Silicon Valley and Internationalization: A Historical and Policy Overview*

By

Martin Kenney

Distinguished Professor

Community and Regional Development

University of California, Davis

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Senior Project Director, BRIE

Berkeley Roundtable on the International Economy

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Content

1. Introduction

The San Francisco Bay Area encompassing Silicon Valley is arguably the most important region in the world for the application of digital technologies to social and economic life. Martin Kenney and John Zysman (2016) have argued that a new economy based on digital platforms is emerging and Bay Area firms are at the center of this development. The current conjuncture is the result of a set of historical forces, some of which are very local and others of which are global and national. The region is the result of an intensely local process even as its firms, entrepreneurs and markets are global. Silicon Valley's rise to prominence, since, at least, the early 1980s, has had an increasingly significant effect upon the global political economy through its gradual emergence as the center of the world's information and communication technologies (ICT).

In the 1990s Silicon Valley achieved iconic status for economic development planners globally. But how did the particular constellation of public goods, private sector actors, concentration of human skills, and even a particular ideology come into being? This paper argues that the rise of Silicon Valley was a social process of emergence in which a number of social and technical forces combined to create the region. As new actors emerged, they created solutions for various problems that they confronted and, as they met with success and gained strength, they participated in the transformation of existing regional institutions such as the local universities. For the most part, these were responses to immediate problems or path-dependent drifts, rather than wisely considered, far-sighted solutions by prescient economic actors maximizing their utility functions. Like the Panda's thumb, solutions that "worked" were diffused, repeated, and adjusted, gradually evolving into routines and institutions (Nelson and Winter 1982).

When discussing a region that derives its dynamism from new firms commercializing new technologies, it seems proper that the technology (ies) and its (their) trajectory (ies) should be examined (Dosi 1984). The technologies, socially constructed and shaped, are the raw material that entrepreneurs utilize to create their firms. The information and computer technologies (ICT) are the technical bases for the region. Thus, on one dimension, understanding Silicon Valley is predicated upon tracing the evolution of technologies and the industries based on them, and, on the other dimension, the evolution of the institutions, practices, and cultural understandings that orient action.

Schumpeter recognized that technological change offers possibilities to entrepreneurs, but establishing a new firm is difficult and risky. During the past five decades in regions like Silicon Valley, a support infrastructure of institutions that assist in new firm creation has evolved to mitigate the liabilities of newness (Stinchcombe 1965). In Silicon Valley, successful entrepreneurship preceded the creation of the institutions such as venture capital (Feldman 2001; Kenney 2000) and after these support organizations came into existence they incited further entrepreneurship by creating demand for startups. They also lowered entry barriers by simplifying the firm formation process, and speeding the growth of startups. Through the provision of capital, services, and advice, they increase the probability of new firm formation and speed new firms' growth.[1] Gradually, the institutions providing such assistance became part of the environment, thereby altering the trajectory of further evolution. The institutions and the agents within Silicon Valley have survived repeated downturns that have winnowed participants and business models.

[1] There is considerable debate as to whether location in the cluster increases survival rates.

1.1. Short History of Silicon Valley

The genesis of Silicon Valley (SV) is difficult to date exactly, as already before World War Two there were electronics firms including a fledgling Hewlett Packard operating in the region (Sturgeon 2000). However, the semiconductor industry from which Silicon Valley draws its name can be considered to have begun in 1956 when William Shockley, one of the inventors of the semiconductor at Bell Laboratories, established Shockley Semiconductor in Santa Clara, California. At this early date, there was no reason to believe that the semiconductor industry would concentrate in the San Francisco Bay Area – there were an ample number of other regions with sufficient technical expertise for the early industry. Shockley proved to be an incompetent manager, and in 1958 eight of his best scientists left to form a new firm, Fairchild Semiconductor. Fairchild was funded by an East Coast industrialist, Sherman Fairchild. Fairchild Semiconductor's earliest customers were federal agencies such as the Department of Defense and NASA. As important as it was technologically, more important was that engineers and managers, almost immediately began leaving Fairchild to form new startups (Lecuyer 2006). The proliferation of semiconductor startups led the editor of *Electronic News* in 1973 to describe the region as "Silicon Valley" – a moniker that continues to be used to this day.

