5

Paths and Regions: The Creation and Growth of Silicon Valley

Martin Kenney
University of California, Davis
Berkeley Roundtable on the International Economy

Urs von Burg
University of St. Gallen, St. Gallen, Switzerland

For the last 40 years, a geographic and mental space in the San Francisco Bay Area now known as Silicon Valley has been the birthplace of many of the largest and fastest growing electronics firms in the world and a number of new industrial sectors.[1] The technologies these firms commercialized have had a significant impact on many aspects of social and economic life. To facilitate the commercialization, a set of institutions evolved in Silicon Valley to nurture the new firms; these were established to exploit the potential for rapid growth stemming from electronics innovations.

The observation that technologies and places have histories and that these histories matter is, by itself, unremarkable (see Bassanini & Dosi, chap. 2, this volume). If, to invert Voltaire's (1999) Dr. Pangloss, it is accepted that the current situation is not necessarily the best of all possible worlds; then we would leave the world of microeconomics and enter a world of struggle, strategy, and serendipity, in which human beings working alone

[1]This region is also the home of a large number of medical equipment firms and the largest concentration of biotechnology firms in the United States. These startups derived critical benefits from proximity to institutions such as venture capital described later in this chapter.

and in groups, create novelty, while being conditioned by their history. In this world, the theoretical models of microeconomics lose power and can only be accepted as partially valid, at best; more often, are irrelevant. Freed from the simplistic, totalizing, ahistorical model of microeconomics, we are regrettably confronted with complexity.

Path dependency directs inquiry toward the ways in which today's realities are based on yesterday's events. Silicon Valley is, in many ways, an ideal case for examining the strengths and weaknesses of path dependent explanations. The concepts from path dependency literature provide a useful departure point for understanding the creation and evolution of Silicon Valley. For one thing, Arthur (1994) specifically referred to Silicon Valley as an example of path dependent industrial clustering due to agglomeration effects. Implicit, but not articulated and examined, is the idea that paths are created by human actors operating in time (Karnøe & Garud, 1998). Throughout this chapter, our evaluation of the applicability of path dependent arguments for explaining the dynamics of Silicon Valley integrates the creative dimension of path development.

Particularly important for understanding Silicon Valley is linking the opportunities technological evolution provided with the creation of institutions and even specific regional industrial cultures.[2] In effect, path dependency is intimately related with path creation. Silicon Valley's institutions and cultures can be understood as a set of evolving, path dependent routines nurturing specific combinations of extrafirm industrial patterns within its circumscribed region (Foray, 1991; Storper & Walker, 1988). Regional growth cannot be reduced to either business or technical developments; rather, technology and institutions dialectically create an unfolding path (Hirsch & Gillespie, chap. 3, this volume). Cook and Seely-Brown (chap. 1, this volume) use the "generative dance" as a metaphor for describing this dialectic.[3]

This chapter considers how the concept of *path dependency* can be extended to thinking about the creation and evolution of regions. The second section reviews the previous explanations for the growth and development of Silicon Valley. It also introduces our argument that to understand Silicon Valley, it is helpful to see it as two separate economies. The first economy consists of existing firms, whereas the second economy consists of the institutions that have evolved to nurture new startups. The third section examines the genesis of Silicon Valley as a high-technology region. The fourth section shows how it was the spin-off pattern developed among the semiconductor firms that catalyzed the industry, which was central to the creation of the institutions that now exist in Silicon Valley. The fifth section singles out venture capital as one critical institution for the development of Silicon Valley. The conclusion discusses the strengths and weaknesses of the path dependent perspective for explaining the creation and subsequent evolution of Silicon Valley.

[2] See Rao and Singh (chap. 9, this volume) for a discussion of the institutionalization of particular technologies. Especially interesting is their discussion of the biotechnology industry, which was a clear beneficiary of the Economy Two, which will be discussed.

[3] *Ex poste facto*, the outcomes of this generative dance can be seen as a path or even a technological trajectory (on technological trajectories, see Dosi, 1984).

PATH DEPENDENCY

The concept of path dependency was developed by economists such as Arthur (1988) and David (1986) to describe the phenomenon they noticed of apparently inferior technologies dominating market spaces (for a more detailed discussion, see Hirsch & Gillespie, chap. 3, this volume). Arthur (1994) developed abstract mathematical models showing how features such as increasing returns could create winner-take-all outcomes. David (1986, 1990, 1997, 1999), in a series of historical articles, demonstrated how this occurred in the adoption of specific technologies. They found that under certain conditions, early decisions reverberate through history, closing alternative paths and validating a single path. The implication is that history matters and outcomes need not be rational or optimal.

Though there have been a number of critiques of the claims of path dependency,[4] this chapter considers path dependency as a significant contribution precisely because it problematizes the present. Path dependence accepts that small events can have very large later impacts. What is significant in this stance is that it permits these small events to be precipitated by noneconomic events. This is a critical opening for explanations not dependent on simple short-term profit maximizing. In a path dependent world, social constructions and strategic maneuvering in a nondeterministic environment are critical for path formation.[5]

It is not a great leap to accept that technology and the institutions in which it is embedded coevolve from path dependency (For the definitive discussion of evolutionary economics, see Nelson & Winter, 1982; on

[4] Critiques from the economic mainstream include Liebowitz and Margolis (1990, 1995). Sabel (1998) argued that in theoretical terms, path dependency removes human choice and collective action from the evolutionary process. One curious oversight in the QWERTY versus Dvorak debate is the fact that Dvorak was introduced in the 1930s. Dvorak had a much more difficult task, that is, dislodging an already established technology, QWERTY. A more comprehensive discussion and critique is provided by Ruttan (chap. 4, this volume) and Bassanini and Dosi (chap. 2, this volume).

[5] See Pinch (chap. 14, this volume) for an exposition of the social construction of technology perspective. We sympathize with the social constructionist perspective, but find the implicit deliberative and planned meaning of "construction" quite dangerous. Here, Cook and Seely-Brown's metaphor of a "generative dance" (chap. 1, this volume) is closer to our perspective on how technologies and institutions evolve. There are no blueprints and no certainty.

embeddedness, see Granovetter, 1985). Hirsch and Gillespie (chap. 3, this volume) point out the nested, intertwined nature of many path dependent phenomena, that is, a particular technological choice is often an outcome of the interaction of a number of path dependent processes. Implicit, but not well developed, is the recognition that any path is, in fact, built by actors creating, using, and reshaping the infrastructure of institutions, routines, and organizations in which the technology is embedded. This activity includes suppliers, but ranges further to include capital equipment makers, specialized financial institutions, marketing and distribution organizations, educational institutions, and a myriad of other organizations, many of which are specialized in the needs of a particular industry. Often, perhaps more important, is creation on the demand side where occupying a market space and developing customers can be critical for the adoption of an innovation. Christensen (1992) showed in the hard disk drive (HDD) industry that the emergence of new customers was critical for the survival and growth of new entrants. At times, this also extends to creating new distribution, marketing, and retail networks. In other cases customers have to be mobilized; for example, what Lampel (chap. 11, this volume) terms *technological spectacles* or *races* establish the characteristics of particular brands or even technological solutions (see also Rao & Singh, chap. 9, this volume).

