Francisco [Sturgeon, 2000: 31, 35, 40; Flehr, 1989].

Paul D. Flehr represented a legal link between California’s early industries and its high-tech future. After working in the U.S. Patent Office, in 1925, he joined the San Francisco firm of White, Prost and Evans. Flehr’s first client was the Federal Telegraph Company. William White’s previous firm, Miller & White, had performed Federal’s initial patent search in 1911, months before Federal had any revenue. [1914 report] Before his engagement with Federal, White’s work had involved agriculture and oil—two of California’s initial big-ticket industries. Flehr’s early career preceded the takeoff of electronics on the Peninsula, so he also worked with clients in agriculture, mining, and other industries. In the 1950s, four relatively young firms in what would later be called Silicon Valley (San Mateo County and Santa Clara County) made initial public stock offerings, sending a signal that there was serious money to be made in tech. Founders of three of the four (Hewlett-Packard, founded in 1938; Ampex, founded in 1944; and Varian Associates, founded in 1948) had been clients of Paul Flehr.

Donald Lippincott's career was focused on electronics. A 1913 graduate of the University of California, Donald Lippincott worked in the electronics industry for several years (including as chief engineer at Magnavox, a spin-off of Federal Telegraph, in Oakland) before earning a law degree in the late 1920s. In the 1930s, Lippincott represented San Francisco inventor Philo Farnsworth in his legal battle with RCA over the rights to television, and worked for Stanford engineering professor Frederick Terman on legal aspects of his work with International Telephone and Telegraph (ITT). During World War II, Lippincott was chief patent officer for the U.S. Signal Corps. Lippincott's firm later handled the patenting of the integrated circuit for Fairchild Semiconductor.

As high-tech enterprise clustered in Santa Clara County and automobile traffic between the Valley and San Francisco became increasingly congested, local access to patent-law expertise became an advantage. No law firm would exploit that advantage more successfully than Palo Alto-based Wilson, Sonsini, Goodrich and Rosati, which expanded from a handful of attorneys in the 1970s to more than 600 by the year 2000. [Johnson, 2000: 326]. Wilson Sonsini adapted to the needs of their customers; in many cases, taking an equity position in lieu of the start-up's all-too-scarce cash.

Not until its second half century would the high-tech region develop a local innovation system of organizations whose primary mission is to enable start-ups. Prior to the arrival of such organizations, there was one institution that—although it had a different explicit mission—enabled local start-ups: Stanford University.

The Third Mission

Silicon Valley benefitted not just from growing up amidst the world's leading economy, near the West's premier financial center, and in a country developing the world's largest system of national defense. The Valley was also in proximity to key nodes in the world's foremost system of research universities. Roger Geiger emphasizes the "decentralized competitive structure" of America's university system, which fostered "innovative and entrepreneurial behavior." [Geiger, 2004: 132]. From the late nineteenth century to the late twentieth century, America's distinctive blend of public and private higher education experienced two revolutions. The first involved a shift from a focus on teaching to inclusion of the German-style research university, beginning with the Johns Hopkins University. The second revolution involved a "third mission" for the university, to help foster regional economic growth.

Stanford University was part of both revolutions. No individual played a bigger role in catalyzing such efforts than Frederick Terman. As department chair of electrical engineering, as dean of the engineering school, and then as provost, Terman established key relationships with industry that were of sufficient importance that he became known as the "Father of Silicon Valley." Resources accruing to the university because of those relationships, and activity on behalf of the government helped Stanford elevate its academic reputation into the ranks of the elite universities. [Gillmor, 2004].

The existing literature on Stanford's development describes a parallel to the Valley's transformation from orchards to chips. Thanks in no small part to language that Terman and Stanford President J. Wallace Sterling applied after the fact, Stanford has been portrayed as having been a "regional" university on the eve of the Cold War.

