

Praise for Tapan Munroe's
What Makes Silicon Valley Tick?
The Ecology of Innovation at Work

"What Makes Silicon Valley Tick offers a fascinating, up-to-date account of Silicon Valley's enduring vitality. Anyone interested in understanding the region that continues to invent the future should read this insightful book."

*AnnaLee Saxenian, Dean and Professor, School of Information,
University of California, Berkeley*

"What Makes Silicon Valley Tick is a tour de force: comprehensive, systematic, authoritative, and highly readable. It showcases what Silicon Valley insiders have known for a long time—that Tapan Munroe is our foremost interpreter and expositor."

*Russell Hancock, President & Chief Executive Officer,
Joint Venture: Silicon Valley Network*

"Tapan Munroe admirably captures the spirit of Silicon Valley—both its working parts and the ethos that drives it. What comes across clearly is its unplanned, organic nature, which makes the Silicon Valley experience hard to replicate. As Munroe points out, its story in many ways describes the entire San Francisco Bay Area, and explains why the region has emerged as a center of global innovation. While, as Munroe candidly points out, it faces significant challenges, the dynamism and flexibility of the Silicon Valley model holds an important key to U.S. competitiveness, where the ability to innovate and create new value will differentiate communities that will prosper from those that will not in the future."

*Dr. R. Sean Randolph, President & CEO,
Bay Area Council Economic Institute*

Praise for Tapan Munroe's
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(Continued)

"This book does a terrific job of analyzing the innovation economy of Silicon Valley. Understanding the lessons from the Valley's success at this time of global crisis is of paramount importance to ensure innovation and economic prosperity. It is a must read for leaders of business, venture capitalists, universities and research organizations who would like to replicate the innovative magic of Silicon Valley in their own region."

Richard C. Atkinson, President Emeritus, University of California

"A superbly written book, it demonstrates the authors' insight into the Silicon Valley technology enterprise and the innovation process. In addition to entrepreneurs and managers of technology, I would highly recommend this book to engineering and business schools and anyone interested in the management of technology and the innovation process."

*Ravi Jain, PhD, PE, Dean and Professor, School of Engineering and
Computer Science, University of the Pacific*

"If ever we needed to understand and develop innovation economies globally, the time is now, in the face of the worst economic crisis since the Great Depression. Tapan Munroe's highly engaging and penetrating analysis is a must read for leaders and entrepreneurs across the private, public, and nonprofit sectors. Munroe deconstructs the region that still leads the world in technology. He proposes a timely model to apply in meeting both anticipated and unanticipated global economic challenges. This book is an inspiration and incentive for us all to develop and sustain transformational ecologies of innovation as an antidote for a seriously ailing global economy."

*Barbara K. Bundy, PhD, Executive Director,
Center for the Pacific Rim, University of San Francisco*

“Tapan Munroe lucidly explains why this extraordinary innovation economy continues to reinvent itself time and again despite many challenges for more than a half a century. Silicon Valley’s dynamic innovation ecosystem, as described and analyzed by the authors, provides various Science Parks and technology regions around the world a powerful model to emulate and a benchmark to assess their performance. This is a must read for all who are interested in understanding the key to a successful and sustainable economy in the twenty-first century.”

*Dr. Felipe Romera Lubias, President, Association of Science and
Technology Parks of Spain (APTE)*

“In this clear, compelling volume, Tapan Munroe has distilled the very essence of Silicon Valley. As the prototypical cluster of innovation, Silicon Valley is often held up as a unique ecosystem. Munroe deconstructs its uniqueness and helps us understand it, one key element at a time. Anchored by a strong, deep understanding that comes from decades of experience in the Valley, Munroe’s profoundly clear analysis makes a very helpful guide for anyone wanting to navigate or do business with this resilient entrepreneurial community.”

*Jerome S. Engel, Executive Director, Lester Center for Entrepreneurship &
Innovation, University of California, Berkeley*

“Tapan highlights what can and must be done if the U.S. is to remain a viable and productive economy that counts in world economic affairs. He is to the East Bay what Thomas Friedman is to the East Coast. Tapan documents and identifies the megatrends that will guide economic and social development in this century.”

*Douglas W. Borchert, Northern California Underwriting Counsel,
Fidelity National Title Insurance Company*

Praise for Tapan Munroe's
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(Continued)

“Dr. Munroe has the unique ability to sort through an immense amount of seemingly unrelated data, to connect the dots, and then provide important conclusions. This remarkably researched book is the key to understanding the unprecedented success of Silicon Valley and it provides a model for others to follow. It’s a must read for CEOs and other executives.”

Donald R. Cottle, Group Chairman, Vistage International, Inc.

“As a consummate Silicon Valley insider, Tapan Munroe enjoys an unmatched perspective on the events that make Silicon Valley both a top performing economy and an extraordinary phenomenon. Tapan Munroe and Mark Westwind look at the interconnections and links among the diverse agents making up the Valley, shedding light on their co-evolution as a very dynamic system able to innovate and create wealth despite many challenges in the last six decades.”

*Dr. Tomas Gomez, Transamerica Associate Professor of Marketing
and Global Business, St. Mary’s College of California*

“You don’t have to be a business techie to enjoy this book! Munroe and Westwind have skillfully interwoven their analysis of Silicon Valley—based on an ecological model—with the Valley’s historical development. They have created a fascinating story that will appeal to the technologically literate and illiterate alike. This is not a puff piece: Silicon Valley is exposed, warts and all. For anyone who wants to know more about how Silicon Valley works, buy this book and read it immediately.”

Rollin Odell, Jr., MD

“In times of economic change and stress, there is no better tonic than Tapan Munroe’s compelling vision of a business environment driven by creative innovation. This book, so excellently researched and written, provides a compelling basis for confidence in what can be accomplished if we choose to learn from the remarkable culture that is Silicon Valley. In an age when so much seems to have been lost due the unrestrained greed of a few, his hopeful perspective provides a foundation for collaboration which can benefit us all.”

*Rev. Peter Whitelock, Senior Pastor, Lafayette Orinda
Presbyterian Church, Orinda, California*

“In a world where so many aspects of our lives are globalized, Silicon Valley casts a long shadow both as a center and symbol of innovation. And in a world that is currently mired in a serious recession, *What Makes Silicon Valley Tick?* is a lively and well-illustrated read for anyone interested in the economics of hope. Choosing a biological metaphor, Munroe traces the growth and continuing evolution of Silicon Valley by aptly identifying and describing the seven factors crucial to its success. In doing so, he not only educates us about the importance of innovation in today’s economy, he provides us with hope for the future.”

Thomas Scovel, Professor of Linguistics, San Francisco State University

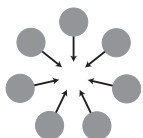
“A long-time observer of the region, Dr. Munroe offers an insightful view of Silicon Valley’s remarkable evolution. Like a learning organism, the Valley is genetically driven to thrive in the face of relentless change, constantly regenerating and diversifying its relationship with the world around it. As the preeminent innovation-driven economy, Silicon Valley may offer the best proof yet that innovation is not a luxury, but a necessity, and the best and only way to sustain prosperity.”

*Robert Brant, Executive Vice President, City National Bank,
San Francisco and Beverly Hills*

What makes

Silicon Valley

tick.~



The Ecology of
Innovation at Work

Tapan Munroe, PhD

with Mark Westwind, MPA



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Innovation is the central issue in economic prosperity.

Michael Porter, Harvard University

Today the U.S. is in the midst of one of the worst economic downturns since the Great Depression of the 1930s. The housing debacle and credit crisis have decimated the housing and financial industries. Our domestic auto industry is also in great trouble. These have been serious blows to our house-and-car oriented economy. The current economic meltdown is not just an American problem, however; its impact is now being felt in the European Union (all of the Eurozone countries are in recession at this moment) and throughout the rest of the world.

As far as the U.S. is concerned, business as usual will no longer help us to get back on a path of economic growth once the current recession is over. We need to move beyond gas-guzzling SUVs, McMansions, and financial gymnastics if the U.S. is to regain prosperity, attain sustainable economic growth and remain competitive in today's highly competitive global economy.