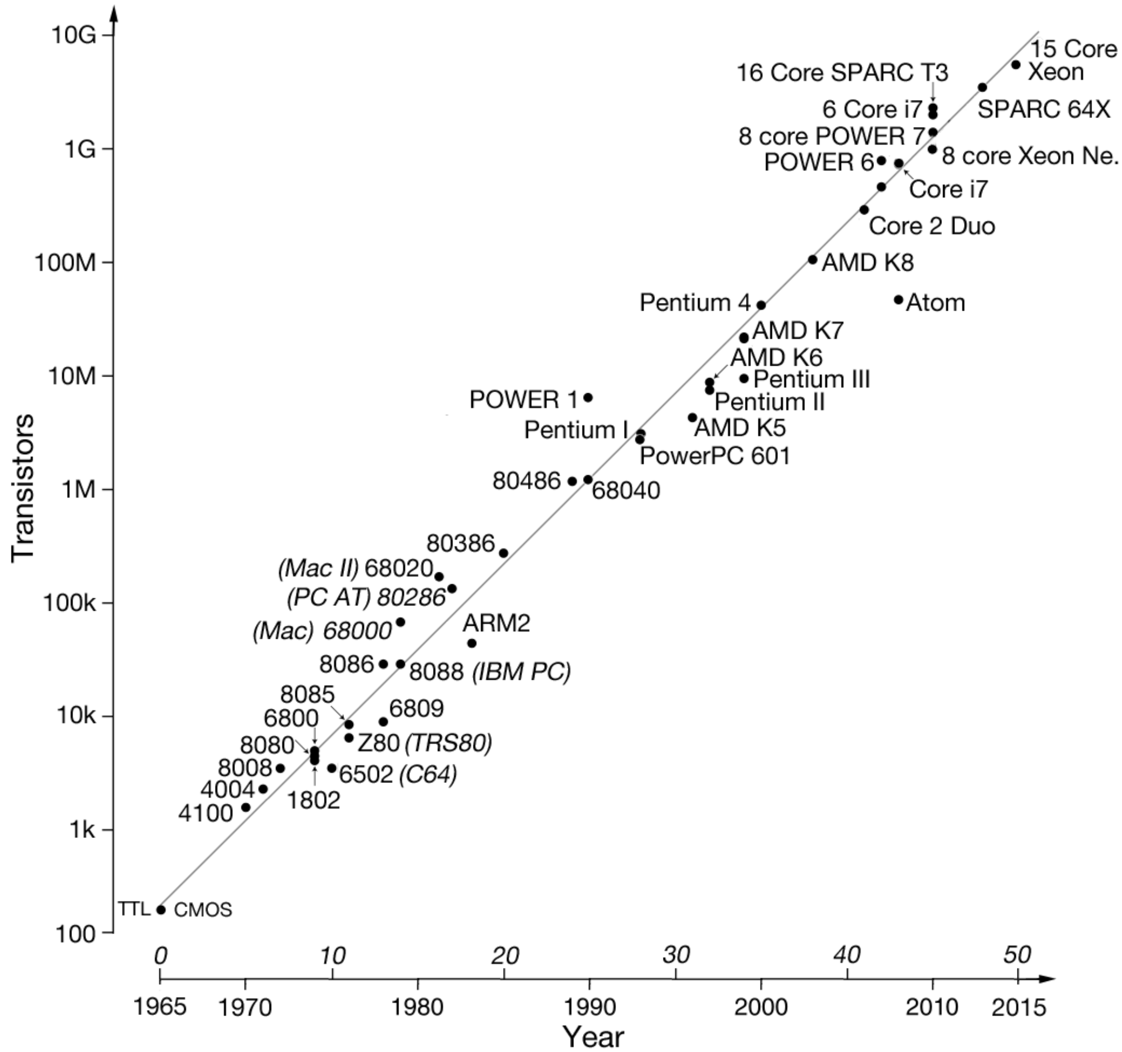
Of course, the region was not a tabula rasa. Frederick Terman, the former Dean of Engineering and Stanford Provost, encouraged Shockley to establish his firm in Palo Alto. Terman was actively encouraging the growth of a local electronics industry in the region. Many East Coast firms established branch R&D operations in the region and in 1952 IBM decided to establish a branch of its Yorktown Heights research laboratory in San Jose to tap the skilled personnel in the area. Even as Terman was encouraging the development of a regional electronic industry, he was also aggressively building Stanford's research capability through securing military funding for research (Leslie and Kargon 1996). At its root, as we shall see, the success of the cluster in the region is the result of the strategies of key actors, happenstance, and institutional evolution.

2. Technology

Technology cannot determine social or economic activity. And yet, as both Marx and Schumpeter recognized, it creates opportunities for entrepreneurial activity. To paraphrase Marx, it is an important force for dissolving barriers to entry to old economic activities and facilitating the creation of entirely new industries – or to put it in the contemporary vernacular, "disrupt" previous businesses.