Definitive explanations of industrial emergence and firm clustering in specific regions remain elusive. In a parallel to the path dependence and dominant design theories (Arthur, 1994; David, 1986; Henderson & Clark, 1990), industrial geographers such as Storper and Walker (1988) found that there are periods of locational opportunity before an industry clusters and locks-in into specific locations. Both economists dealing with innovations and industrial geographers studying regional industrial growth find that often there is an initial period of openness with a number of contenders prior to the selection of a dominant design or dominant location. It is at such moments that the small events can result in the long-term differences.

Arthur (1994) explicitly argued that positive feedbacks led to the clustering of the electronics industry in Silicon Valley. In an industry in which spin-offs are frequent, the industry will tend to cluster in a certain region when there are agglomeration economies. In the abstract model, the actual location selected is random and the spin-offs or agglomeration economies reinforce clustering in a particular region. This formal model is powerful, but even at the earliest stage, not all regions have equal competencies.

SILICON VALLEY—AN INTRODUCTION

Silicon Valley, as we shall see, had many antecedents and is the outcome of a pastiche of forces, accidents of history, planning, and human foresight. Although integrated circuitry was the triggering technology for the development of the Silicon Valley agglomeration, it was not the only electronics technology in which it became a leader. For example, in the 1940s, Silicon Valley already had entrepreneurs experimenting with magnetic recording techniques at Ampex. But it was IBM's decision in 1952 to open a laboratory in San Jose to develop magnetic recording techniques for data storage that created the intellectual capital, which evolved into the merchant disk drive industry (Gan 1991). This magnetic recording expertise led not only to the HDD industry, but provided a basic technology for the telephone call processing equipment industry. Another important industry, computer networking, had its antecedents in the Xerox Palo Alto Research Center (PARC) laboratory and an Exxon-founded semiconductor firm, Zilog. Much of the knowledge that led to the relational database software industry was developed in the computer science department of IBM's San Jose Laboratory. What all these fields shared was extremely rapid technical change and quickly growing markets. The proliferation of new industry segments meant Silicon Valley could grow even faster than it would have had it been entirely dependent on the semiconductor industry.

For heuristic purposes, Silicon Valley can be conceptualized as two interrelated economies.[6] *Economy One* includes existing firms producing integrated circuits, software, computer networking equipment, computers, and a myriad of other electronics products, that is, the existing high-technology firms and other institutions, such as universities. *Economy Two* is a loosely structured network of venture capitalists, lawyers specializing in high-technology, accountants, and consultants. Their intention is to facilitate the creation and growth of firms that can later be sold to larger firms or listed on the stock exchange not to ship products. The introduction of this division is not so much driven by theoretical concerns, but rather for the optic it provides for understanding the dynamics of the region. The ability to develop new firms to exploit technological opportunities is dependent on different institutions than those necessary to operate already established firms.

The two economies are interrelated because Economy Two depends on Economy One. Conversely, firms successfully nurtured by the institutions of Economy Two become members of Economy One. However, these economies are not identical. In Economy One, the firms create products and services to be sold. In Economy Two, the product *is* firms, which embody a set of technologies and routines that another firm will purchase or that capital markets are willing to invest in by purchasing equity. In both cases, the pur-

[6]This distinction is not theoretically driven. The purpose is to separate two quite different activities: the operation of existing firms and institutions and the operation of institutions dedicated to creating firms *de novo*. The point being that the dynamics of Silicon Valley are best understood through this analytic distinction, which is ungeneralizable to most other regions.

chases are justified by the belief that the firm will grow sufficiently to increase its value. In and of itself, innovatory activity in an already established firm does not directly benefit Economy Two of Silicon Valley. However, indirectly inventions and innovations in existing firms can be extraordinarily beneficial because they are the raw materials for new opportunities for entrepreneurship. Not surprisingly, Economy One firms are the single largest source of entrepreneurs for Economy Two.

When these two Economies are conflated or one is ignored, it is difficult to understand Silicon Valley. Regional growth in Silicon Valley is predicated on Economy Two. A suggestive study by Almeida and Kogut (1997; see also, Kogut, Walker, & Kim, 1991) using patent data and semiconductor firm location showed that the presence of the large semiconductor firms is highly correlated with the incidence of small firm establishments. They found that the large number of semiconductor firms (density) created the conditions for the establishment of still more firms. And, not surprisingly, the greatest density was in Silicon Valley. In effect, since the creation of Fairchild, the region developed a set of extrafirm institutions and routines that fueled growth and continuing reproduction. Of critical importance here is the intervening variable of an environment making large numbers of new entrants possible. This environment is composed of the institutions of Economy Two.

The dynamism of new firm creation and the wealth in Silicon Valley has drawn great interest from academics and policymakers. A number of explanations of the dynamics and operation of the Silicon Valley regional economy have been advanced. Saxenian (1994) explained Silicon Valley's success by comparing it to the relative stagnation of Route 128 in Boston during the 1980s. The heart of her argument is the proposition that Silicon Valley's firms remained flexible and interactive, whereas those established along Route 128 became hierarchical and rigid.[7] She held that Route 128 firms were vertically integrated whereas Silicon Valley firms either remained, or wisely, decided to become specialists. There are difficulties with this comparison and explanation, as it ignores the fact that Route 128 was built on minicomputer systems, whereas Silicon Valley was built on the semiconductor component—a far more general or basic electronic part (Robertson, 1995). Silicon Valley cannot be reduced to existing firms or their interactions, rather any explanation of the dynamism must also explain the regional routines and institutions that nurture new firm formation.

There are also a number of cultural explanations of Silicon Valley (Weiss & Delbecq, 1990). Here, Economy Two is equated with a culture of entrepreneurship. Yet this provides little explanation of the economic and technological foundations for the culture and the concrete conditions that sustain it. In this particular formulation, *culture* refers to economic activity, that is, purposeful activity directed toward financial gain. Few of these cultural explanations connect individual's actions to their pursuit of financial gains. In effect, economic acts are explained by cultural attributes and potential economic explanations are downplayed (Weiss & Delbecq, 1990). As an example, the propensity to establish new firms is attributed to a culture of startups. Curiously, these explanations make no reference to the potential for the entrepreneur to secure large capital gains and the fact that the entire infrastructure of Economy Two has evolved to facilitate and share in those capital gains. The infrastructure does not encourage startups that have no potential for realizing large capital gains; in fact, venture capitalists even have a word for firms that do not go bankrupt, but cannot be sold—these are known as "zombies." This is a pejorative term for companies that are too small and have insufficient growth potential, but already have the venture capitalists' investments.