Attaining a Culture of Innovation

There is wide agreement that innovation is the best, and perhaps the only way, for us to sustain our prosperity. Instead of simply creating new waves of the same old consumer products and services that continue to exacerbate our problems, we need to focus on transforming smart ideas that address real problems and needs into valuable products and services. *Innovation* needs to be our mantra from here on, practiced consistently and frequently, until it becomes part of our national psyche and culture.

Leading-edge science and technology have been America's strong suits since its inception. The country's culture of innovation has been a foundational factor, and the list of American innovation successes is long and impressive. Four of the

eight winners of *The Economist* magazine's 2008 innovation awards are Americans. They include Jimmy Wales for Wikipedia, the free online encyclopedia; Steve Chen and Chad Hurley for YouTube, the popular video-sharing website; Arthur Rosenfeld for the promotion of energy efficiency; and Bill and Melinda Gates for developing a businesslike approach to philanthropy. Their foundation provides an enabling platform for non-profit organizations that are improving the lives of millions of people around the world.

For the U.S. to prosper in the 21st century, the nation must encourage the growth of world-class innovation regions. The good news is that we already have a number of them, including the Route 128 region around Boston, the Research Triangle in North Carolina, the high-tech region in Austin, and many others. But none surpass Silicon Valley in the San Francisco Bay Area of California in creating new businesses stemming from innovations, or in maintaining an impressive record of sustained progress for more than five decades. Silicon Valley undoubtedly is the "mother of all innovation regions" in the world.

Who is This Book For?

Understanding and replicating the Valley throughout the nation is of paramount national importance, particularly at this time of economic crisis. *Business leaders* across the country will benefit greatly from following the examples of successful companies in the Valley. *National and regional economic development leaders* would be wise to shape regions elsewhere along the lines of Silicon Valley, especially since the Valley's model now extends beyond high-tech industries. Understanding the key elements of what makes Silicon Valley tick is a must for *academic leaders*, as well as leaders of *think tanks* and *research organizations*, who play vital roles in the enhancement of innovation regions. It is also important for *venture capitalists and angel investors* to fully understand the vital roles they play, not only in providing the capital that is so vital for starting new businesses, but also in providing expertise and resources that are critical to the success of early-stage companies. Finally, it is vital for *government officials* at all levels to understand the

critical role of policy, finance, law and resources in the emergence and enhancement of businesses in the innovation economy.

How This Book Came to Be

Continuous innovation has been at the heart of the Valley's prolonged success and resilience for nearly a century. My interest in understanding the Silicon Valley economy goes back several decades to the time when I worked for the Pacific Gas & Electric Company in San Francisco, one of the largest utilities in the United States. Silicon Valley is an important region for the company's energy sales. As PG&E's Chief Economist, I tracked the Valley's economy on a quarterly basis for more than a decade.

I have continued to track the Silicon Valley economy over the years since my PG&E days, first as a columnist for the Media News Group, and more recently as a Director for the worldwide consulting firm, LECG, LLC. Furthermore, in the process of writing *Dot-Com to Dot-Bomb: Understanding the Dot-Com Boom, Bust and the Resurgence* (2004), a book that analyzes the severe Boom/Bust cycle that the Valley experienced in 2000-2001, I came to understand how the Valley regained economic vitality after experiencing a severe economic upheaval.

This book builds on an earlier volume, *Silicon Valley: Ecology of Innovation*, which I was commissioned to write by the Science Parks Association of Spain (APTE) in 2008. A limited edition of that volume was published in English and Spanish and distributed directly by APTE to science parks officials and key stakeholders throughout Spain and abroad.

What Makes Silicon Valley Tick? is based on a series of papers and lectures that I presented at several conferences in Spain in late 2008 plus updated information on the state of Silicon Valley. My presentations in Spain included the APTE annual conference in Orense and the Red de Espacios Tecnológicos de Andalucía (RETA) annual conference in Malaga in November 2008. The general theme of these presentations was the critical role that innovation regions such as Silicon Valley play in 21st century economic development. The goal of these

presentations was to provide science park executives with a framework for understanding Silicon Valley's economy, with the expectation that this would ultimately enhance the success of the scores of science parks currently operating in Spain.

This book answers many frequently asked questions put to me by representatives from many aspiring technology regions in the U.S. and in Spain over the last few years. They ask: What is Silicon Valley? How does the Valley's economy work? Why has this region been so successful? What underlies its resilience? What threats does it face, and what can be done about them? What can we learn from the Valley that we can apply to our region?

The Innovation Ecosystem

In seeking a framework for analyzing the economy of the greater Silicon Valley region, I concluded that the most effective framework was that of an ecosystem—an innovation ecosystem. Looking at an economy from a more organic, less mechanical perspective has been gaining popularity among economists. William Wulf, the researcher, entrepreneur and former president of the National Academy of Engineering, has used the phrase *ecology of innovation* to describe how various factors interact in the U.S. economy to enhance or hinder its ability to innovate. These factors, according to Wulf, include intellectual property law, tax codes, patent procedures, export controls, and immigration regulations.

In this book, we've taken a broader approach to identifying the key elements of the Silicon Valley's innovation ecosystem. Like every living ecosystem, Silicon Valley's very survival is the outcome of the complex interplay of a number of factors. Viewed as an innovation ecosystem, you can see Silicon Valley as a unique, lively creature which consumes and transforms knowledge and ideas into streams of innovative products and services through the continuous formation of new companies, within a complex matrix of relationships among various stakeholders in the region.

In developing our concept of the Valley's innovation ecosystem, we surveyed existing literature on Silicon Valley and applied our own experience, research and available data. We believe our framework provides a balanced and well-integrated model of the seven key elements that form the core of this highly successful innovation ecosystem. We offer this framework in hopes that it ultimately helps contribute to the prosperity of other regions, here and abroad.

Tapan Munroe

As of the last count there are nearly 59 technology regions that include the *Silicon* moniker.¹ Names range from Silicon Alley in New York City's lower Manhattan and Silicon Alps in Austria to Silicon Tundra in Ottawa, Canada and Silicon Wadi in Israel. This phenomenon reflects the enormous worldwide reputation and appeal of the Silicon Valley model of a successful technological region. The hope is always that the success associated with the *Silicon* moniker will somehow rub off on an aspiring region. Such is the strength of the Silicon Valley brand.

In my travels to other high-tech regions around the world, the questions I am asked most often are: What is Silicon Valley? How does the Valley's economy work? Why has this region been so successful? What underlies its resilience? What threats does it face, and what can be done about them? What can we learn from the Valley that we can apply to our region?

Ecosystem Basics

The key to understanding what makes Silicon Valley's innovation economy so successful can be understood via the workings of the unique evolutionary model: the biological ecosystem. Just like any biological ecosystem, a successful innovation ecosystem is based on key elements that adapt and evolve in the face of constant change. The ability of these key elements to rapidly adapt to change assures resilience in response to external shocks and internal upheavals. Resilience supports long-term sustainability so that the hard-earned prosperity of one cycle of success becomes the foundation for the next cycle, and so on. The success of an innovation ecosystem relies on the vitality and health of each of these elements and their interconnectedness. Conversely, a failing or unhealthy element can undermine the existence of the entire ecosystem.

Innovation

The process of commercializing an idea in the form of:

- A new or improved product
- A new production method
- A new business organization
- New uses for existing products
- New markets for existing products
- New distribution channels

Ecology of Innovation

The study of the key elements of an economy that foster and support innovation and their relationships to each other within that economy.

At the heart of this book are the key elements that make up the core of the Valley's innovation ecosystem. This thriving high-tech region in the southern San Francisco Bay Area is a unique economic environment where bold, new ideas compete and then are transformed into products and services that reshape our world. In this process of transformation, the Silicon Valley entrepreneur becomes part of a symbiotic web of supportive relationships. In a world of innovation, ideas need entrepreneurs to survive and entrepreneurs need ideas to flourish.

Modeling the Innovation Ecosystem

In Silicon Valley's innovation ecosystem, the following key elements, each playing different and mutually supporting roles, maintain and enhance the ecosystem's health:²

- World-class research universities
- Entrepreneurs
- Investment capital
- A talented, well-educated workforce
- Social and professional networks
- A favorable business climate
- A high quality of life quotient

They each contribute in many interconnected ways to the success of entrepreneurs' ventures, and in doing so, contribute to their own prosperity and the prosperity of the region.

