TECHNOPOLES OF THE WORLD

The making of twenty-first-century industrial complexes

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SILICON VALLEY: WHERE IT ALL BEGAN

Silicon Valley has a guaranteed place in history as the original industrial core of the revolution in information technologies. While its reputation is based on the basic fact of a concentration (in 1989) of some 330,000 high-technology workers, including 6,000 Ph.D.s in engineering and science,[1] it stems also from the saga of Silicon Valley, hailed worldwide as an heroic model of innovation in the service of dynamic economic growth.

This 40-mile by 10-mile (70-kilometer by 15-kilometer) strip in the peninsula south of San Francisco, stretching from Palo Alto to the southern suburbs of San Jose (Figure 2.1), has become the popular epitome of entrepreneurial culture, the place where new ideas born in a garage can make teenagers into millionaires, while changing the ways we think, we live, and we work. It is also seen as living proof of the fundamental relationship between science and economic development, a process that emphasizes the role of universities and research as driving forces of human progress. Last but not least, Silicon Valley embodies the new power emerging from new technologies: the battles of future wars are fought in its electronics laboratories; competitiveness in the world economy largely depends on access to the kind of technological excellence that is so richly concentrated here; industrial and military spies make a living out of it; companies line up to establish joint ventures with its innovative firms; presidents, ministers, and dignitaries come in pilgrimage here, in well-publicized delegations that aim to capitalize the visit in social prestige or political votes back home.

In Santa Clara County, the area's true geographical name, and in its immediate surroundings were concentrated in the 1980s about 3,000 manufacturing electronics firms, 85 percent of which had fewer than 50 workers (Table 2.1). Another 3,000 firms in the area provided necessary producer services, and 2,000 other firms were engaged in high-technology activities, giving a total of 8,000 firms in the complex.[2] Yet, as late as 1950, Santa Clara County was mainly an agricultural area, with only 800 manufacturing workers, most of them in food processing plants.[3] During the 1970s one new firm was created every two weeks, and 75 percent of them survived for at least six years, a much higher rate of resilience than American companies