[7] I do not examine this argument here. For an analysis of this position, see Kenney (1998).

A less prominent stream of study has designated Economy Two as the critical feature of Silicon Valley. For example, Schoonhoven and Eisenhardt (1989) argued that Silicon Valley is an "incubator region," in which there are numerous institutions whose *raison d'être* is to nurture the establishment and growth of small startup firms aiming to exploit a market opportunity. They empirically tested the incubator region concept by examining the creation and survival of new semiconductor firms in the United States from 1978 to 1986. Their findings show that the Silicon Valley firms had greater survival rates. In other words, the social institutions existing in the region provided environmental resources that incubated these new firms. Florida and Kenney (1988a, 1988b) advanced the concept of a "social structure of innovation," by which we meant an interactive set of institutions dedicated to encouraging technological innovation.[8] More recently, Bahrami and Evans (1995) conceptualized Silicon Valley as an "ecosystem" consisting of various institutions, skill sets embodied in individuals, and an entrepreneurial spirit. These three perspectives identify the ingredients that have made Silicon Valley so successful in creating new highly successful firms; however, they do not explicitly weave the trajectories of the technologies being exploited into their explanations.

The differences between firm organization in different regional industrial agglomerations can also be explained on another dimension, namely the technological dynamics the particular industry faces. For Robertson and Langlois (1995) the innovatory situation a region's industry faces in terms of

[8] Lynn, Reddy, & Aram (1996) advanced yet another somewhat similar concept of an "innovation community," however their concept is more general and seems to fit established industries better than it fits environments such as Silicon Valley or Route 128. Also, it is not quite as explicitly spatial.

the product cycle conditions the organization of the region's networks, interfirm interaction patterns, and firm structures. For example, the high-fashion garment district firms of Northern Italy face constant change in fashion designs, but these changes occur only along very limited dimensions, that is, in the designs, colors, fabrics, and shapes of the particular item; but the product, such as, jackets, pants, etcetera, does not change. In this situation, the change in production equipment and worker skills is gradual.

Silicon Valley faces a far more complicated set of changes including technologies, products, processes, and entire industrial categories. Not only are product generations rapid, but new product categories can emerge, even as other entire categories disappear (Kenney, 1998). This means turbulence is ongoing and interfirm and intrafirm relations are under continual stress. No firm or set of firms can be certain that its particular technology or product will survive. Requisite skills change rapidly, as established products evolve or are discontinued to be made in other regions (e.g., floppy disk drives and DRAMs), entirely new products are introduced constantly, customers and suppliers change, and new customers or suppliers emerge (for discussions of hard disk drives see Christensen, 1992; for RISC microprocessors, see Garud & Kumaraswamy, 1995; for LAN systems, see von Burg, 1998). New firms with superior technology can emerge rapidly and displace older firms committed to obsolete technologies.

The Langlois and Robertson (1995) thesis—that the industrial organization of regions and firms is correlated to the region's position on the product cycle—is an important contribution to understanding the linkage between particular types of networks and industrial regions. Their model explicitly recognizes the importance of the types of innovation or market changes facing firms, thereby incorporating technical change as a critical variable—a factor surprisingly underplayed in many explanations. For example, in the semiconductor industry, even while particular industrial segments such as DRAMs and microprocessors developed predictable trajectories and/or strong incumbent firms, new segments emerged, igniting a new cycle by lowering entry barriers and allowing new startups. Therefore, the semiconductor industry as a whole did not mature, rather the locus for new firm entry constantly shifted. In computer local area networking, there was a similar process of new firm formation at each discontinuity in the expansion of the network (von Burg, 1998). Economy Two is based on these technical and market discontinuities.

The economic dynamism of Silicon Valley is partly from the fast-growing established firms, such as Intel, Sun Microsystems, or Hewlett Packard, which have graduated to Economy One, but much more important are institutions of Economy Two that encourage new firm formation. Rapid firm formation is not unique to Silicon Valley; there have been periods and regions

before that experienced rapid firm formation. For example, Rao and Singh (chap. 9, this volume) discuss the early phases of the automobile industry. For autos, a dominant design emerged and new firm entry became quite difficult. The electronics (and also biotechnology) industries experienced repeated new opportunities, so even as certain segments developed a dominant design and entrenched firms, new segments opened up creating new spaces for new firm formation.

However, displacing explanation to a set of entities such as regional institutions does not really help us understand the development of Silicon Valley. Most observers treat economic institutions as natural phenomena that exist *sui generis*, when, in fact, they are created. Economic institutions and routines such as the venture capital investment process are the outcomes of complicated evolutionary paths, reinforced by success or diminished by failure. Obviously, the greater the success of such routines the more they were reinforced; in this way, they could eventually become an attribute of the "culture."

This section argued that there are two economies in Silicon Valley and both exhibit path dependent characteristics. The actual evolutionary process is quite complicated because both Economy One and Economy Two are moving along trajectories made possible by Moore's and Metcalfe's Laws, which postulate a world where value and capabilities are increasing so dramatically that new commercial opportunities are constantly being uncovered.[9] The next section illustrates the path dependent nature of the semiconductor industry in Silicon Valley.

SEMICONDUCTORS

In 1947, the first operating semiconductor transistor was developed at Bell Laboratories in New Jersey.[10] At that time, few foresaw the vast technological possibilities that the semiconductor's evolution would make possible. Semiconductors would permit the digitalization of many analog functions and quickly displayed an improvement curve that allowed a doubling of capacity approximately every 18 months driving the cost per transistor down dramatically. This meant that problems relating to insufficient or too expensive calculating capacity were constantly being solved, permitting a constant flow of new applications (i.e., watches, calculators, mobile phones, communications computers, ever smaller computers, and various

[9]Moore's Law states that the number of circuits that can be placed on a given area of silicon doubles roughly every 18 months (Moore, 1965). Metcalfe's Law states that for any number of *n* machines linked by a network you get *n* squared potential value (Gilder, 1993).