Innovation and technological change are undoubtedly the main drivers of economic growth at organizational, industry, and macroeconomic levels. The

fundamental point is that without innovation, there is no increase in productivity, and without productivity, there is no increase in prosperity.

For decades, Silicon Valley has sustained its success by consistently providing a steady stream of ideas and innovations that have created value for consumers and organizations worldwide. In this book we will help you understand what has made Silicon Valley so successful and what factors have contributed to its long-term sustainability as a world-class high-tech economy.

In order to do so, we must understand the Valley's ecosystem by identifying its key elements, in Part 1. In Part 2, we learn how they interact to sustain and enhance one of the most well-known and extraordinary regional economies in the world.

Finally, in Part 3, we examine the vulnerabilities of the Valley's ecosystem—after all, no ecosystem is immune to risks, threats and challenges to its continued survival and vitality.

For more than a century, the southern region of the San Francisco Bay Area known as Silicon Valley has been a highly successful hub of invention and innovation.³ Dubbed Silicon Valley by Ralph Vaerst, a Northern California entrepreneur, and popularized in 1971 by his friend Dan Hoefler, a reporter for the trade journal *Electronic News*,⁴ the name has been widely embraced by the media and the public.

Santa Clara County and Silicon Valley

While there are no official borders of Silicon Valley, the term was originally used to define the area in and around the city of San Jose (often referred to as the Capital of Silicon Valley). Today, Silicon Valley includes Santa Clara County as well as adjacent parts of Alameda County, San Mateo County, and Santa Cruz County. (See map, opposite.)

Silicon Valley embraces 29 cities, including Palo Alto, San Jose, Mountain View, Sunnyvale and Fremont, though the region's economic base extends up to San Francisco. The region's economic influence extends for a full two-hour commute to the north into Marin, Napa and Sonoma counties, into the East Bay counties of Alameda and Contra Costa, and further east into San Joaquin County.⁵ In 2006, 11 Valley cities ranked among the top 20 most innovative cities in the United States.⁶ Figure 1 provides a snapshot of the region and its population.

Stanford University

The seeds of Silicon Valley's innovation economy were sown in 1891 when former California governor, U.S. Senator and wealthy railroad magnate Leland Stanford and his wife, Jane, opened Stanford University on the grounds of their

Figure 1

Profile of the Silicon Valley Region

Area:	1,500 square miles
Cities:	9
Largest City:	San Jose
Population:	2.44 million
Average Annual Wage:	\$74,302
Education (Degree):	
Bachelor's	26%
Graduate/Professional	18%
Ethnicity:	
White, Non-Hispanic	42%
Asian	29%
Hispanic	24%
Black	3%
Other	2%

Source: U.S. Census Bureau, 2006

Palo Alto ranch.⁷ Since then the region has grown to become one of the world's preeminent powerhouses for innovation. No other region has so consistently yielded such a prolific harvest of revolutionary technologies and world-class companies. (Figure 2) Many of these technologies have changed (sometimes radically) our way of living and, in the process, made many of the region's innovators, implementers and investors enormously wealthy. No other region has so successfully managed to repeatedly reinvent itself in the face of ever-changing technology, major economic upheavals, and rapid globalization.

While Stanford University played a catalytic role in the birth of Silicon Valley and it continues to be instrumental in supporting the Valley's success, Silicon Valley has, over the years, also been influenced by its proximity to other world-class research universities and think tanks. These include the University of California (UC) campuses of UC Berkeley, UC San Francisco, think tanks such as the Xerox's Palo Alto Research Center, and research laboratories such as Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory and Sandia National Laboratory.

Figure 2

A History of Silicon Valley Innovation

1891	Stanford University founded
1909	Federal Telegraph Company founded
1912	Lee De Forest perfects vacuum tube
1938	Hewlett-Packard founded
1951	Stanford Industrial Park established
1956	Shockley Semiconductor Laboratory founded
1957	Fairchild Semiconductor founded
1968	Intel founded
1976	Apple Computer founded
1982	Sun Microsystems founded
1984	Cisco Systems founded
1994	Yahoo! founded
1995	Netscape IPO triggers the Dot-Com Boom; eBay founded
1998	Google founded
2000	Dot-Com Bust and Telecom Meltdown
2007	Rise of Web 2.0/3.0 and Cleantech

Source: *Joint Venture: Silicon Valley Network*

These highly-regarded universities and think tanks have consistently provided the Valley with a steady stream of ideas, inventions, engineers and entrepreneurs. In presenting the history of Silicon Valley, we are quite aware that our discussion of events, people and achievements is very Stanford-centric. We believe the Bay Area's University of California campuses and the UC system as a whole have played an equally important role in contributing to the development and success of Silicon Valley. We will focus on the UC system's role in a later

chapter. In fact, Silicon Valley is much more of a San Francisco Bay Area regional economic entity than strictly a South Bay economy.

The popular story of Silicon Valley is to a great extent the story of the inventions, innovations and business ventures initiated by Stanford students, graduates, faculty, and friends. Stanford's open and entrepreneurial culture (influenced heavily by its founder) was a major factor supporting and encouraging the integration of business and education in a way that was considered heretical in academic circles. Even in this, Stanford University was a pioneer of innovation. That was because historically, the academic study of business was not considered an appropriate use of university resources and faculty time.

Sparks of Innovation

Silicon Valley's heroes are the successful entrepreneurs who have taken aggressive professional and technical risks: the garage tinkerers who created successful companies.

AnnaLee Saxenian

Source: The New Argonauts: Regional Advantage in a Global Economy

It is common lore that the birth of what we recognize as Silicon Valley (both geographically and economically) began with the founding of the Hewlett-Packard Company in 1938. Others attribute the birth of the Valley to the formation of Stanford Industry Park in 1951, or to the relocation of the pioneering electronics firm Varian Associates from Santa Clara to the Park in 1953. Others credit the defection of a handful of engineers (the so-called "Traitorous Eight") from Shockley Transistor to form Fairchild Semiconductors in 1955.

In his book, *How the Silicon Valley Came to Be*, Timothy Sturgeon of Massachusetts Institute of Technology points out that these are certainly seminal events in the long history of the Valley, but it is important to recognize that the roots of today's Silicon Valley extend back to the turn of the twentieth century.⁸ Hewlett-Packard and Varian were not the first important electronics companies to rise near Stanford, and Fairchild Semiconductor was not the region's first spin-off.⁹

Rather, the roots of today's worldwide electronics industry can be traced back to the pioneering innovations of two Silicon Valley technologists and entrepreneurs. The first was Stanford graduate Cyril Elwell, who developed a highly successful radio telephone system. Backed by David Star Jordan, the president of Stanford University, and C.D. Marx, head of the University's Civil Engineering Department, Elwell founded the Federal Telegraph Company (FTC) in 1909.¹⁰ The second was Lee De Forest, a brilliant young innovator who perfected the vacuum tube in 1912 while working for FTC. De Forest's vacuum tube revolutionized the radio industry, literally launching the Age of Electronics.¹¹ In fact, as William Hewlett, co-founder of Hewlett Packard Company, has commented, "the beginning of Silicon Valley was a supernova [that] caused a rippling effect, setting the stage for future events."¹² Hewlett attributes this supernova to the young De Forest and his work at Federal Telegraph Company.¹³

The ripples from FTC's impact on the world of electronics resulted in the first wave of Silicon Valley spin-offs, including Magnavox, Litton Industries and Fisher Research Laboratories. Magnavox became a recognized leader in manufacturing a broad range of consumer electronics products and pioneered the first home video game system in 1972.¹⁴ Harold Elliott, an FTC engineer, developed the core technology that was the foundation of RCA's groundbreaking "single dial tuner," the home radio set that hit the market in 1927.