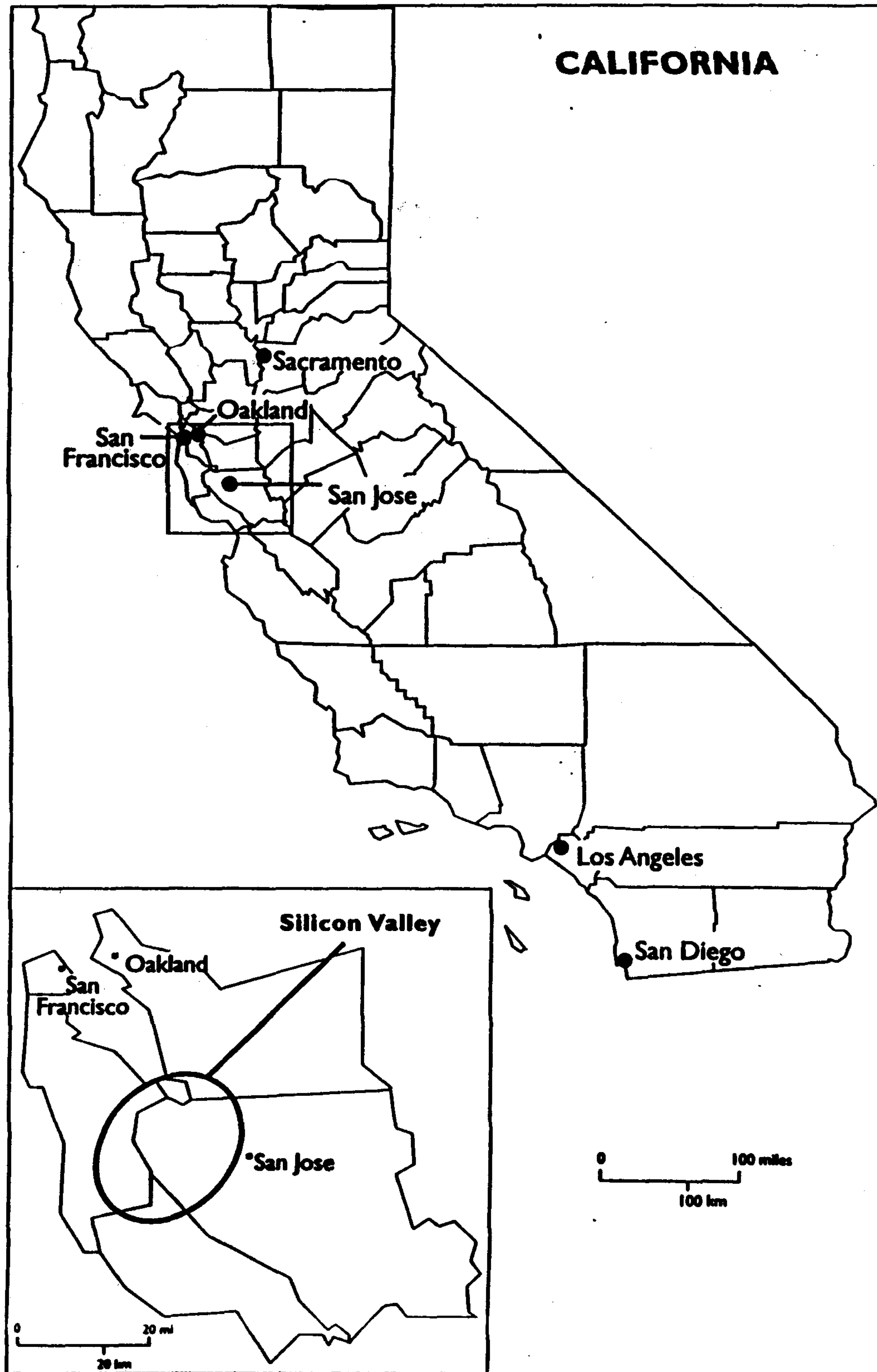

Figure 2.1 Silicon Valley: general location
Source: Rand McNally World Atlas, 1992

Table 2.1 Silicon Valley: employment structure

Employment	*SIC*	*1959*	*1965*	*1970*	*1975*	*1980*	*1985*
Computers	3,573	0	0	8,938	19,902	52,738	56,126
Other office machines	357*	0	0	979	1,869	2,582	2,748
Communications	366	895	5,027	7,271	10,043	19,603	29,677
Semiconductors	3,674	0	4,164	12,290	18,786	34,453	47,069
Other electronic components	367*	4,295	4,619	14,174	11,622	25,472	23,731
Missiles/parts	372	0	0	2,274	0	0	750
Instruments	38	328	1,202	2,567	14,646	24,912	19,382
Drugs	283	0	282	0	750	1,976	1,954
Software/data processing	737	0	0	0	3,887	7,813	15,368
IC labs	7,391	118	2,193	1,978	1,642	3,856	6,133
Electronic wholesale	5,065	131	693	1,107	2,092	3,703	9,179
Computer wholesale	5,086	199	243	373	620	2,005	2,807
Total high-tech employment		5,966	18,423	51,951	85,859	179,113	214,924
Total manufacturing employment		61,305	88,038	131,613	154,126	256,437	272,332

Source: US Bureau of the Census, County Business Patterns, selected years
Note: * SIC Codes 357 and 367 exclusive of 3573 and 3674, respectively

overall.[4] During the 1980s, in spite of a severe downturn in the computer industry in 1984–6, the dynamism of the regional economy continued unabated, with a growth of 35 percent in total employment in 1980–9. Since 1970, median family income in the area has been the highest in California and one of the highest in the United States.[5]

This vibrant economy is based on an extraordinary capacity for innovation: most of the key inventions in microelectronics and computing have originated in Silicon Valley, including the co-invention of the integrated circuit, the planar process, the microprocessor, the Unix system, and the development of the personal computer.[6] The fact that such new industrial power could emerge from an area without any previous manufacturing basis or business tradition – San Francisco was always clearly external to the Silicon Valley complex – has struck the imagination of policy makers and the media the world over. However, it is precisely because the story is extraordinary that it must be carefully and analytically reconstructed. Only thus is it possible to avoid the ideological pitfalls that, inevitably, are linked to the legend. For, in reality, Silicon Valley cannot be reduced simply to a bright illuminated billboard proclaiming the virtues of free-market ideology.

THE SILICON VALLEY STORY

While the Silicon Valley story has been told many times – although, oddly enough, rarely in scholarly research, with some notable exceptions[7] – it is

still useful to recount the facts in historical sequence, in order to be able to comprehend both the area's uniqueness and its potential for generalization. It is helpful to summarize the development of Silicon Valley as a major industrial technological center in a sequence of stages:

1 The historical precedents of technological innovation in Silicon Valley, from the early twentieth century.
2 The creation of its high-technology industrial basis in the 1950s around the Stanford Industrial Park.
3 The growth of innovative microelectronics firms in the 1960s, on the basis of spin-offs of the first generation of firms, and with the support of the Department of Defense's electronics-based programs.
4 The consolidation of semiconductor merchant producers in the microprocessor era, together with the launching of the personal computer era during the 1970s.
5 The growing domination of the computer industry, the internationalization of the industrial structure of the Valley, and a new round of innovative spin-offs in the 1980s.

This historical sequence is crucial to understanding Silicon Valley. For, though the factors that are generally associated with its growth and success have all been important, individual elements have been important at different periods and with different intensities in each period – a fact that makes all the difference in the world for the purpose of analysis and generalization.

First of all, in spite of its lack of a previous industrial basis, the area did have a significant research tradition in electronics going back to the invention of the vacuum tube by De Forest in 1912, in a firm, the Federal Telegraph Company, that was formed by a Stanford University graduate with support from the University.[8] During the 1920s Stanford maintained a tradition of excellence in electrical engineering around Dr Harris Ryan, many of whose students stayed to work in electronics in the area, creating their own firms.