[10]For excellent discussions of the development of the semiconductor, see Braun and Macdonald (1982), Riordan and Hoddeson (1997).

other artifacts that contained embedded computing power). Analog functions and signals could be replaced by the increasingly sophisticated integrated circuitry, so records were replaced with compact disks, watch gears with a chip, typewriter gears and levers with word processing programs, or human hands and brains with computer controlled machine tools. The semiconductor eventually would allow physical phenomenon to be digitized that no one could have foreseen.

The pace of change confirmed by Moore's Law meant incessant change and the continuous emergence of new business opportunities to produce either inputs to integrated circuit production, integrated circuits optimized for various functions, or artifacts using integrated circuits. In this environment, obsolescence of artifacts, technologies, and capabilities was incessant, thereby opening space for new entrants (for a discussion of this, see Kenney, 1998; Kenney & Curry, 1998). In other words, market-dislocating technological advances occurred frequently. Yet, even more important, were innovations defining new markets and repeatedly semiconductors were critical enabling components for industries ranging from computer networking equipment to personal computers and mobile phones. For semiconductor companies, so many new business opportunities emerged that management had to decide which ones to pursue, recognizing that if a project was blocked internally, the engineers developing the technology might decide to use the knowledge to build a new firm (Intel, 1984).

Semiconductors were at the heart of a massive technological revolution (Gilder, 1989). The exponentially increasing processing power of integrated circuits permitted the creation of new products and the transformation of old products and industries. The per-unit price of information processing power embodied in integrated circuitry dropped at a 40% annual rate for more than 20 years. Braun and Macdonald (1982) provided the example of a Fairchild transistor sold in 1959 for $19.75 that in 1962 was sold for $1.80. Most significant, invariably the transistor was profitable at both prices as learning curve and mass production economies lowered costs and the design costs were amortized during the initial part of the learning curve. This incessant fall in prices meant that by 1997 the price per transistor on an integrated circuit chip dropped to less than $.000001. These extraordinary price-learning curves created fantastic opportunities for increased profitability and constantly opened new business opportunities that could be exploited by startups (Gilder, 1989).

THE GENESIS OF SILICON VALLEY

Silicon Valley is a postwar phenomenon, however there were precursor firms in the prewar period. Sturgeon (2000) maintained that the Bay Area's pre-World War II successes in developing vacuum tubes and a number of other devices formed the base on which the postwar growth was built. For example, in 1906, Lee de Forest invented the triode in the Bay Area and later in the 1920s, Philo Farnsworth relocated from Utah to the Bay Area with the intent of developing a working television. Farnsworth received financial support from W.W. Crocker, president of the Crocker National Bank (Fisher & Fisher, 1996). In the 1930s, Hewlett Packard was founded by two engineers at the behest of Frederick Terman, the dean of engineering and later provost at Stanford University (Leslie, 1993; Lowen, 1992). However, these disparate activities did not coalesce into a coherent pattern or set of practices.

World War II was a watershed for the U.S. electronics industry and the Bay Area benefitted greatly from massive electronics-related armaments spending. In Silicon Valley, a number of startups were established to take advantage of this spending. Also, defense contractors built a number of factories and research facilities in the area. During World War II, other smaller electronics firms were also established in the area (Sturgeon, 2000).

During World War II, Frederick Terman had gone to Boston to manage Radio Research Laboratories at Harvard University. After the war he returned more committed than ever to establishing an electronics industry in the Stanford vicinity. For the next 20 years, he encouraged major East Coast electronics firms to establish research and development (R&D) facilities close to Stanford University (Leslie, 1993). Also, he urged Stanford students, such as the Varian Brothers, to form electronics companies.

Terman's single most important intervention was convincing William Shockley, one of the coinventors of the transistor at Bell Laboratories, to return to his hometown, Palo Alto, and establish the startup firm, Shockley Semiconductor. There was an element of good fortune at play in luring Shockley back to Palo Alto. Shockley left Bell Laboratories and wanted to launch a firm to commercialize semiconductor technology. He approached a number of institutions on the East Coast, in particular, negotiating with Raytheon, an important transistor manufacturer, about funding his proposed startup. He demanded $1 million and after a month of bargaining, Raytheon refused (Scott, 1974). He also negotiated with the Rockefeller venture capital division, but no agreement could be reached. After these failures, he began discussions with Arnold Beckman, the founder of Beckman Instruments in Los Angeles. They reached an agreement and Beckman funded Shockley to start a firm in Palo Alto (Riordan & Hoddeson, 1997).

Shockley's decision to locate in Palo Alto in itself was not significant, as Shockley Transistor never became an important firm. But, as fate would have it, a small significant event occurred. Shockley proved to be an ineffective manager, and eight of his engineers left to form Fairchild Semiconductor. These eight catalyzed the pattern of new firm formation that put the "silicon" in Silicon Valley.

When the first semiconductor startups were established in Santa Clara, there were already existing institutions in the area that could be drawn on for resources. And yet, as the path dependent model would have it, in 1955 there was no certainty that Silicon Valley would become the largest center of U.S. high-technology electronics production. Boston with MIT and Harvard developed a concentration of firms, especially in using germanium for transistors. Other regions that might have become the leader include: New Jersey with Bell Laboratories, RCA Sarnoff Laboratories, Princeton, and Rutgers University; Los Angeles with Caltech, UCLA, USC, and numerous defense contractors (see, for example, Norberg, 1976); or Dallas, Texas (the headquarters for Texas Instruments); or Chicago with its many large and small electronics companies including Zenith and Motorola. A number of smaller Chicago firms attempted to enter the industry and Motorola was very successful, although it located all of its semiconductor operations in Arizona.

The critical semiconductor startups established in the 1950s were not spinouts from either university laboratories or defense-oriented corporate laboratories. Little semiconductor technology was drawn from universities. Robert Noyce pointed out "that it was after the original success of Fairchild that the two schools [Stanford and UC Berkeley] became important supporters of the technology" (Braun & Macdonald, 1982; Moore, personal communication, May 30, 1997). Corporate success fed the improvement of the engineering departments at the Bay Area universities, as they were able to attract better students, who found employment in the growing high-technology industry igniting a virtuous circle.

It is not necessary to deny the role of research universities in Silicon Valley industrial growth to place their contribution into proper perspective. Given the large number of MIT graduates becoming important entrepreneurs, it might be possible to argue, at least, in the earliest days, MIT contributed as much to Silicon Valley's growth as did Stanford. Nonetheless, the greatest source of entrepreneurs was other companies, and corporate laboratories dedicated to civilian technology development, such as IBM's San Jose Laboratory or Xerox PARC. These were the critical sources of entrepreneurs and, as important, the source of inventions that were transformed into commercial products by startups.[11]

[11]In the 1950s Admiral, GE, ITT, Philco–Ford, Sylvania, and Westinghouse located laboratories in Silicon Valley (Saxenian, 1980). However, many of these would be aimed at military research, especially in the microwave field (Leslie, 1993). There were a few startups but they never created an important industry. The reason is hard to ascertain, but perhaps it is because these technologies never found a civilian market. The exception, of course, was the microwave oven developed in Silicon Valley by Charles Litton. Litton Industries was later sold to Teledyne.