That same year, a young Stanford instructor, Fred Terman, launched the University's first radio and electronics engineering program. Terman's enthusiasm for radio and electronics helped him befriend many of the budding industry's luminaries, including Cyril Elwell of FTC and Philo Farnsworth, who invented the television at his San Francisco laboratory. Under Terman's leadership, Stanford's Radio Engineering Laboratory (REL) became one of the nation's top academic electronics centers. From the very beginning, Stanford leaders envisioned the role of the University as helping the region to build a strong local economy. This sense of regionalism helped the University align its interests with those of local high-tech firms.¹⁵

Stanford's "Secret Weapon"

Out of this fertile intellectual ground came two Stanford graduates, William Hewlett and David Packard. Both were students in Fred Terman's electronics program. Terman's field trips to nearby electronics research labs and his stories about entrepreneurial inventors inspired Hewlett and Packard to launch the Hewlett-Packard Company (HP) in 1938 in a Palo Alto garage. Nearly 70 years later, HP is one of the world's largest information technology firms.¹⁶ HP's early success, the end of the World War II and Stanford's growing reputation as a world-class university set the stage for the Valley's second supernova: the Stanford Industrial Park. In the late 1940s, Stanford was experiencing financial troubles stemming from the University's rapid growth following the end of World War II. Selling any part of the University's large land holdings was out of the question, forbidden by Leland Stanford's gift to the University. Instead, the University opted to lease its surplus land—a decision that Terman called "our secret weapon," and one that ultimately transformed the region's economy. It was Terman who suggested that leases be limited to high-tech companies with which there could be a mutually beneficial relationship with the University and its students.¹⁷ This was a bold move that contributed significantly to the Valley's culture of business-academic cooperation. From a financial perspective, the University benefited greatly from royalties coming from products spawned from campus-supported research, and from interests held in spin-off companies resulting from commercial research conducted in campus labs.

In 1951, the Stanford Industrial Park (renamed in 1955 as Stanford Research Park) was opened with the goal of creating "a center of high technology close to a cooperative university." A number of iconic technology companies, including Varian Associates, General Electric, and Eastman Kodak, quickly signed leases. In 1952, IBM set up a key research facility nearby. Soon after, in 1956, Lockheed Corporation located an aircraft division in the Stanford Research Park. These cutting-edge companies, crafting their technological wonders in such close proximity, had enormous impact on the local economy. The heart of

Silicon Valley pulsed in Stanford Research Park, while many related and supporting companies flourished in surrounding communities.¹⁸

The Silicon Revolution

While Stanford Industrial Park was signing leases with its first tenants, William Shockley, a brilliant yet sometimes brash engineer, co-invented¹⁹ the first commercially viable transistor in 1951, marking the beginning of the semiconductor revolution in electronics. At the urging of Fred Terman, Shockley moved to Mountain View in 1956 to head up the newly-founded Shockley Semiconductor Laboratory—a division of Beckman Instruments—which became Shockley Transistors Corporation in 1958.²⁰ Shockley was a genius, but he was also a difficult man to deal with, and while he was able to attract top talent because of his reputation, his management style made it difficult to keep his team together.

In one of the Valley's most historic events, Robert Noyce, Gordon Moore, and six other Shockley engineers²¹ resigned en masse in 1957 to form Fairchild Semiconductor in Palo Alto. Known as the "Traitorous Eight" (or "the Fairchild Eight" or "Shockley Eight"), these men left Shockley Semiconductor Laboratory in 1957 in a disagreement with Shockley over the use of silicon as the exclusive material for making semiconductors. Noyce, Moore and the others believed that designing a silicon-only semiconductor was an important technical opportunity to pursue, but Shockley disagreed and actively discouraged them from this line of research. Fairchild became the first company to mass-produce integrated circuits, thereby replacing Shockley's technology. Shockley sold his company in 1961 and joined Stanford University as a faculty member.

Fairchild Semiconductor also eventually became a parent to over forty local high-tech companies,²² laying the foundation of another core value of the Valley's entrepreneurial culture: the belief that anyone with a good idea can find the capital, put together a team and go after a market opportunity.²³ By the 1960s, no other region had such a concentration of cutting-edge high-tech companies—

and no other region could boast of being the birthplace of the electronics revolution with so many firsts in the field. Yet the Valley's culture of innovation was brewing new and even more revolutionary inventions. In 1968, Noyce and Moore formed Intel (now the world's largest semiconductor company) in Santa Clara, roughly at the geographical center of Santa Clara County and the South Bay Area. In 1971, Intel created the first microprocessor, the platform technology for the coming microcomputer revolution.²⁴ In 1972, Eugene Kleiner co-founded Kleiner, Perkins, Caufield & Byers—one of the Valley's best-known venture capital firms. Sheldon Roberts, Jean Hoerni and Jay Last founded what became Teledyne, while Julius Blank co-founded Xicor. Victor Grinich became a professor at UC Berkeley and Stanford University. Other "Fairchildren" (as spin-offs of Fairchild Semiconductor are sometimes called) include National Semiconductor and Advanced Micro Devices (AMD).

Parallel to the evolution of Fairchild Semiconductor, the geniuses at the Xerox Palo Alto Research Center (PARC) were developing the first graphical user interface for computers, the platform technology for all of today's highly visual operating systems and software applications. No other region has so influenced the development of such fundamental technologies in electronics. But there's more. In 1973, Stanley Cohen of Stanford University and Herbert Boyer of UC San Francisco invented a technique for splicing genes, leading to the formation of the biotech industry.

The Digital Explosion

With all of the foundational hardware and software technology pieces at their disposal, two more young innovators, Steve Jobs and Steve Wozniak, put the pieces together to launch Apple Computer in 1976. In doing so, they totally changed the way we interact with computers (and now music and telephones). The Apple Macintosh graphical user interface was built upon work done by Doug Engelbart at Stanford Research Institute and by engineers at Xerox PARC. In 1982, Stanford graduate students Andy Bechtolsheim, Vinod Khosla and Scott McNealy plus Bill Joy founded Sun Microsystems as a spin-off of the

Stanford University Network (in fact, “Sun” is an acronym for “Stanford University Network”).²⁵

That same year, Jim Clark, an associate professor of electrical engineering at Stanford, founded Silicon Graphics, Inc. (SGI), with a group of seven Stanford graduates and research staff. SGI created the first graphic workstations.

In 1984, Leonard Bosack and Sandra Lerner, also from the Stanford University Network, founded Cisco Systems, the premier Internet router company in the world. With the creation of the World Wide Web in 1989 and the explosion of opportunities that this presented, Clark hired the Mosaic web browser pioneer Mark Andreessen in 1993 and formed Mosaic Communications, predecessor of Netscape Communications Corporation. Soon thereafter, Netscape’s hugely successful initial public stock offering (IPO) in August of 1995 lit the fuse that launched the Dot-Com skyrocket. The Internet proved to be both a blessing and a curse for the Valley, as we will discuss later.

In 1994, Jerry Yang and David Filo, both PhD candidates in electrical engineering at Stanford, started a simple directory of websites that exploded into Yahoo!, one of the Web’s most popular search portals. A year later, San Jose became home to eBay, the Web’s most popular online auction site, founded by Pierre Omidyar, who earlier had worked for Claris, a software subsidiary of Apple Computer. The very next year, two more Stanford PhD students, Larry Page and Sergey Brin, formed Google, underwritten by a \$100,000 check from Andy Bechtolsheim, co-founder of Sun Microsystems. Six months later, Google landed \$20 million in equity financing from rival venture capital firms Kleiner Perkins Caufield & Byers and Sequoia Capital. Yahoo!, eBay and Google have become icons of the Internet Age, and their success has created many young multimillionaires as well as a few billionaires.

Innovation and Evolution

One can easily see in this brief historical overview that Silicon Valley’s success was not the result of a well-planned economic development policy. Nor did the Valley’s high-tech industry spring full-blown from a single event. Its success has

evolved over 100 years, a result of the synergy among the region's well-established entrepreneurial culture, the influences of a handful of visionary and entrepreneurial leaders, and the pioneering innovations of many talented individuals who leveraged their ties with a world-class university. In this way, they changed the world with their revolutionary technologies, and made their fortunes while doing so.

Stanford University's entrepreneurial approach to integrating teaching and research with business once ruffled feathers in more traditional academic circles.²⁶ Eventually, though, it proved invaluable as an inspiration for generations of entrepreneurs and engineers who, to this day, maintain a culture which fosters the open exchange of ideas, friendly collaboration and world-class creativity. The sheer number of cutting-edge technology companies that were drawn to and spawned from the Stanford Research Park is a testament to Fredrick Terman's vision of a "center of high technology close to a cooperative university."