But the crucial link between the early stage of electronics and the formation of Silicon Valley was provided by Frederick Terman – the man who, more than anyone else, can be considered the central figure of the story. Frederick Terman was the son of a Stanford psychology professor and grew up on the campus. He studied chemistry and electrical engineering at Stanford, then enrolled in the doctoral program in electrical engineering at the Massachusetts Institute of Technology (MIT), the best in the country at that time. Completing his degree, he was appointed to the MIT Faculty, but he contracted tuberculosis, and decided to stay in Palo Alto because the climate was better for his health, becoming Professor of Radio Engineering at Stanford. Thus, given the centrality of his role to the development of Silicon Valley, we may say that climate did play an important place in its emergence as a high-tech center – but not so much

for its contribution to the quality of life, as we will see, as for its contribution to the health of Terman. He was promoted head of the communications laboratory at Stanford, and later Dean of Electrical Engineering, before becoming Provost and Vice-President of the whole University during the 1950s.

Convinced as he was of the critical need to link University and industry, he used all his connections, his influence, and sometimes his own money to encourage his best graduates to start up electronics firms, a high-risk venture in the 1920s and 1930s.[9] Among his students were Charles Litton, who in 1928 founded Litton Engineering Laboratories, and two particularly gifted graduates, William Hewlett and David Packard. Terman protected them, helped them with their research, persuaded them to set up a commercial firm to exploit their research, and lent them $1,538 to start the company in 1938; by 1942, company sales reached $1 billion. World War Two, with its appetite for electronic devices, gave a decisive impulse to Hewlett-Packard and to the other start-ups around Stanford, while Terman himself spent his time at MIT managing a high-technology military project.

Upon his return to Stanford he went on to build up a major program in electrical engineering, modeled after the much superior East Coast programs, with support from local corporations. But his main goal was still to be able to diffuse R&D results in the industrial world. Since Stanford was a land-rich university, from its original grant, in 1951 Terman decided to use this asset to create the Stanford Industrial Park, the true ancestor of all the world's future technopoles. Terman leased the land to firms with very advantageous terms, on the basis of their excellence in electronics technology and of their close contacts with the University.

The first company to move to the Park was Varian, another Stanford spin-off which had Terman on its Board of Directors. Hewlett-Packard moved to the Park in 1954. By 1955 there were seven firms, by 1960, 32, by 1970, 70, and by the 1980s, 90, with about 25,000 workers. By 1954 Terman's dream of a "community of technical scholars," based upon the relationship between the University and private industry,[10] had become a reality, constituting the nucleus of what would be Silicon Valley. However, for all the efforts in upgrading the West Coast universities, they were clearly behind the traditional East Coast centers in electronics research until the 1960s. Thus, technology transfer from these centers became a necessary condition for Silicon Valley to develop a base in cutting-edge innovation.

Here enters the story the other godfather of the legend, Nobel Prize winner William Shockley, co-inventor of the transistor in 1947 with a team at Bell Laboratories in New Jersey. Shockley left Bell in 1954 to form his own company to commercialize his research.[11] He first tried the Boston area but because of the lack of support of the large firms there (Raytheon rejected his proposal), he moved to Palo Alto – because, among other reasons, his aged mother lived there. In 1955 he founded Shockley Semiconductors

Laboratory in Mountain View, near Palo Alto. Young electronics graduates responded immediately to his first job announcement, and he recruited the eight brightest; they would all become multimillionaires and technological innovators, including Robert Noyce, the co-inventor of the integrated circuit in 1957.

However, Shockley was as brilliant a scientist as he was a bad businessman and generally unpleasant person (he was a self-proclaimed racist), regarded as difficult to work with. His stubbornness led to his commercial demise, since he insisted on working on four-layer diodes and refused to move into silicon transistors, as his young disciples advised him to do. Thus, in 1957, the eight young engineers left Shockley and founded a new company, Fairchild Semiconductors, then the only transistor firm to work exclusively in silicon.

Within a few years, Fairchild was credited, mainly through the work of Bob Noyce, as the co-inventor of the integrated circuit (IC), and the inventor of the planar process, the critical manufacturing technology required actually to produce ICs. Fairchild attracted the best young talent in microelectronics but, at the same time, could not retain it because of their ambition and dynamism. By 1965, 10 new firms had been created by former Fairchild engineers.[12] Furthermore, when Fairchild was taken over by an East Coast parent corporation unable to understand the local innovative dynamics, its founders also left the firm, leaving it an empty shell.