[Sterling, 1965; Leslie, 1993: 45]. Stanford University was born important, like other notable academic start-ups in the late nineteenth century, such as Johns Hopkins, the University of Chicago, and Stanford's perennial rival, the University of California at Berkeley. In 1900, Stanford was one of fourteen inaugural members of the Association of American Universities, and, in addition to one of the largest university endowments, already had world-renowned scholars and departments (including electrical engineering) by early in the twentieth century. [Geiger, 1986: v, 39, 276-277] Moreover, Stanford's relationship with industry antedated not only the Cold War, but the twentieth century. Instead of a weak regional institution, Stanford provided a significant regional endowment for development of the Valley from its beginning.

Before Stanford was ten years old, in 1898, Professor Frederick Perrine had contract work with the electric power industry. [Williams, 190-192] Perrine's successor, Harris Ryan, fostered close participation with the power industry, attracting industry sponsorship for the nation's state-of-the-art electrical laboratory in 1926. [Williams: 193] A prolonged budget crisis in the 1930s and 1940s cut so deep that it gave ex post facto support for the notion of Stanford's humble beginnings. In any case, the crisis provided an opportunity for its Stanford's administrators to generate entrepreneurial responses [Adams, 2005].

When Frederick Terman became dean of engineering in 1945, he sought resources from both industry and the federal government. In the immediate aftermath of World War II, U.S. industry had no peer, especially in big business, as the multidivisional organization gained popularity. [Chandler, 1962]. Stanford found many deep pockets through various programs of outreach to American industry: the Stanford Industrial Park

(rents from primarily high-tech firms), the Honors Cooperative Program (double tuition for graduate work by employees of local firms), and Affiliates Programs (annual stipends from firms wishing to hire Stanford high-tech graduates, and seeking early access to Stanford-developed technology). Most of the money Stanford attracted was from established firms based outside of the Valley [Adams, 2005].

The deepest pockets of all were those of the federal government. During the early stages of the Cold War, the United States was building technological capabilities for defense, and Terman sought to make Stanford a key research player for the government the way Harvard and MIT had been during World War II. [Pursell, 1972: 338]. He succeeded. Increased flows of defense money from government and industry helped Stanford create key laboratories and hire important faculty members. [Leslie, 1993: 44-75; 102-132; 160-187]. He did so by using a different model (seeking funding from the private sector and from Washington) than UC Berkeley during this period (relying more on money from the state of California than from industry) [Adams, 2009].

After having been what Stuart Leslie terms a "benchwarmer" during the war, in 1946 the university had government contracts worth $127,000, which included Stanford's first contract with the Office of Naval Research (ONR). [Leslie, 1993: 45] By the mid-1960s, Stanford's defense total became $13 million (including contracts with the Army Signal Corps and the Air Force), in addition to $50 million from the Atomic Energy Commission for the Stanford Linear Accelerator. [Leslie, 1993: 45-46]

Stanford was not the only player in the higher education game on the Peninsula, nor did its administrators want it to be. It was a relatively small university, and its engineering school did not pursue a comprehensive staffing strategy. Instead, the school

sought to develop what Terman called “steeples of excellence,” a few fields in which its faculty’s research was internationally competitive. This resulted in a division of labor in which Stanford focused on graduate education, leaving much of the training of undergraduates to others. Along the way, Stanford fostered development of San Jose State’s engineering program, which opened its doors in 1946. San Jose State has since been a leading supplier of engineers for the Valley’s workforce, so its engineering program is one of Stanford’s most important spin-offs [Adams, 2011b].

By the 1960s, Frederick Terman was helping shape the high-tech landscape not just in Silicon Valley and California, but also in other states and overseas. Terman was in demand as an advisor to academic, industry, and governmental officials in places such as South Carolina, Colorado, Texas, New Jersey, and South Korea. [Leslie & Kargon, 1996; Adams, 2009]. After his 1965 retirement from Stanford, Terman had increasing time for such consulting engagements. As he travelled and discussed the Stanford model and high-tech growth in the Valley, important changes were under way back home that were transforming the region.