Sixty years after the opening of Stanford Research Park, the Valley is still rich with entrepreneurial spirit and innovation, even though the region's economy has undergone massive change and experienced much hardship as well as success over that time.

Our next look at Silicon Valley will be from a more traditional perspective.

The Silicon Valley Economy

In the past 25 or so years, Silicon Valley's world-class innovation economy has experienced dramatic ups and downs. This is not surprising: a highly innovative economy is risky business. The Valley economy has soared as new technologies replaced old ones, then slowed as once cutting-edge products became commodities—until the “next big thing” arrived on the scene.

A World-Class Innovation Economy

The most dramatic economic rise and fall occurred in the Boom/Bust cycle of 1998–2001, when the region's economy rode the Dot-Com rollercoaster.²⁷ Despite the volatility in the Valley's economy, the region has enjoyed average annual real economic growth of 5% since 1978—a full 1% greater than in California, and 2% greater than the U.S. growth rate for the period. With the Dot-Com Bust of 2000, personal income declined in Santa Clara County and in the Bay Area for two straight years—a decline of more than \$7 billion to the region's economy. Growth returned to “normal” again by 2004 and out-paced state and national growth at 5.7% to 6.4% through 2006.

The Valley's economy recovered in the period 2004-2007, but once again it is being tested by the financial and economic meltdown of 2008-2009. The region is resilient but not immune to severe economic downturns. Nonetheless, it is expected that the region will perform relatively well despite the worldwide recession. We discuss the Valley's ability to survive economic shocks in Part 3.

Silicon Valley's San Jose area currently leads other high-tech regions of the world in terms of “knowledge competitiveness.” (Figure 3) Based on an index established by the Center for International Competitiveness, which is made up of nineteen “knowledge economy” indicators that include per-capita jobs in

Figure 3

World Knowledge Competitiveness Index

Top Ten Regions

1	San Jose, California, U.S.
2	Boston, Massachusetts, U.S.
3	San Francisco, California, U.S.
4	Hartford, Connecticut, U.S.
5	Seattle, Washington, U.S.
6	Grand Rapids, Michigan, U.S.
7	San Diego, California, U.S.
8	Stockholm, Sweden
9	Rochester, New York, U.S.
10	Los Angeles, California, U.S.

Source: Center for International Competitiveness, 2005

intellectual property development, per-capita patent registrations, and per-capita venture capital dollars invested, San Jose was rated the top “knowledge economy” worldwide, followed by Boston, San Francisco, Hartford, and Seattle. In terms of per-capita jobs in intellectual property development and per-capita venture capital dollars invested, Silicon Valley also ranked first in the world over prominent Asian rivals such as Tokyo, Shanghai, Beijing, Seoul, Singapore, Taiwan, and Bangalore.²⁸

Industry Clusters and Specialization

One of the aspects of Silicon Valley’s economy that is indicative of a mature innovation economy is the strength of its high-tech industry clusters. Michael Porter of Harvard University popularized the notion of industry clusters in 1990.²⁹

Industry clusters are geographic concentrations of competing and collaborating companies in the same or similar fields of business, as well as the specialized suppliers, service providers and other related businesses and institutions that support these core companies. A cluster emerges when a “critical mass” of core industry companies locates in an area in order to capitalize on local competitive advantages. A cluster becomes established when its aggregate employment reaches a significant level and, as a group, the core businesses become a major contributor to the local economy.

The 19th-century economist Alfred Marshall³⁰ suggested that when businesses in the same or complementary industries locate in the same region, they improve their access to resources of all kinds (e.g., skilled labor, business and technical expertise, etc.), thereby enhancing their competitiveness. Porter argues that competition is the driving force behind cluster development. As a competitive business grows, it generates demand for related industries. Competition between rival firms in the cluster forces them to be innovative. This spurs new technologies, spin-off businesses, more research and development, and new skills and services.

Businesses within an industry cluster generally draw from the same pool of skilled workers, who often move from one firm to another within the cluster. This free-flow of skilled workers becomes a channel for transferring knowledge and skills, further promoting competition and growth. That growth leads to what Porter calls “horizontal clustering,” as new technologies and skilled labor move to related industries in different sectors of the regional economy.

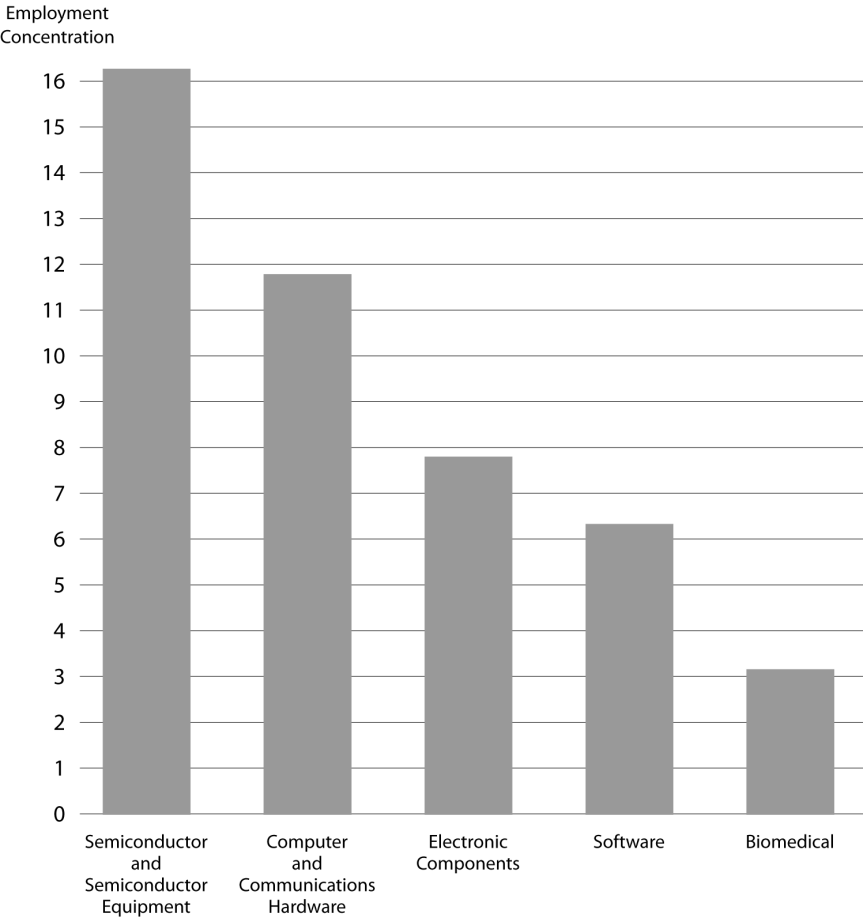
A measure called *employment concentration* compares the percentage of employment in a regional cluster to the percentage of employment in the same cluster nationally. An employment concentration that is greater than the national percentage for a regional cluster indicates that it is what is called a traded industry. This means that this cluster is reliant on markets outside the local economy for maintaining its competitive advantage. The so-called traded industries account for nearly 30% of regional jobs in the U.S. In addition they have higher wages, higher productivity, and higher rates of innovation.

Looking at employment concentrations, data suggests that the Valley's economy includes seven high-tech industry clusters: semiconductors, software, computer and communication hardware, innovation services, biomedical, electronic components, and creative services.

Figure 4

Silicon Valley Cluster Employment Concentration Relative to the U.S.