Thus, about one-half of the 85 major American semiconductor firms were created as direct or indirect spin-offs from Fairchild, which thus became the major mechanism for the diffusion of technological know-how throughout the area.[13] Among Fairchild's spin-offs are Intel (created by Bob Noyce in 1968), National Semiconductors, Signetics, Amelco and Advanced Micro Devices, all leaders in the industry today. All these companies set up shop in Silicon Valley, moving to the next available nearby location to continue work on the same programs and almost with the same people. Of the 45 American semiconductor firms created between 1959 and 1976, 40 were located in Silicon Valley.[14]

However, for this process of spin-off to be successful, other factors intervened in the 1960s; and these made the Silicon Valley story more complex. The first was the dramatic expansion of military demand for electronic devices in the late 1950s and the 1960s, as the aerospace program took shape in the wake of the shock provoked in the American establishment by the launching of the first Sputnik.[15] For instance, in 1959 Fairchild was awarded a $1.5 million contract to provide the transistors for the Minuteman missile, and in 1963 the integrated circuits for the Apollo spacecraft's guidance computer. In the late 1950s the share of military markets in total shipment of semiconductors reached the 70 percent level, and it oscillated around 50 percent during the 1960s, with the defense market being concentrated in the higher layers of the technology.[16]

Both the Defense Department and NASA paid high prices for the most innovative technologies, which were also the riskiest in terms of investment; thus, they played the role of subsidizers of R&D for Silicon Valley firms. In addition, the practice of second-sourcing and technology sharing by military departments, to ensure the timely provision of the required devices, led to rapid technology diffusion among firms, and to lack of proprietary control over the inventions. Indeed, unless they were classified as military secrets, the Defense Department required the public diffusion of the discoveries realized through its funding.[17] Thus, military and aerospace demand provided the first mass market for the infant microelectronics industry concentrated in Silicon Valley, and facilitated the necessary capital for high-risk investment, while making possible the diffusion of technological breakthroughs among the firms.

But Silicon Valley firms were able to take advantage of the military bonanza because of their extraordinary versatility, entrepreneurialism, and high level of mutual interaction. Scholarly research, in particular the pioneer work by AnnaLee Saxenian, has emphasized the decisive role of social networks and of a shared culture of innovation in the formation, development, and continuing vitality of Silicon Valley.[18] The Fairchild spin-offs were often projected, discussed, and decided in a nearby restaurant in Mountain View, Walker's Wagon Wheel Bar and Grill, frequented by the company's engineers.[19] The constant circulation of talent from one firm to another made it literally impossible to maintain proprietary rights over each innovation. The only way out of the problem was for each company to accelerate its own path of innovation, eventually giving way to new spin-offs, in an endless process of extraordinary technological and industrial self-stimulation.

But while scientists and engineers would change jobs easily, always looking for better opportunities and for more exciting research challenges, they generally stayed in Silicon Valley because they kept alive their informal networks, based on face-to-face interaction over common technical or professional issues. These informal networks, as Saxenian has demonstrated in her doctoral dissertation,[20] constituted the very basis of the process of innovation in Silicon Valley, and they increased in complexity and importance over time. They were simultaneously channels of communication of technological innovation, forms of organization of the job market, and the material basis for the formation of a culture that emphasized the values of technological excellence and free-market entrepreneurialism, while serving to transmit the role models of the Valley: the brilliant young engineers who achieved wealth and fame through technical expertise and social irreverence.

These networks supported the development of another key ingredient of Silicon Valley, the venture capital firms, that were decisive in providing finance for the development of electronic firms outside the original narrow ground of military markets. But, against the common view on the matter,

it seems that venture capital firms did not originate in the San Francisco financial markets, but from the wealth generated in Silicon Valley itself.[21] In fact, there were engineers and businessmen among the first wave of electronics firms who invested their money in the next round of start-ups, having verified from their own experience the feasibility of the process, and feeling competent enough to judge the possibilities of the proposed new firms. Thus, although in the 1980s major financial institutions opened up shop in the venture capital market in the Valley, earlier – in the 1960s and early 1970s – the Valley's own social networks created a self-support system of finance, reinvesting part of their wealth in fostering the next generation of entrepreneurs.

By the mid-1970s Silicon Valley had developed its social networks, its industrial basis, its supporting financial and service activities, and its professional organizations, to the point of constituting an innovative milieu able to absorb and propel into the market key innovations that were not of its own. That was particularly the case of the product that changed the world and the Valley, opening up a new industrial era for the region: the personal computer.[22] The personal computer was first produced in 1974 – in Albuquerque, New Mexico, by an engineer, Ed Roberts, working out of his small calculator company, MITS – in the form of a model named "Altair." Altair, in spite of being a primitive machine, was an instant commercial success. But its main impact was to mobilize the informal network of computer hobbyists that was already in existence in the San Francisco Bay Area.

The core of this network was the Home Brew Computer Club, formed by young electronics engineers and computer lovers, meeting regularly to exchange information and discuss developments in the field. The network included people like Steve Wozniak, the future inventor of Apple; Bill Gates, the software guru, founder of Microsoft; and other young visionaries who would go on later to start 22 companies, including Apple, Microsoft, Comenco, and North Star. This was the network that took up Roberts's example of a personal computer, out of a romantic vision of giving computer power to the people, while established companies, including Silicon Valley companies such as Hewlett-Packard, rejected the first technical proposals.