America’s public-sector part of what Henry Etzkowitz dubbed the Triple Helix (university, industry, and government) evolved in the latter third of the twentieth century. Granted, the federal government would continue to matter a good deal to high-tech regions. The government’s role shifted to a greater emphasis on setting rules to help foster economic development: changes to the capital gains tax and the Prudent Man Rule (which encouraged institutions to include private equity in their portfolios), enactment of the Bayh-Dole Act (which encouraged university involvement in high-tech enterprise) and the Immigration Acts of 1965 and 1990 (which helped attract more talent, especially

from East and South Asia), and establishment of the United States Court of Appeals for the Federal Circuit (which helped in defense of intellectual capital). Although defense work would remain a mainstay in several corners of the Valley through the 1980s, commercial work as a percentage of the whole increased dramatically, and consumer products (beginning with digital watches, calculators, video games, and personal computers) played an expanding role. As John Findlay notes, "consumer goods really represented a second career for [the Valley's] high-tech businesses." [Findlay, 1992: 144]

The Valley turned less frequently to San Francisco for resources, and developed its own set of local institutions. As time went on, the Valley would rely less on the skills and resources of satellite operations of firms based elsewhere. [Adams, 2011a]. Local venture capital and legal capabilities became distinct aspects of the innovation system. Silicon Valley firms would become responsible for about one-third of America's total venture capital investments, and the Valley became home of the world's preeminent high-tech law firm. Beginning in the 1960s, San Francisco played less of a role in shaping the Valley, and (especially in the twenty-first century) the Valley would play an increasing role in shaping San Francisco. The localization of the infrastructure accompanied a shift to more indigenous enterprise. A new phase of the Valley's development was under way.

Conclusion

The Silicon Valley of 1909-1959 was very different from the Valley we see today, and even from the Valley that received increasing attention in the 1980s. During the Valley's first half century, a more far-flung innovation system was at work, one that featured

financial and legal services from San Francisco. In this earlier system, the federal government provided defense contracts and loans; established firms invested in satellite operations in the Valley and provided many skilled workers and administrators.

In 1994, AnnaLee Saxenian published *Regional Advantage*, which remains the most influential scholarly book about Silicon Valley. Saxenian asks how Silicon Valley overtook the Route 128 area outside of Boston as the world's leading high-tech region, and then provides two major explanations: contrasting cultures and different organizational forms. Route 128, the "loser" in this competition, settled for being merely one of the world's most prolific entrepreneurial high-tech regions [Saxenian, 1994; Roberts and Eesley, 2011].

I would pose another question: How did two top high-tech regions end up in the same country? One of Silicon Valley's competitive advantages was its location in the United States as it used its wealth to project political, military, and technological power on the world stage. In that respect, the Silicon Valley story fits the institutional interpretation of Baumol and Strom regarding the relationship between the "nature of entrepreneurial incentives" and governmental rules. [Baumol and Strom, 2007: 234]

Silicon Valley grew up in the world's wealthiest country, in proximity to the principal financial center west of the Mississippi. It grew up in a region with capital to repurpose from mining, oil, shipping, and agriculture. It grew up in a state with laws that favored branch banking, encouraging the suburbanization of technical industry. It grew up in a region of geopolitical importance in a country that was becoming the world's leading military power—and provided financial and legal support to defense contractors. It grew up near one of the primary nodes in the world's top system of research

universities. The first half century (1909-1959) of this high-tech region was a process reliant upon an abundance of supporting institutions and accessible resources rather than one garage-based start-up after another inscribed upon a tabula rasa.

Michael Porter has argued that in the twenty-first century, economic prosperity would be "created" through innovation rather than inherited through factor endowments, such as natural resources. [Porter, 1998: 554]. Silicon Valley inherited a different set of endowments, by virtue of its location. During Silicon Valley's first fifty years, innovation was made possible by an existing innovation system. As other regions craft strategies to become the next Silicon Valley, their policy makers need to know the extent to which the "master cluster" benefitted from being in the right place, at the right time.

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