Values greater than 1 indicate concentrations greater than the U.S. as a whole



Source: *Economy.com*

Of these, five have higher employment concentrations than other major high-tech regions in the U.S.: semiconductors, computer and communications hardware, electronic components, software, and biomedical. (Figure 4) By definition, these five clusters are traded industries and have higher wages, productivity, and innovation levels than the U.S. economy-wide average for the same industry sectors. This explains the broad level of technological competency of the Valley relative to other regions such as Austin, Boston, and Raleigh-Durham.³¹

Many studies have analyzed and compared the country's top regional economies in order to determine why and how these regions developed and maintain their individual levels of prosperity. In 2001, the Brookings Institute looked at fourteen of the nation's top regional economies.³² One of their areas of study examined "principal product specializations." Their research showed that while most of these top economic regions excelled in two product specializations, only the Boston, Washington, D.C. and Austin regions showed specializations in three principal product fields. Meanwhile, Silicon Valley excelled in seven: semiconductors, computers, software, communication equipment, semiconductor manufacturing equipment, electronic design automation software, and data storage. This broad-based excellence of Silicon Valley has been a key factor in the region's global competitive advantage as well as its long-term viability. (Figure 5)

Economic Performance

Looking back on 1977-2007 figures, the Silicon Valley economy has grown at an average annual rate of 5%—a full 1% greater than California's average rate of 4% and 2% greater than the U.S. rate of 3%.³³ (Figure 6) But this "average rate" masks a story of much more dramatic fluctuations in economic fortune. Coming out of the 1970s, the Valley was flying high with an economic growth rate of more than 10%. While the nation stumbled on the oil crisis of the early 1980s and fell into a recession, the Valley's economy kept on humming along, though at a steadily slowing pace. At that time, oil was not the driving factor in the Valley's economy as it was to the nation as a whole. Semiconductors were, though, and the Valley had other cost issues to contend with.

Figure 5

U.S. Regional Product Specializations

Atlanta	Databases, (Telecommunications)
Austin	Semiconductors, Computers, SME*
Boston	Computers, Medical Devices, Software, (Biotechnology)
Denver	Data Storage, Telecommunications Equipment and Software
Minneapolis–St. Paul	Computers, Peripherals, Medical Devices
Phoenix	Semiconductors, (Aerospace)
Portland	Semiconductors, Display Technology, SME, EDA,** Silicon Wafers
Raleigh-Durham	Computers, Databases, (Pharmaceuticals)
Sacramento	Computers, Semiconductors
Salt Lake City	Software, Medical Devices
San Diego	Communications Equipment, (Biotech)
San Jose	Semiconductors, Computers, Software, Communication Equipment, SME, EDA, Data Storage
Seattle	Software, (Biotechnology, Aerospace)
Washington D.C.	Databases, Internet Service, (Telecommunications, Biotechnology)

Note: Parentheses indicate secondary specializations

*SME = semiconductor manufacturing equipment **EDA = electronic design automation software

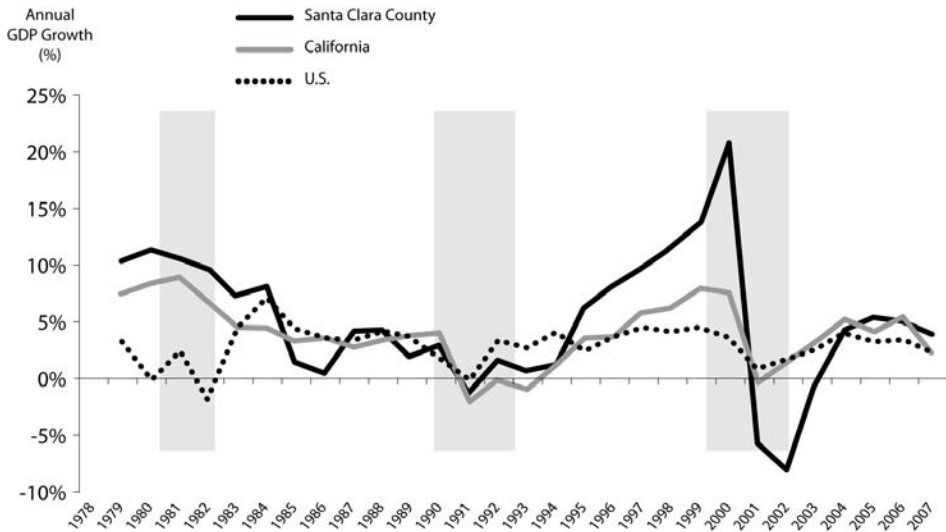
Source: Brookings Institute, 2001

Coming out of the 1981-82 recession, the Valley's growth was still well over 5%, but the cost of manufacturing semiconductors was soaring. The Valley's semiconductor industry was struggling to find a new business model. Economic growth came almost to a halt in 1986 (with only 0.5% growth) before innovative chip designers found a way to partner with Asian chipmakers in a symbiotic relationship. Out of the ashes, the *fabless* semiconductor business model was born. A fabless company (the word is compressed from fabrication-less) only

Figure 6

Economic Growth

U.S., California and Santa Clara County, 1978-2007



Note: Gray panels indicate U.S. economic recessions and slowdowns. Data for 2007 is forecast.

Source: Bureau of Economic Analysis, Munroe Consulting, Inc.

designs, develops and markets its chips, outsourcing the manufacturing stage. Valley firms proved that by outsourcing chip manufacturing to Japan, Taiwan and elsewhere, they could protect profits.

But just as the Valley's moguls thought they had dodged a bullet and economic growth had returned to a respectable 4.1% in 1987, the Cold War ended. By 1990, many Valley businesses were faced with the loss of key defense contracts—the lifeblood of many electronics and high-tech firms like Lockheed

Corporation (now Lockheed Martin). National defense spending declined by about 16.9% between the final Reagan Administration defense budget (FY 1989) and the final George H.W. Bush Administration budget (FY 1993).³⁴

Subsequently, defense spending declined by another 18% between FY 1992 and FY 1997 under the Clinton Administration.³⁵ Given California's heavy involvement in defense-related industries in the Bay Area, as well as in the Los Angeles and San Diego areas, California's economy experienced three years of decline between 1991 and 1993 (-1.9%, -0.1% and -1.0% respectively).³⁶

It wasn't the U.S. Cavalry that saved the Valley, however... it was the U.S. consumer. By the mid-1990s, the consumer electronics revolution had taken hold and sales of high-tech gadgets, particularly personal computers (PCs), soared. Annual PC sales grew by 20% a year in the early 1990s. Sales hit 18 million units in 1994, up 23% over 1993.³⁷ At the time, the market research firm IDC predicted that sales would continue to grow at a 15% to 20% clip in 1995.

But 1995 would turn out to be a good year in Silicon Valley—a very good year indeed. Setting the stage for one of the most dramatic economic booms in history were two key events. The European Organization for Nuclear Research, abbreviated as CERN, announced that its previously internal communication network called the World Wide Web would be open and free to anyone.³⁸ And Mosaic Communications Corporation announced the release of the Netscape Navigator Web browser in November 1994. The Age of the Internet was born. But the pivotal point in time was in August 1995, when Netscape's IPO stunned both the financial markets and the tech community. The Dot-Com Boom took off like a skyrocket... and so did the Valley's economy.

Supporting and even driving the surge in personal computing and Web browsing was the release of Microsoft's Windows 95 (Win95) in August of 1995—the first operating system to provide PC users with an experience similar to Apple's popular Macintosh. While the first releases of Win95 did not include an Internet browser, subsequent releases did. Microsoft had spoken, and Web browsing became a new national pastime. The post-Cold War doldrums of the early 1990s became a faded memory as the magic of the personal computer

and all of its cousins (e.g., the PDA, the inexpensive cell phone) captivated the world. From 1994 to 2000, the Valley's economic growth rate soared from 1.2% to 20.8%.

It was like a dream, a boom that would never end. But it did. Just as August 1995 was a pivotal time in the Valley's history, so was March 2000, when the Dot-Com bubble burst and over a trillion dollars in equity vaporized almost overnight. The Valley's economy dropped precipitously from its peak in 2000 by 5.9% in 2001, another 8.1% in 2002 and then another 0.4% in 2003. Such turmoil in one of the nation's most powerful economic engines had to have broad-reaching impact. And it did: Both the state and the country saw a decline in economic growth, though not as significantly as the Valley's. And both the California and national economies recovered more quickly, as the Valley's entrepreneurs and investors retreated to their respective corners to lick their wounds, count their remaining pennies and figure out what to do next. It wasn't until 2004 that the Valley's economy would grow again, this time inspired by visions of new fortunes from clean energy, green technology, the highly interactive Web 2.0, nanotechnology, and new advances in biotechnology.