The most widely publicized story of technological audacity and business imagination came out of this process: the development of the Apple Personal Computer by two school drop-outs in their early twenties, working out of their garage in Menlo Park in the summer of 1976. Steve Wozniak was the designer of the computer, and Steve Jobs the business genius who sensed the commercial potential of their product and went on to build a company that jumped from zero to $100 million sales in four years, to become a decade later a truly multinational corporation. It is important to notice that Jobs and Wozniak were only able to start the company because a former

Intel executive, Mike Markkula, came into the project as a third partner, lending them $91,000.[23]

It is this high-risk funding by individuals who were knowledgeable about the trade, and who shared and understood the culture of the innovators, that made possible the endless birth of new firms in Silicon Valley. When in 1981 IBM introduced its own PC, making official the importance of the new market, Silicon Valley networks started to generate computer companies, both in hardware and software, as well as computer services business, making computers by the mid-1980s the most important activity of the region, even surpassing semiconductors. In addition to Apple, and to the continuing expansion of Hewlett-Packard, a new computer company, Sun Microsystems, created in the early 1980s out of the same social networks, became another example of the capacity of Silicon Valley to generate major companies in a few years, out of new ideas and new technological breakthroughs, in the case of Sun mainly due to the contribution of another young computer guru, Bill Joy.

However, when in 1984–6 Japanese competition and a world downturn in the computer industry struck the region, forcing the lay-off of over 21,000 workers, many observers concluded that the aging industrial structure of Silicon Valley had peaked, and forecasted a slowing-down of the innovation drive. Yet, in the second half of the decade, the social networks in the area continued to act as magnets to information and capital from all over the world, generating new spin-offs, starting up new companies, and diversifying and making more complex the pre-existing industrial structure.[24] While the established semiconductor companies lost ground to Japanese competition in high-volume, standardized production, a new wave of companies, both in semiconductors and computers, went on to develop a new flexible production system, concentrating on high-value customized devices, and upgrading their technological level to edge off the competition.

Silicon Valley now became increasingly specialized in the high level of technological production in microelectronics and computers, with companies automating their manufacturing plants and/or moving them to other cheaper areas in the United States while keeping in the Valley the high-level functions of R&D, design, and advanced manufacturing. Changing networks of firms, specializing in various operations, and deepening their technological leadership at each stage of the production process, were the source of a new round of innovation and industrial growth that kept Silicon Valley ahead of the competition and growing, economically, demographically, and territorially, at the very time that other high-technology regions, such as Boston's Route 128, were hurt by the decline of military markets.

Thus, from the mid-1970s Silicon Valley became a self-sustaining innovative milieu of high-technology manufacturing and services, generating its own production factors: knowledge, capital, and labor. Universities, including Stanford, San Jose State, Santa Clara, and to some extent the *relatively*

distant Berkeley, continue to be critical in providing the labor market with well-trained engineers and scientists. However, their role as sources of R&D has substantially declined in comparison to the endogenous research capacity of the industry, although cooperative research programs continue to link universities and firms.

But, for the innovative milieu to become self-sustaining, it had to be supported for a long period by the set of interactive elements whose development we have presented here. And for such elements to cluster together into a synergy-generating process, they have to be supported by a specific local culture both resulting from the high technology industry and contributing to its innovative capacity.

THE SILICON VALLEY CULTURE

Technological revolutions have always been associated in history with the emergence of specific cultures.[25] Such cultures are essential ingredients of the ability to innovate and to link innovation to the applications most valued in a given society, from the building of cathedrals to worldwide commercial sales or to the mastery of military power. The territorial concentration of innovation processes in certain core areas seems to be a prerequisite for the development of such culture and for the positive interaction between technological innovation and cultural change.[26]

In the case of Silicon Valley, there is indeed a strong cultural specificity in the values and lifestyle of executives, engineers, technicians, and skilled workers that forms the human basis of this leading milieu of innovation. Some of the features of this culture do not fit entirely with the virtues heralded by the legend, while others in fact do. There is little systematic scholarly research on the subject, so that our analysis is necessarily tentative. Yet, there is enough survey information, including journalistic reports and trade books written by scholars, to provide the basis for some broad characterization of the patterns of social values and behavior in the Valley.[27] We have used in particular a very important survey on a representative sample of Santa Clara County workers, conducted by the major local newspaper, the *San Jose Mercury News*, in August–September 1984,[28] a date prior to the crisis that struck the industry, thus modifying some of the classical social patterns in the area.

While accepting the risk of excessive schematism, we could synthesize the predominant Silicon Valley culture by nine interrelated features:

1 *The centrality of work*. Silicon Valley, like all major industrial centers, is as far as can be from the "laid-back" Californian image. For 49.2 percent of people surveyed "what they do at work is more important than the money they earn," and 38.7 percent said that their "main satisfaction in life comes from their work." Fifty-nine percent claimed to be "very satisfied" with their jobs, against 46.7 percent for the whole of the United

States. People do indeed work: 30 percent work between 41 and 50 hours a week; 10.4 percent spent more than 51 hours working; 28 percent take work home at least once a week. Job satisfaction increases with the number of hours worked.

Thus, hard, intense work is the basic feature of life for Silicon Valley producers, particularly for the most skilled segments of the population. As in the case of other technological-economic revolutions, the drive to produce and to successfully compete is the basic source of the new social organization. And, as in the previous industrial revolutions, work and the workplace tend to be the primary focus of social activity.