For the most part, Silicon Valley firms produce either systems products, such as computers, routers, switches, and hubs, or components such as semiconductors and hard disk drives. Their customers are generally other companies, distributors, or large institutions such as universities and governments. There are exceptions, for example, some segments of the personal computer and games software industry sell (through distributors and retailers) to consumers as final users.[12] The most important of these is Apple Computer, the sole survivor of the large number of Silicon Valley personal computer startups (Freiberger & Swaine, 1984). Quite often, forays by Silicon Valley firms into consumer sales failed, such as the debacles in digital watches and calculators. The exception has been Hewlett Packard (HP), which established a strong position in scientific and engineering calculators.[13]

Emphasis on institutional markets allows the startups to enter niche markets that do not require large initial investments in manufacturing and marketing. Of course, becoming a major company means expanding the niche until it is the mainstream of a market or developing follow-on products allowing the firm to expand its offerings. For example, in the 1960s and 1970s, the entry barriers to manufacturing semiconductors were fairly low. In the 1980s and 1990s, manufacturing had become a fundamental barrier to a startup. However, even as the barrier to entering manufacturing increased, a number of firms, many of them in Asia began to offer contract manufacturing services. This, once again, lowered entry barriers and provided the complementary resources enabling the creation of a generation of "fabless" semiconductor firms headquartered and doing their design in Silicon Valley, while contracting production to other companies.[14] Essentially, the Silicon Valley's semiconductor industry was able to evolve with major changes in the structure of its value chain.

Semiconductor Firms Structure the Valley

The semiconductor industry forms the core of its namesake, Silicon Valley. However, as Braun and Macdonald (1982) indicated, this was not a foregone conclusion in 1950. In the 1950s, both large diversified electronics firms and various startups around the country began transistor production. East Coast and midwestern firms were leaders and the most important customer was the Department of Defense. By the early 1960s, it was possible to clearly define

[12]It is necesary to be careful here. Some major personal computer retailers, Business Land and Computer Land, were established in Silicon Valley.

[13]HP is a unique firm that should not be confused with other less diversified Silicon Valley firms. Often, HP is the exception to the point we make about Silicon Valley firms.

[14]Fabless semiconductor firms do not remain fabless. When their annual revenue surpasses $500 million, they often build or purchase a fabrication facility or, at least, dedicated capacity.

three important small companies: Transitron in Boston, Texas Instruments in Dallas, and Fairchild in Palo Alto. Most independent Boston firms, especially the leader, Transitron were incorporated in the early 1950s to manufacture transistors. The problem was that most were unable to make the transition to the use of silicon and the consequent integrated circuitry. By the early 1970s, most of the Boston firms had left the business (Tilton, 1971).

The new industry divided into three branches: the captive producers, including IBM and AT&T, two small but rapidly growing merchant producers, Texas Instruments and Fairchild, and Motorola, an established firm and a merchant producer. The merchants quickly became leaders as evidenced by the fact that Fairchild was responsible for more major product and design innovations than any other single firm, including Western Electric/Bell Laboratories (calculated from Dosi, 1984).[15] Fairchild would play an even more important role as the source of semiconductor spin-offs (Braun & Macdonald 1982). This is graphically illustrated in a Semiconductor Equipment and Materials Institute (1986) genealogy chart which includes 124 startups formed through 1986, almost all of which can be traced back through generations of startups to Fairchild. As early as 1971, observers noticed that with every new technological discontinuity, there were spurts in the number of semiconductor firms (Lindgren, 1971).

In the semiconductor industry there have been recurring waves of new entrants that correlate with the development of new technologies or market spaces. As indicated, the semiconductor industry in Silicon Valley has had at least four important technological waves. The first were memory related integrated circuits, then microprocessors, then RISC microprocessors, and, most recently, application specific integrated circuits. Even, if these were perhaps the most important waves, so many other lucrative niches emerged, such as BIOS chips, programmable logic devices, and specialized chips designed for graphics, communications, and audio, to name just a few.

The startup phenomenon is interesting, but what catalyzed this process and how it assisted in creating the institutions of Silicon Valley is even more important. We have already mentioned the rapid rate of technical change and Fairchild's leadership role, but there are some more significant social patterns that were established at and because of Fairchild. Perhaps, the most significant pattern was a reaction to the situation at Fairchild. When the eight engineers resigned from Shockley Semiconductor and received funding from Fairchild, what would prove to be the most significant contract provision was one that permitted Fairchild to purchase the entire firm in 3 years for $3 million. The $3 million in proceeds was to be divided among the eight

[15]The second greatest number of innovations were made by Intel Corporation, the Fairchild spin-off. In contrast, AT&T had by far the greatest number of major process innovations.

founders who owned 80% of the firm and the brokerage firm (Hayden, Stone) that arranged the financing and owned the remaining 20%.

This is very significant. The founders signed away the upside potential of their shares; in other words, their gains were capped. So, when Fairchild experienced enormous success, the founders were unable to participate in the capital gains, even though they provided all the management and all of the technical skills. They were bought out by Fairchild at a price that had no relationship to the value they created. The decision not to allow the engineers to share in the capital gains was a rational decision from the perspective of the East Coast Fairchild management. Little did they know it would have critical implications for the future.

As soon as the founders' stakes were acquired, the engineers were relatively wealthy and had no reason beyond salary to continue at Fairchild. This would be problematic, because in the 1960s, there were low entry barriers in the semiconductor industry and an exploding market making the environment conducive to starting new firms. Moreover, there was an as yet inchoate network of investors willing to back engineers with projects with commercial potential. Often, the early investors were, like Fairchild, seeking a position in the new field of microelectronics. As an incentive for potential entrepreneurs, these financiers were willing to permit the entrepreneurs to retain substantial equity in the fledgling firm. Fairchild's short sighted policy regarding equity participation ensured that there would be a flow of spin-offs and the extremely rapid technical change in semiconductors ensured that opportunities would emerge.

Because cash compensation often is relatively low, the reward for entrepreneurship is realized when the company goes public or is acquired. Substantial equity means that entrepreneurs can graduate from being salaried to being an owner. Another reason for liquefying their equity through a public offering or outright sale is the extremely rapid technical changes that can dramatically lower the value of a firm experiencing difficulties (e.g., the recent situation at Apple Computer).