Employment

When we look at a profile of Santa Clara County from the perspective of employment, we see a markedly different pattern than is typical of the state and the nation. (Figure 7)

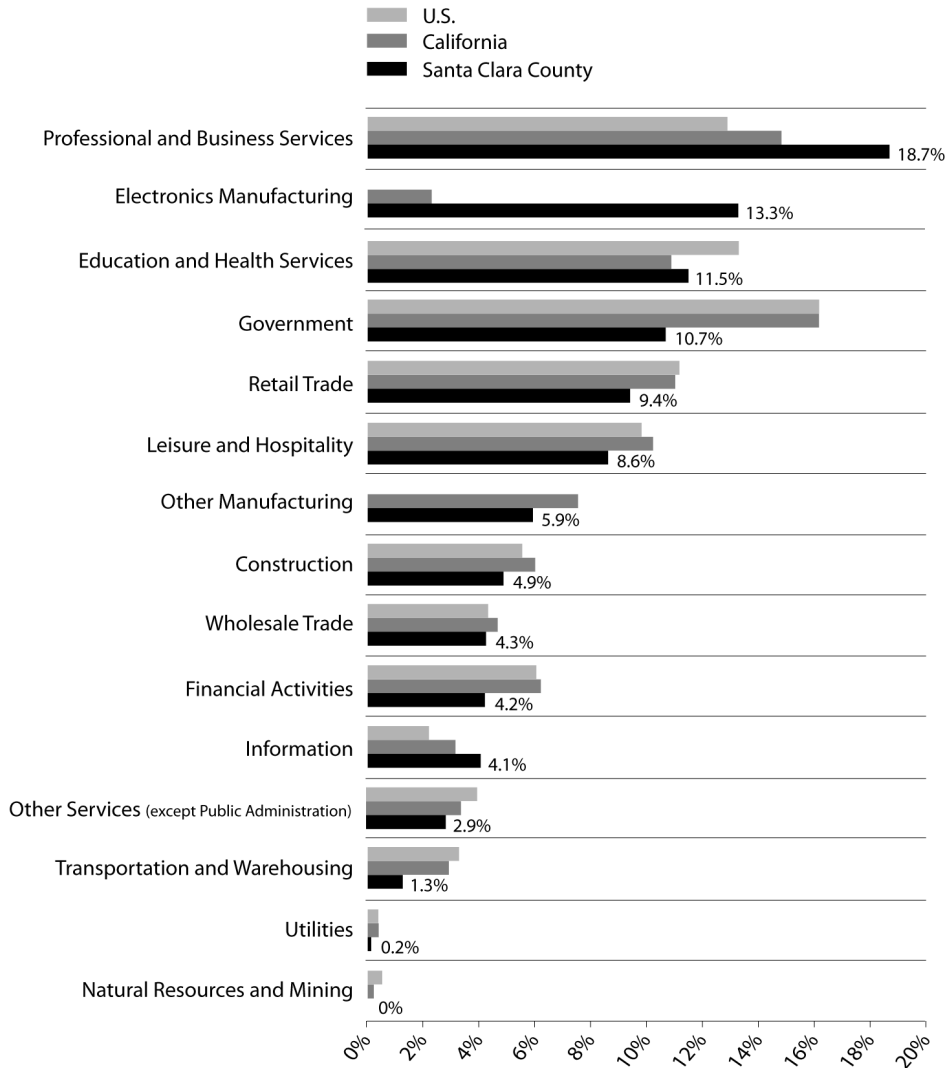
Of course, bundled together, the services subsectors—including professional and business services, education and health services, and leisure and hospitality, represent the largest single primary employment in the county, as it does statewide and nationally. But when we look at a more representative profile of the county by breaking out services into more discrete subsectors, we can clearly see how different the region's economy really is.

Despite the steady trend toward outsourcing manufacturing labor overseas, manufacturing generates the largest share of non-farm jobs in Santa Clara County (19.2% in 2007). In contrast, manufacturing jobs make up only 10% of

Figure 7

Employment by Sector Shares

U.S., California and Santa Clara County, Forecast for 2007



Note: Data for the U.S. is not available for the Electronics Manufacturing or Other Manufacturing subsectors.

Source: Bureau of Labor Statistics, Munroe Consulting, Inc.

state and national employment. A closer look shows that electronics manufacturing represents a lion's share of the Valley's manufacturing jobs (69.1% in 2007), dwarfing the state average of 2.3%.³⁹ In fact, with a 13.3% share of the county's employment, the electronics manufacturing ranks second only to professional and business services as the region's top jobs sector.

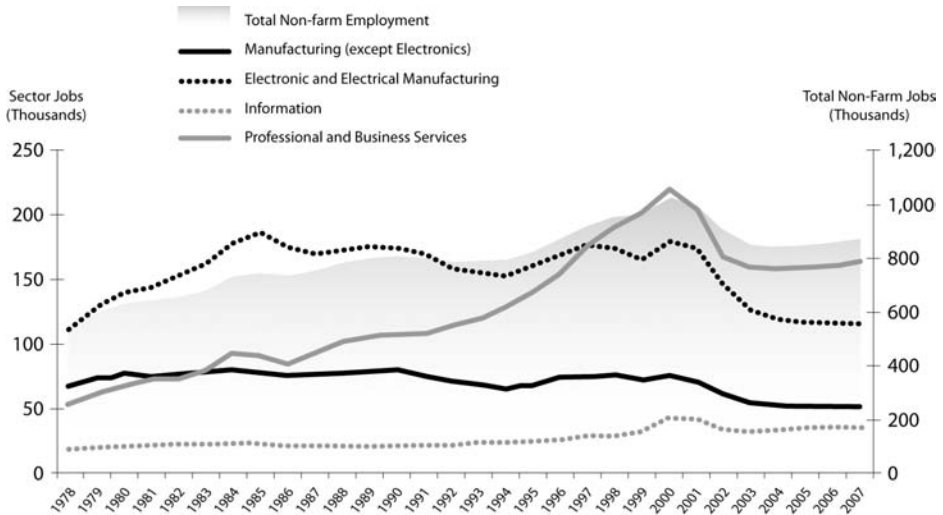
One would think that the information sector would be a major source of jobs in Santa Clara County. Certainly it is a high-profile sector, as the county is home to eBay, Adobe and other internationally prominent software companies. But the professional and business services sector provides a much larger share of the county's jobs (18.7% in 2007). This, too, is a significantly larger share than we see across the state (14.9%) or around the country (12.9%). The information sector provides only 4.1% of the county's jobs, but this too is above the state and national averages of 3.1% and 2.2% respectively.

It is important to note that government provides an unusually smaller number of jobs in major entrepreneurial regions, and Silicon Valley is no exception. Federal, state and local governments provide only 10.7% of Santa Clara County's jobs (2007)—much lower than what we see at the state and national levels (16.2% for both). Clearly, high-tech manufacturing has been a key sector of the Valley economy. The sector has weathered numerous economic shifts and shocks, yet has maintained its position as a major source of employment and wealth-generation. Employment in electronics manufacturing peaked in 1986 at 186,000 jobs, then fluctuated over the next fifteen years until peaking again in 2000 at 179,800. But looking at the electronics manufacturing sector over the last seven years, we see a picture of steadily declining employment, with little evidence that jobs in this sector will ever recover to levels seen before the Dot-Com Bust.

In most regions of the U.S. economy, the share of manufacturing jobs as a total of all employment has been declining for decades, and the story is similar for the Valley. More than 64,000 jobs have been lost in electronics manufacturing since 2000 and projections call for steadily declining employment through 2020.⁴⁰

Figure 8

Santa Clara Employment Selected Sectors, 1978-2007



Note: Santa Clara County is considered as a surrogate for Silicon Valley in this analysis.

Source: Bureau of Labor Statistics, Munroe Consulting, Inc.

Jobs in non-electronics manufacturing have also been declining steadily since the late 1980s, but this trend is expected to level off over the next decade.⁴¹ What we are seeing here is the Valley's steady shift from a manufacturing-based economy to a knowledge-based economy, similar to what we are seeing in most high-tech regions in the U.S. This is a result of a combination of factors including rising productivity in manufacturing, the elimination of many jobs through automation, and the migration of manufacturing jobs to lower labor cost countries such as China, India, Taiwan, and several eastern European countries.