2 For the technical-professional component of the employed population (accounting roughly for 50 percent of high-technology workers) there is also a *positive feeling towards work as the opportunity for innovation.* They have the ideology of the innovators, expressed in the feeling of being in the cutting edge of technology and sensing the importance of it.

3 *Entrepreneurialism* is a fundamental feature of the culture, in spite of the fact that the majority of professionals and engineers work for large companies. Yet, the role models continue to be the young leaders of start-up companies who became millionaires out of their capacity to innovate and of their audacious attempts to create new firms. This culture provides the ground for endless spin-offs that have nurtured the durability of innovation of the Valley, in spite of the efforts of companies in the 1980s to slow down the very process that had been their origin, in a futile attempt to close the door once they were established in the market.

4 Another key cultural attitude is *aggressive competition*, both between individuals and between firms. There is an all-out struggle to keep ahead, leading to loose moral standards in professional relationships; this is something that seems to be characteristic of many historical contexts of major innovation, when the frontier spirit becomes cut-throat competition. Thus, 36 percent of workers surveyed think that "their co-workers" falsify their career histories. Forty-two percent think that "their co-workers" take material or computer time from the company without authorization; 16 percent believe that use of company secrets for personal gains occurs frequently; and 55 percent of high-tech workers think that "some people will do anything to get ahead." It is precisely this personal drive, invested in revolutionary technologies applied to a strategic industry that leads to the acceleration of the innovation process in the area, either through the existing firms or through their spin-offs.

5 As one could imagine, this is a culture of *extreme individualism*, possibly stimulated by the continuing immigration to the region of thousands of young professionals from all over the world, attracted by the "Silicon Rush." In 1984, 31 percent of the workers surveyed had never married; 15 percent were divorced; and only 20 percent of the labor force was over 45 years of age. Such an individualistic pattern has direct consequences

on housing markets, on the school system, on traffic behavior, on leisure, and on politics, governments of all kind being universally distrusted and taxes being considered a crude assault on the individual citizen. The "free rider" ideology blossoms in Silicon Valley on the basis of a highly educated, often single, mainly out-of-state immigrant population that strives for the high rewards in which it believes. The rewards are actually there – if not for everybody, at least for enough people to make everybody believe in the possibility of reaching them.

6 Although not a cultural element in itself, it is important to emphasize that such cultural expressions rely on a material basis: *the affluence of the area*. To be sure, there are also dark sides to this prosperity: poverty, discrimination and exploitation are present in Silicon Valley as in all class societies. Yet, on the average, and in relative terms to other areas, including high-technology areas, there is an undeniably high standard of living for the majority of the population. Such reality leads to high expectations from most people, who feel it is possible to make a good living while still young. A direct consequence of such a feature is the inability to pay attention to, or even to understand, those left out of the affluent group, reinforcing individualism, and digging even deeper the trenches of urban segregation.

7 Merciless individualistic competition, and the relentless drive for work and innovation have a major cost: *technostress*, as it is called in Silicon Valley, meaning social and psychological stress in all their manifestations. Thirty-eight percent of all surveyed workers, 42 percent of women, and 43 percent of professionals, said that job-related stress affected their lives off the job. Job-related stress is associated in the opinion of most experts with widespread social ills in the area:[29] alcohol and drugs (one-third of those surveyed think "their co-workers" often use drugs at work); family disruption (with one of the highest divorce rates in the United States); frequent emotional problems for children, etc. Furthermore, in addition to stress in itself, there is also a culture of stress, that is, a value system in which extreme stress has become part of the lifestyle as the necessary price to pay to be on top of the world. Mechanisms to deal with stress were generated by the Valley's firms and institutions, becoming an integral part of the local culture. The following two are the main such mechanisms.

8 The emergence of *corporate subcultures*, of which Hewlett-Packard is the most distinctive. Feelings of company loyalty are very strong for 65 percent of the surveyed workers (against 46 percent at the national level). Firms tend to stimulate such feelings of membership via recreational activities, flexible working schedules, and informal styles of personal interaction. The aim is to offset high labor turnover and to retain in the company the brain power that represents the main asset of a research-based firm. Thus, the pattern of cut-throat competition we have described

is somewhat smoothed by team work and by interpersonal cooperation in the workplace, a device providing psychological support among equally workaholic individuals.

9 Another major mechanism to relieve stress is what could be labeled *compensatory consumption*, at least for the affluent half of the population. Because of the drive for innovation and the search for immediate rewards, helping to release stress, consumption styles tend to emphasize extravagance, experimentation, and lavish, *nouveau riche* behavior. The "hard work–hard play" syndrome of Silicon Valley is a way of materializing in the short term the rewards workers expect from the effort they put into innovation and competition. The classic deferred gratification pattern of the Protestant ethic is replaced by an immediate gratification pattern, coupled with the importance of work as a goal in itself. So, consumption is not in this culture as much an expression of status-oriented conspicuous behavior as a tension-release mechanism, that feeds back the desire to keep going in the domain where the real action is: innovation and career making at the workplace.