The semiconductor firms had a central role in shaping the institutions, structures, expectations, and culture of Silicon Valley. Advances in microelectronics formed one of the critical technical foundations for further developments, because they were critical components in so many later products such as computer networking equipment and desktop computers, which form the basis for the current high-technology gold rush related to the Internet. Fairchild also established the pattern of spinning off and, as significant, was the source of one of the primary institutions of Silicon Valley's Economy Two, the venture capitalists. It was the financial success of the early spin-offs that encouraged other entrepreneurs and attracted more capital and venture capitalists. For Silicon Valley, the semiconductor industry proved to be a critical catalyst to the development of the institutions of Economy Two.

Venture Capital

Although venture capital was first developed as an proto institution by the Rockefeller and Whitney funds in the 1930s in New York, and fully formalized in the Boston area by the firm, American Research and Development (Florida & Kenney, 1999), Fairchild and its spin-offs catalyzed the establishment of venture capitalists in Silicon Valley. *Venture capitalists* are financiers that specialize in providing funds to high-risk startups in return for an equity stake, in the hopes that corporate success will dramatically increase the value of their stake. Because they actually own part of the company, the venture capitalists receive seats on the firm's board of directors, enabling them to take an active role in monitoring firm performance.

Before World War II, there were wealthy northern Californians who invested informally in promising young companies. However, these investors were not professional venture capitalists dedicated solely to investing in startups. (They much more resembled informal investors, who currently are called "angels.") As mentioned earlier, the investment by Sherman Fairchild and Fairchild Industries in Fairchild Semiconductor was brokered by Arthur Rock, then an employee of the East Coast brokerage firm, Hayden Stone. After Fairchild's success and other experiences securing financing for small technology based firms, Rock moved to California. In 1961, he established a partnership with a manager at the Kern County Land Corporation, Thomas Davis. Davis and Rock were the general partners and their investors became limited partners (Rogers & Larsen, 1984; Wilson, 1985). The partnership was designed to last 7 years. They raised $3.5 million in funds from individuals, such as Fairchild executives, and proceeded to invest in various high-technology firms. Davis and Rock were very successful and when the partnership was completed, their profit from the partnership was $20 million. Both Davis and Rock and the limited partners were pleased.

[16]Other methods for funding high technology startups had been tried. For example, federally funded small business investment corporations (SBICs) were another organizational form for funding. However, SBICs suffered many problems, including the fact that they made loans rather than took an equity stake. This meant that they had high risk but no method for participating in the capital gains. Many important venture capital pioneers did come from the SBICs. American Research and Development in Boston was a public company and suffered from the problems stemming from being listed on the market. Finally, there were the family funds, the best known of these started by the Rockefellers and the Whitneys. The family funds were very successful but could not hope to meet the increasing need for funds or undertake all the opportunities presented. In the end, all of these other vehicles would pale in comparison to the partnerships.

The partnership organization Davis and Rock developed became the dominant form for organizing venture capital funds.[16] The limited partners (i.e., investors) pay a management fee of approximately 2% to 3% for salaries and the operational expenses of the fund. The incentive for the venture capitalists is the fact that they receive at least 20% of the profits after they return the initial investment. As with stock options and equity for the entrepreneurs, the venture capitalists receive a share of the capital gains.[17] The success of the early investors attracted more capital and more venture capitalists.

In the 1960s, venture capital in Silicon Valley constituted loosely coupled groups of individual investors. Often, as investments matured and needed more capital, it was necessary to partner with East Coast firms. In the 1970s, the Silicon Valley venture capital community grew and matured as an institution. Also, the maturation of venture capital made the process of securing capital far more transparent to entrepreneurs and this encouraged more entrepreneurship. The success of the firms provided high rates of return, therefore attracting more capital and venture capitalists to the region.

Initially, the individual venture capitalists came from a variety of sources. For example, Fairchild alumni, such as Eugene Kleiner of Kleiner and Perkins, Pierre Lamond and Donald Valentine of Sequoia Capital, became very successful venture capitalists. By the mid 1980s, venture capital was becoming more organized and routinized, and often, newly minted MBAs were recruited as associates or junior partners in venture capital partnerships. Another important source of venture capitalists were high-level mangers at existing firms. If these recruits were successful, they could become full partners, or begin their own partnership.

As central actors in Economy Two, firm formation is critical to the survival of venture capitalists and, of course, the venture capitalists encourage this process. As the venture capitalists became more sophisticated, they were able to take even partially formed ideas for firms and recruit the missing management functions. Thus, someone with a plan to establish a firm could approach a venture capitalist and, if an investment was made, the venture capitalist would actively assist in the recruitment of other members of the management team. This constant need for personnel created the demand for what has now become another feature of the Silicon Valley environment, organizations specialized in recruiting for high-technology startups.

When a particular technology is considered hot either by the stock market or other firms seeking to acquire capabilities in the field, frenzied startup activity can be ignited. Sahlman and Stevenson (1985) described this in the early 1980s in the Winchester disk drive industry, and Kenney (1986) described a similar frenzy in the biotechnology market the late 1970s and early

[17]This is best illustrated in a genealogy of Silicon Valley venture capitalists prepared in the mid 1980s by the Silicon Valley venture capitalist, Franklin "Pitch" Johnson's wife, Cathie Johnson (1984).

1980s. More recently, in the mid- to late 1990s, there was a frenzy in the Internet related businesses. During such periods, venture capitalists become extremely aggressive in raiding existing firms for senior engineers and managers, both to establish new firms and complete management teams in already funded firms. This raiding of established firms earned venture capitalists the moniker of "vulture capitalists" from executives at existing firms (Florida & Kenney, 1990). In other words, by the 1980s, Economy Two had developed to such a powerful extent that it now was actively creating its resources (i.e., entrepreneurs) for spin-offs. The culture of spin-offs did not simply emerge, it was nurtured into existence. The actors in Economy Two needed the "startup culture" and worked to make it happen.

The evolution of Silicon Valley venture capital was path dependent, but rather than being a second-best solution, such as QWERTY or VHS, it is difficult to imagine a more efficient system for forming high-technology startups.[18] Over the last 40 years, the institution of venture capital has evolved from individuals or two-person partnerships with less than $10 million under management to partnerships consisting of five to seven general partners and numerous associates with between $300 million to $1 billion under management. These much larger funds have become increasingly well equipped to undertake more difficult financings requiring greater quantities of capital and ventures with longer term payback periods, as is the case of biotechnology (Kenney, 1986).