Evidence of this structural shift is the steady growth in the professional and business services sector over the last thirty years. (Figure 8) Employment in this

sector has more than tripled since 1977. Certainly, this sector rode the Boom/Bust rollercoaster up from 140,000 jobs to a peak of 220,000 in 2000, then down to 158,000 in 2004. But as of 2006, employment had returned to pre-boom levels (163,000) and forecasts suggest steady gains averaging 2.5% per year into the future.⁴²

Jobs in the information sector also doubled in the last thirty years. Growth in this sector has averaged 2.7% per year, despite the Boom/Bust surge and decline. Employment in the sector has returned to mid-1999 levels and forecasts suggest modest but steady growth (1.3%) going forward.



The Seven Key Elements of Silicon Valley's Innovation Ecosystem

As we noted in the Introduction, the success of Silicon Valley springs neither from the brain of a brilliant planner nor the grandiose vision of a forward-thinking economic development agency. The evolution of the Valley as a global center for high-tech innovation was almost totally organic, rather than intentional. Certainly, the creation of the Stanford Industrial Park was an intentional effort to provide a center of high technology located near a university that shared its vision, but virtually every other aspect of the emergence of the Valley's prominence was unplanned, unexpected and unintended on the macro level. Its evolution represents a long series of individual initiatives, great innovations, and interactions among the stakeholders via ever-expanding social and professional networks.

James F. Moore formally introduced the concept of a business ecosystem in a *Harvard Business Review* article in 1993.⁴³ He described a business ecosystem as:

[An] economic community supported by a foundation of interacting organizations and individuals—the organisms of the business world. This economic community produces goods and services of value to customers, who are themselves members of the ecosystem. The member organizations also include suppliers, lead producers, competitors, and other stakeholders. Over time, they co-evolve their capabilities and roles, and tend to align themselves with the directions set by one or more central companies. Those companies holding leadership roles may change over time, but the function of an ecosystem leader is valued by the community because it enables members to move toward shared visions to align their investments and to find mutually supportive roles.

Major companies such as Hewlett Packard, IBM, SAP, Microsoft, Softbank, and Intel initially used this economic community concept for business strategy development. Lately it has been more broadly applied to many problems, including foreign policy as well as economic development strategy development.

Ecology: The study of the relationship between organisms and their environment.

Ecosystem: A complex set of relationships among living resources, habitats, and residents of an area. When an ecosystem is healthy and is in balance it is sustainable. Diversity is a contributing factor to the health of an ecosystem.

Key Ecosystem Elements

So what are the fundamental elements that have served and sustained Silicon Valley's economy so successfully for so long? We have identified seven key elements⁴⁴ of the Valley's innovation ecosystem:

1. Research Universities

World-class research universities such as the University of California (UC) at Berkeley, UC San Francisco, and Stanford University form the foundation for a world-class innovation economy in many ways: via the generation and licensing of intellectual property; through the involvement of faculty as consultants and advisers to businesses; by

supporting faculty in capitalizing on their innovations; by providing the private sector with a steady supply of talented engineers, designers, managers, etc.; by providing innovators with access to cutting-edge laboratories and equipment; and by encouraging a continuous dialogue among industry experts, faculty and students.

2. Entrepreneurs

In the innovation ecosystem, the entrepreneur is the biological host. Without the unique talents, traits and tenacity of the entrepreneur, bold new ideas would never see the light of day. We all have lots of new ideas, but the entrepreneur, driven by the energy and excitement of the core idea that is the seed of innovation, as well as by a hefty dose of self-interest and visions of personal gain, makes the commitment and takes the risk to manifest the innovation as a new product or

service. A culture of entrepreneurialism and a tradition of serial entrepreneurship are key features of the Valley's ecosystem.

3. Investment Capital

Very few high-tech ventures can launch and grow to become world-class companies without large infusions of cash at crucial stages of development. While the Valley offers relatively convenient access to high net-worth individuals (sometimes called angel investors), multimillion dollar venture capital firms, and top investment banks, the brutal competition for cash is one of the primary survival tests for both innovations and entrepreneurs. (Theoretically, this competitive process should assure that only the best innovations make it to market, but as we have seen, this has not always proven to be true.) Investors do more than just provide money; they also offer a wealth of technical expertise, business experience and valuable connections to resources and people.

4. Workforce

No business venture can thrive without a skilled and dedicated workforce. The Valley is a magnet for talent from all over the world, and the diversity of the region's workforce has been a source of its strength and success. More so even than the social environment, the Valley's business environment is a melting pot of people and ideas from a wide range of ethnic backgrounds, academic disciplines, business cultures, etc. At the same time, as in every ecosystem, organisms (i.e., skilled workers) at every level are opportunistic. In a culture where job-hopping is an accepted practice, retaining talented employees is challenging for every company. As a result, Valley companies are experimenting with various innovations in the workplace to keep their employees loyal and happy.

5. Social and Professional Networks

Just as money is the primary fuel for innovative ventures, information is vital for survival and success, particularly when competing on a global scale. Information takes many forms and comes from a myriad of sources, including both formal and informal social and professional networks. Information, ideas, contacts and connections flow freely despite the hyper-competitive spirit that pervades the Valley. The degree to which the Valley's business community has successfully

managed the tension between collegiality and competitiveness has proven to be a major contributor to the unique culture of its business environment.

6. Business Environment

Every ecosystem is dependent on the surrounding environment. That environment may be nurturing and supportive of vitality and growth, or it can be a source of stress and hinder or even threaten the long-term viability of the organisms within it. The same is true in an economic ecosystem. A region's economic environment includes many complex and interdependent factors: its social framework and political structure, its physical and economic infrastructures, its population profile, etc. In these ways and more, the Valley has created a healthy business environment for innovation.

7. Quality of Life

Business is business, but we're all human, and it's safe to say that world-class innovators, investors, and workers all appreciate a world-class lifestyle. The overall quality of life in Silicon Valley and the Bay Area is a significant contributor to the region's long-term economic success. With its comfortable Mediterranean climate, scenic beauty, first-rate cultural venues, cosmopolitan ambiance and proximity to sun, surf and snow, the San Francisco Bay Area easily qualifies as one of the most attractive regions in the United States. While quality of life may not seem the most important element of an innovation ecosystem, we believe that the Valley's locale has played a key role in its birth, evolution and long-term success. The people of California and the Bay Area have worked hard to protect their natural treasures and encourage a wide range of artistic and cultural expression, and the region as a whole benefits from it.

Innovation in an Interactive Web

As in any biological ecosystem, these key elements work in concert—no one element stands on its own. And, just like in nature, these elements form a web of relationships, interacting with each other in synergistic ways that strengthen the overall economic environment and contribute to the Valley's resilience,

sustainability and long-term survival as a hub of innovation. While it may seem that one or two elements—research universities and venture capital, for example—are dominant factors in maintaining the balance of the system, seemingly lesser elements such as quality of life and business environment are also highly influential. Venture capitalists choose where they live and work and appreciate a region with cultural and recreational assets—they have neither the need nor desire to compromise their tastes. A research university may be top in training engineers, but if a region’s business environment or culture does not encourage entrepreneurship (think of pre-1990s China), talented innovators will relocate to more supportive areas like the U.S.

As we will see, some or all of these same elements may be found in other regions, but the unique qualities and richness of these elements in Silicon Valley are the sources of its sustained economic vitality. For example, other regions of the country have an abundance of skilled workers (e.g., Detroit), but for various reasons, the industries that employ them like the auto industry and the surrounding social environments have not created cultures of life-long learning nor encouraged the kind of adaptability that is innate in Silicon Valley’s workforce. Other regions (e.g., Spain) may have an abundance of entrepreneurs, but they may approach starting a business as a form of lifetime employment rather than taking the more aggressive start-grow-sell path of the serial entrepreneur. As we will see, serial entrepreneurs are catalysts and active agents in the social and professional networks that inspire and support new entrepreneurs, thus fueling the innovation economy. Without them, a region’s networks lack the vitality to stimulate and support world-class business leaders. In the next section, we will take a closer look at each of these elements individually in the context of the Silicon Valley’s economy, then examine the Valley’s economy as a whole to see how it has survived, adapted and thrived for so long as the world’s most dynamic economic ecosystem.