These cultural trends certainly vary according to the social position of the workers. An immigrant woman in an electronics assembly line will hardly be driven by the desire for innovation. Yet, the culture described is the dominant culture in the area, for two main reasons. On the one hand, there has been and continues to be a constant social upgrading of Silicon Valley, since unskilled workers and traditional ethnic minorities find fewer and fewer jobs and residences in such highly valued space, being pushed out to the outlying areas, while many of their jobs are either offshored or automated. So the dominant occupational group in the area is formed by professionals, managers, engineers, and technicians. On the other hand, even for blue-collar workers, there is a pervasive cultural influence coming out from this drive for technological poise and easy material wealth, that frames their behavior, either as a model to imitate or as an ideology to reject on the basis of their daily experience.

Thus, the values that we have outlined seemed to form the dominant culture of Silicon Valley, in the traditional sociological sense. Such values have been critical in keeping alive the innovation capacity of the area, because so much of that capacity is linked to a decentralized, entrepreneurially-based process of innovation, that combines individual ambition and organizational support of work-related social networks. This is why Silicon Valley outgrew its origins to become a self-sustaining milieu of innovation.[30] While doing so it had also to confront the reality of the problems generated by economic growth without social control.

THE QUALITY OF LIFE IN SILICON VALLEY

The experience of Silicon Valley is characterized by the stark contrast between the promises of high technology for the quality of life and the

disruptive social and environmental effects produced by fast-track development on the area, on its residents, and on the industry's workers. There is, as Lenny Siegel and John Markoff wrote, a "dark side of the chip."[31] This is an important matter, because it could provide a warning sign for other areas in the world considering a similar growth process. It is also analytically relevant in order to evaluate the potential impact of the deterioration of the quality of life on the capacity of an area to keep attracting high-technology firms.

Indeed, the transformation of the urban structure of Santa Clara County under the impact of rapid industrialization in the 1950–90 period is one of the most striking examples of the contradictions between individual economic affluence and collective environmental deterioration.[32] The intensity of the process of growth put enormous pressure on scarce land – for industrial development, housing, urban services, transportation, and open space. Land prices and housing prices skyrocketed, making real estate very attractive, then adding speculative pressures to functional demands.[33] The supposedly clean industry caused serious chemical pollution, some of it stemming right from Stanford Industrial Park, contaminating water wells in many areas, including upper-middle-class areas, to the point of becoming a serious health hazard.[34] Residents in the area reacted against new development, trying to preserve the quality that had originally attracted them to the area, while raising the prices of their property. No-growth, environmental movements mushroomed, putting pressure on local governments and conflicting with the interests of future industrial development in the area.

Sharp spatial segregation came increasingly to characterize Silicon Valley. In the first stages of development, as studied by Saxenian in her first work on the area,[35] the segregation pattern differentiated four main areas: the Western foothills, with exclusive, upper-income residential communities; the North County, immediately to the south of Palo Alto, core of the high-tech industrial belt, mixing companies and middle-level residential areas; the San Jose area, for a long time the main residence for the mass of semi-skilled workers, increasingly becoming the urban support for business services; and the most distant areas, in the south of the County, where newcomers concentrated to knock on the door of the promised land.

In the 1980s, the endless expansion of the industrial and business services concentration in the Valley led to an upgrading of the activities located in the North County area, to the emergence of San Jose as a truly directional center, and to the expansion of the areas of industrial location of the Silicon Valley complex much further to the south, as far as Gilroy, and to the east of the Bay, into Alameda County beyond Fremont. This highly segregated structure, both in terms of activity and of residence, led to worse than average transportation problems, with huge traffic jams becoming an important part of the Silicon Valley lifestyle. It is not unusual to observe a young engineer driving a $50,000 luxury car with one hand while working

on his portable computer with the other, taking advantage of the fact that average speeds at certain critical times do not exceed 10 m.p.h. Thus, traffic jams, increasingly higher residential density, and chemical pollution have brought significant deterioration to the environmental quality of the area. Most of the famous orchards of the Silicon Valley mythology are gone. The surface of open space per person in the City of San Jose is about one-third of that of New York City. Crime is a major problem, as in all large metropolitan areas in the United States.

And yet, throughout the 1980s, talented engineers and innovative companies from all over the world continued to settle in the Valley, as if its magnetism was endless, disregarding the forecasts of the Japanese domination in the electronics race. In fact, Japanese companies and Japanese capital are now among the major players in the industrial structure of Silicon Valley, either directly (Amdhal, owned by Fujitsu) or indirectly (substantial agreements between Japanese companies and the founding firms of the Valley, such as Intel, Apple, etc.). Thus, Silicon Valley sees its technological preeminence fully recognized, even under the new conditions of the international economy characterized by the decline of American domination in microelectronics. The obvious and rapid deterioration of the very quality of life that was an important factor in the origin of the area as a technological center, has not hampered the vitality of its economy or its capacity to innovate.