This outline of the Silicon Valley venture capital complex mentioned the role of executive search firms. Numerous other highly specialized professional services critical for assisting in the rapid development of fledgling firms have been created in Silicon Valley. For example, Suchman (1994) provided an excellent discussion of the role of Silicon Valley law firms that have evolved specializations in high-technology firm incorporation and intellectual property issues of various types, including separation from former employers—obviously critical issues for venture capital investors. Other significant institutions are the marketing and public relations consulting firms, the most famous of which is the McKenna Group established by the Intel alumnus, Regis McKenna. Venture capital is, perhaps, the most critical institution for Economy Two, but it certainly is not the only one.

Thoughts and Discussion

Path dependence as a concept provides an important opening for noneconomists to contribute to explaining economic institutions using history and the other social sciences. Once technology, firms, institutions, and regions are understood in more evolutionary terms, a purely economistic analysis is no longer possible. The embeddedness of economic institutions in a social context becomes apparent (although it is also equally apparent that economic institutions cannot be explained simply by the social context; profits, capital gains, and technological trajectories also exist and are significant). Sociological concepts, such as embeddedness are both reinforced and undermined by path dependent arguments and our results. As understood by most sociologists, the "bed" is often treated as static, when, in fact, the evidence from Silicon Valley suggests it is also in the process of evolution.

Product cycle-related explanations for the organizational structures in Silicon Valley are fruitful for deepening our understanding of the effects constant technical change can have on the structure and organization of a regional economy (Robertson & Langlois, 1995). However, they do not provide strong explanations for the actual evolution of the Silicon Valley economy. Explanations of Silicon Valley, as a region that facilitates innovation and new firm formation, capture Economy Two, but also are somewhat ahistorical, as they implicitly understand the evolutionary component and would be much improved if they explicitly recognized it (Bahrami & Evans, 1995; Florida & Kenney, 1988a, 1988b, 1990; Schoonhoven & Eisenhardt, 1989). Saxenian (1994) paid particular attention to the interfirm relationships in Economy One, arguing that their success is predicated on an industrial district system based on close supplier relations, but this says little about Economy Two. Each explanation provides important insight into the nature of the Silicon Valley economy, however, considering the emergence of Silicon Valley from a path dependent perspective provides a much richer picture.

We proposed a heuristic distinction between Economy One and Economy Two for the purpose of developing a clearer understanding of the new firm formation component of Silicon Valley's dynamism. We singled out the evolution of the merchant semiconductor firms as components of the industry that provided resources to fuel the establishment of Economy Two and, reflexively, was a product of Economy Two. The evolution of the semiconductor industry had a clear path dependent character. A series of small events, such as the set of decisions by various participants including Shockley led to the creation of Shockley Semiconductor in Silicon Valley, Shockley's and Fairchild's management styles, and early funding patterns. These were the seed events necessary to create the trajectory, enabling the formation of the institutions that comprise the current Silicon Valley. With the spin-offs and the continuing rapid advance of the technology, the semiconductor industry also clustered and locked in to Silicon Valley. Further,

[18]In an earlier book (Florida & Kenney, 1990), I questioned the benefits of the venture capital-funded spin-off system for the entire U.S. economy, arguing that this was creating an economy based on breakthroughs without sufficient follow through.

advances in semiconductor technology were made and exploited in Silicon Valley. In describing this process, path dependence serves us well.

Path dependence also has its limits. It does not provide such a strong explanation of the creation and growth of complementary institutions. Our discussion of venture capital provided insight into the creation of new institutions that also developed paths or evolutionary trajectories. The institutional creation process reinforced positive feedback loops or virtuous circles. The result was Economy Two, which has now become a rich ecosystem continually fed by the nutrient of rapid technical change and large capital gains. The raw materials for Economy Two are a constant influx of technologists, managers, and capital drawn to the region (and internally generated by the region) by the opportunities fueling the process. Path dependence, if construed as a relatively one-dimensional model, does not do full justice to the manner by which Silicon Valley was created an ecosystem.

Still, path dependence provides an important new way of thinking about economic institutions. Here, contrary to the arguments by Ruttan (chap. 4, this volume), we believe Arthur and David must be given great credit; they have broken taboos and liberated thought from the unnatural fetters imposed by neoclassical economics. The criticism that the world of economic institutions is more complex than highly abstract path dependence models is not surprising and we concur. And yet, as this chapter has contended, some of the observations derived from path dependence, and its extension to path creation, provide significant insight into the development of contemporary Silicon Valley.

ACKNOWLEDGMENTS

The authors thank David Angel, James Curry, Giovanni Dosi, Richard Florida, Richard Langlois, Frank Mayadas, Richard Nelson, and Joel West for comments.

REFERENCES

Almeida, P., & Kogut, B. (1997). The exploration of technological diversity and the geographic localization of innovation. *Small Business Economics*, 9(1), 21–31.

Arthur, W. B. (1988). Competing technologies: An overview. In G. Dosi, C. Freeman, R. Nelson, G. Silverberg, & L. Soete (Eds.), *Technological change and economic theory* (pp. 590–607). London: Frances Pinter.

Arthur, W. B. (1994). *Increasing returns and path dependence in the economy.* Ann Arbor, MI: University of Michigan Press.

Bahrami, H., & Evans, S. (1995). Flexible re-cycling and high-technology entrepreneurship. *California Management Review*, 37(3), 62–89.

Braun, E., & Macdonald, S. (1982). *Revolution in miniature: The history and impact of semiconductor devices.* Cambridge, England: Cambridge University Press.

Christensen, C. (1992). *The innovator's challenge: Understanding the influence of market environment on processes of technology development of the rigid disk.* D.B.A. dissertation, Harvard University.

David, P. (1986). Understanding the economics of QWERTY: The necessity of history. In W. Parker (Ed.), *Economic history and the modern economist* (pp. 138–158). Cambridge, MA: Basil Blackwell.

David, P. (1999, September 31). *At last, a remedy for chronic QWERTY scepticism.* Unpublished manuscript, All Souls College, Oxford Univeristy.

David, P. (1997, November). Path dependence and the quest for historical economics: One more chorus of the ballad of QWERTY. Unpublished manuscript, All Souls College, Oxford University.

Dosi, G. (1984). *Technical change and economic transformation.* London: Macmillan.

Fisher, D., & Fisher, M. (1996). *Tube: The invention of television.* Washington, DC: Counterpoint.

Florida, R., & Kenney, M. (1988a). Venture capital-financed innovation and technological change in the USA. *Research Policy, 17*, 119–137.

Florida, R., & Kenney, M. (1988b). Venture capital and high technology entrepreneurship. *Journal of Business Venturing, 3*(4), 301–319.

Florida, R., & Kenney, M. (1990). *The breakthrough illusion: Corporate America's failure to move from innovation to mass production.* New York: Basic Books.