This is because milieux of innovation are a goal in themselves. People do not live in them because of the quality of their life or the beauty of their nature: quality of life is a highly subjective attribute, and many areas in the world are of startling beauty without having much chance to become technological or industrial centers. If young business talents continue to overcrowd the already overcrowded, unpleasant areas of Central Tokyo or Manhattan, it is not to enjoy the rarity of the singing of a surviving bird. It is to be part of, and be rewarded by, the world's financial centers. If film makers and music composers spend their lives on the Los Angeles freeways, it is not to catch a last ray of the sun through the ultimate toxic smog of Southern California; it is to be in the networks of the milieu generated from Hollywood 60 years ago. Similarly, the attraction that Silicon Valley continues to exercise over the high-technology researchers and entrepreneurs of the entire world relies on the simple and fundamental fact of being the depository of the most advanced knowledge in electronics and on its capacity to generate the next generation of such knowledge by processing the flows of information through its social networks and professional organizations. Silicon Valley's fate is to live up to its own historic role as a milieu of innovation of the latest industrial revolution – whatever the consequences for its land and for its people.

IS THERE A SILICON VALLEY MODEL?

Yes, there is. Not in the sense of a general formula that could and should be replicated in any other context, regardless of the economic, technological, geographic, or institutional characteristics of each region. But there is a model in the sense that we can identify, on the basis of our analysis, the elements that underlay the formation of a leading technological milieu, as well as the forms of their combination and the sequence of their development.

As we have presented in some detail elsewhere[36] in the formation of the milieu of technological innovation in Silicon Valley there concurred a number of functional preconditions as well as some key structural elements. In addition, the dynamics of the milieu itself consolidated its development. At the origin of the milieu of innovation was the *historic and geographic* coincidence in Santa Clara County, in the 1950s – at the very dawn of the new production system – of the three major production factors of the new informational age:

1 The new raw material, that is scientific knowledge and advanced technological information in electronics, generated in and diffused from Stanford University (since Shockley himself, while creating his own company, was also recruited to the Stanford Faculty).
2 High-risk capital provided either directly by venture capital investments or indirectly by the guaranty of military markets for still-untested devices, thus making it possible for the new companies to obtain finance on the basis of their assured earnings, regardless of their ability to succeed in their programs. The Federal Government's support through military markets and through tax provisions for small businesses was then critical for the formation of Silicon Valley. However, the reason why the Defense Department supported the effort in the critical take-off stage was because of its belief in the excellence of the technology that the companies could develop. Thus, the availability of applicable science and technology is indeed the primary factor in the development of a milieu of innovation.
3 Availability of highly-skilled scientific and technical labor in the area, from the strong electrical engineering programs of the Bay Area universities (Stanford and Berkeley, at first; San Jose State and Santa Clara, later). While Silicon Valley went on attracting talent worldwide from the 1960s, the first stages of the milieu benefited from the pool of good engineers graduating in the area, with access to support systems in the universities themselves. Thus, universities played a double role: first, particularly Stanford, as sources of new raw material: scientific-technological knowledge; and second, as providers of highly-skilled labor before the milieu could generate its own labor market.

But the clustering of these three fundamental production factors in Santa Clara County, and their articulation in a *deliberate development project*,

:e not purely accidental, unless we consider accidental the rise of an trepreneurial project. The whole project was conceived and implemented / an institutional entrepreneur, Stanford University, under the personal impulse of its visionary Dean of Electrical Engineering, Frederick Terman. The formation of the Stanford Industrial Park, and the spin-offs from the firm founded by Shockley after his joining of the Stanford Faculty, were the material matrix out of which Silicon Valley developed.

However, the vitality and resilience of Silicon Valley over time, and the achievement of its level of technological excellence, were only possible because the Valley itself created social networks among its engineers, managers, and entrepreneurs, generating a creative synergy that transformed the drive for business competition into the desire to cooperate for technological innovation. These networks were constructed on three interrelated foundations: a work-oriented culture that valued technological genius and daring entrepreneurialism; professional organizations that sustained the interests of the Valley's electronics industry and pleaded its cause; and the territorial concentration of work, residence, and leisure that became all-embracing of its own values and interests, while excluding and segregating other social groups and economic activities.

When the Valley reached the age of maturity and the leading world corporations felt the need to be present there, they did so by incorporating themselves into the Valley's specific social organizations, whose vitality as informal networks outlasted the company affiliations of their members. Thus, the entrepreneurial and research-oriented culture, and the collective entrepreneurship of Silicon Valley's work-based, bar-reinforced, social networks, became fundamental elements for the existence and development of the milieu of innovation, just as much as the structural factors of production that made its formation possible in the first place. The interplay between the structural transformation of technology and economy, the new factors of production in the informational age, and the social, cultural, and institutional conditions of new entrepreneurship, seem to provide a necessary and sufficient explanation of the why, how, when, and where, of Silicon Valley.

As for its replicability, it all depends on the ability of firms and governments to understand the lessons of the experience, both positive and negative, in terms sufficiently analytical to be translated in different contexts; but with different strategies, and with different actors. For the very existence of Silicon Valley has changed for ever the spatial division of labor in high-technology research and production, so ironically precluding the direct replication of its own experience.