Florida, R., & Kenney, M. (1999). *Financiers of innovation: Venture capital, technological change and industrial development.* Princeton, NJ: Princeton University Press.

Foray, D. (1991). The secrets of industry are in the air: Industrial cooperation and organizational dynamics of the innovative firm. *Research Policy, 20*, 393–405.

Freiberger, P., & Swaine, M. (1984). *Fire in the valley.* Berkeley, CA: Osborne/McGraw Hill.

Gan, J. (1991). Staking a claim in the west. *Almaden Views*, (Winter), 1–4.

Garud, R., & Kumaraswamy, A. (1995). Coupling the technical and institutional faces of Janus in network industries. In W. R. Scott & S. Christensen (Eds.), *Advances in the institutional analysis of organization: International and longitudinal studies* (pp. 226–242). Thousand Oaks, CA: Sage.

Gilder, G. (1989). *Microcosm.* New York: Basic Books.

Gilder, G. (1993, September 13). Metcalfe's Law and Legacy. *Forbes ASAP.*

Granovetter, M. (1985). Economic action and social structure: The problem of embeddedness. *American Journal of Sociology, 91*, 481–510.

Henderson, R., & Clark, K. (1990). Architectural innovation: The reconfiguration of existing production technologies and the failure of established firms. *Administrative Science Quarterly, 35*(1), 9–30.

Intel Corporation. (1984). *A revolution in progress.* Santa Clara, CA: Author.

Johnson, C. (1984). *West coast venture capital—25 years.* Palo Alto, CA: Asset Management.

Karnøe, P., & Garud, R. (1998). *Path creation and dependence in the Danish wind turbine field.* Copenhagen, Denmark: Institute of Organization and Industrial Sociology, Copenhagen Business School.

Kenney, M. (1986). *Biotechnology: The university-industrial complex* New Haven, CT: Yale University Press.

Kenney, M. (2000). The temporal dynamics of knowledge creation in the information society. In I. Nonaka & T. Nishiguchi (Eds.), *Knowledge Creation.* New York: Oxford University Press.

Kenney, M., & Curry, J. (1998). Knowledge creation and temporality in the information economy. In R. Garud & J. Porac (Eds.), *Cognition, knowledge, and organizations* (pp. 149–170). Connecticut: JAI Press.

Kogut, B., Walker, G., & and Kim, D.-J. (1991). The role of large firms in the entry of start-ups: Centrality and cooperation in the semiconductor industry (Working paper No. 91–102). Reginald H. Jones Center for Management Policy Strategy and Organization, The Wharton School, Philadelphia, PA.

Langlois, R., & Robertson, P. (1995). *Firms, markets and economic change.* London: Routledge.

Liebowitz, S., & Margolis, S. (1990). The fable of the keys. *Journal of Law and Economics, 33*, 1–24.

Liebowitz, S., & Margolis, S. (1995). Path dependence, lock-in, and history. *Journal of Law, Economics and Organization, 11*(1), 205–226.

Leslie, S. (1993). *The cold war and American science.* New York: Columbia University Press.

Lindgren, N. (1969). The splintering of the solid state electronics industry. *Innovation, 1*(8), 2–16.
Lowen, R. (1992). Exploiting a wonderful opportunity: The patronage of scientific research at Stanford University, 1937–1965. *Minerva, 30*(3), 391–421.
Lynn, L., Reddy, N., & Aram, J. (1996). Linking technology and institutions: The innovation community framework. *Research Policy, 25*, 91–106.
Moore, G. (1965). Cramming more components onto integrated circuits. *Electronics, 38*(8), 114–117.
Nelson, R., & Winter, S. (1982). *An evolutionary theory of economic change.* Cambridge, MA: Harvard University Press.
Norberg, A. (1976). The origins of the electronics industry on the Pacific Coast. *Proceedings of the IEEE, 64*(9), 1314–1322.
Riordan, M., & Hoddeson, L. (1997). *Crystal fire.* New York: Norton.
Robertson, P. (1995). Book review of regional advantage: Culture and competition in Silicon Valley and Route 128. *Journal of Economic History, 55*(1), 198–199.
Robertson, P., & Langlois, R. (1995). Innovation, networks and vertical integration. *Research Policy, 24*(4), 543–562.
Rogers, E., & Larsen, J. (1984). *Silicon Valley fever.* New York: Basic Books.
Sabel, C. (1998, February 10). Intelligible differences: On deliberate strategy and the exploration of possibility in economic life. [On-line]. *http://www.columbia.edu/~cfs11/IntelDif.html*
Sahlman, W., & Stevenson, H. (1985). Capital market myopia. *Journal of Business Venturing, 1*, 7–30.
Saxenian, A. L. (1980). Silicon chips and spatial structure. Masters thesis, University of California, Berkeley.
Saxenian, A. L. (1994). *Regional advantage.* Cambridge, MA: Harvard University Press.
Schoonhoven, C. B., & Eisenhardt, K. (1989, August). The impact of incubator regions on the creation and survival of new semiconductor ventures in the U.S., 1978–1986. Report to the Economic Development Administration, U.S. Department of Commerce.
Scott, O. (1974). *The creative ordeal: The story of Raytheon.* New York: Atheneum.
Semiconductor Equipment and Materials Institute. (1986). *Silicon Valley genealogy.* Mountain View, CA: Semiconductor Equipment and Materials Institute.
Storper, M., & Walker, R. (1988). *The capitalist imperative: Territory, technology, and industrial growth.* London: Basil Blackwell.
Sturgeon, T. J. (2000). How Silicon Valley came to be. In M. Kenney (Ed.), *Understanding Silicon Valley: Anatomy of an innovative region*, pp. 15–47. Stanford: Stanford University Press.
Suchman, D. (1994). *On advice of counsel: Law firms and venture capital funds as information intermediaries in the structuration of Silicon Valley.* Unpublished PhD dissertation, Stanford University, California.
Tilton, J. (1971). *International diffusion of technology: The case of semiconductors.* Washington, DC: The Brookings Institution.
Voltaire, F. (D. Gordon, Trans.). (1999). *Candide.* Boston: Bedford/St. Martin's.
von Burg, U. (1998). *Plumbers of the internet: The creation of the local area networking industry.* Unpublished PhD dissertation, St. Gallen University, Switzerland.
Weiss, J., & Delbecq, A. (1990). A regional culture perspective of high technology management. In M. Lawless & L. Gomez-Meija (Eds.), *Strategic management in high technology firms* (pp. 83–94). Greenwich, CT: JAI Press.
Wilson, J. (1985). *The new venturers.* New York: Basic Books.