The fundamental disruptive technology developed in Silicon Valley is, of course, the semiconductor, which has for the last 50 years had a relatively constant improvement trajectory of roughly doubling the processing power for the same price every 18-24 months (see **Figure 1** for a visualization of this process). This increasing ability to process data is so important because digital problems that were too difficult to solve in one-time period become amenable to solution later as processing power increases. For example, transforming analog sounds into digital representations and back to the sound we hear is/was computation intensive and essentially impossible in 1960 as the processing power was not available. It might be possible to write algorithms that could do this theoretically, but practically it was impossible. However, the continuing improvement in semiconductors (and laser systems) would make this possible by the late 1970s and eventually make the compact disk player trivially inexpensive. This example only illustrates the point that what, at one time was impossible, later became possible, and then trivial.

Figure 1: 50 Years of Moore's Law



Source: Elector Magazine 2015

While the semiconductor is the fundamental technology, the development of the microprocessor proved to be particularly important. The microprocessor was essentially a computer capable of processing information that resides on a single chip – and it also experienced the same improvement dynamics as did other semiconductor devices. Firms in different regions developed microprocessors, but it was in Silicon Valley in the late 1960s that Intel emerged from Fairchild and even more importantly, yet other people, particularly hackers such as Steve Jobs, Steve Wozniak, Adam Osborne, Lee Felsenstein and others, began cobbling together small microcomputers (Freiberger and Swaine 1984) based on the newly introduced microprocessors.

Remarkably, nearly simultaneously with the semiconductor, magnetic data storage also began a remarkable technological improvement trajectory, driven in large part by technological developments occurring in the IBM laboratory (and production facility) located in the San Jose area [2] Very soon other technologies would emerge. At the hardware level, there was the emergence of networking equipment as engineers wanted to connect these smaller computers together and to main frames. This included local area and wide area networks. Again, SV would take the lead in this area. Finally, on top of all the physical infrastructure artifacts was software development that would allow SV over time to transition from being centered upon physical computation and objects, such semiconductors and network infrastructure equipment, to software and then the Internet, and today social media. As the software "detached" from the hardware, remarkable new business opportunities emerged due to what Zysman (2006) terms the "algorithmic revolution."

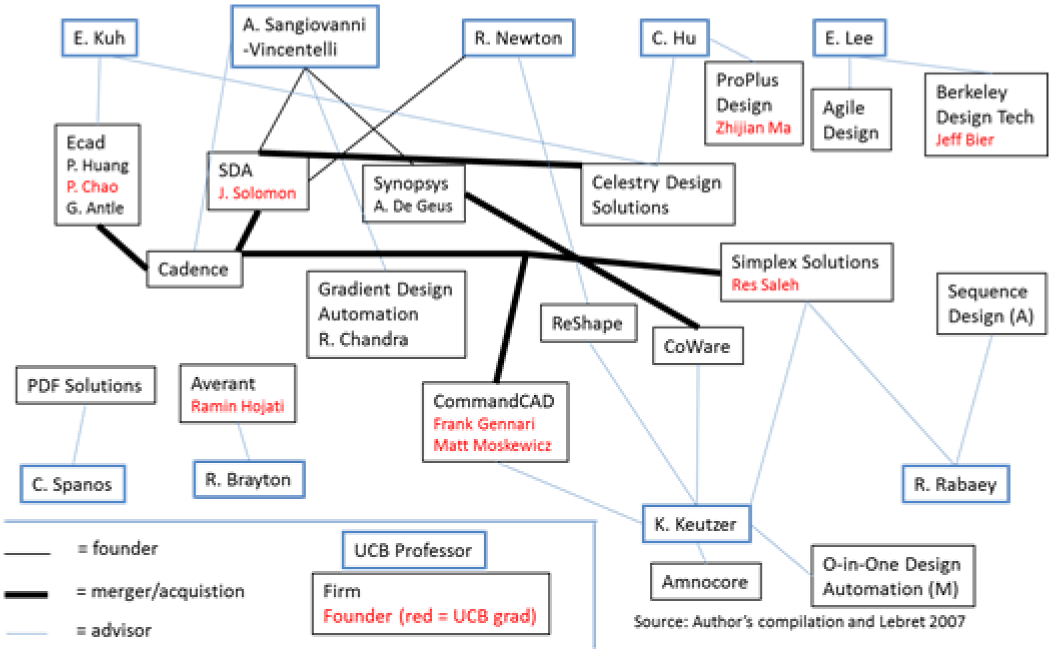
2.1. Semiconductors and Ancillary Industries

Semiconductor technology was so fecund in opening new economic spaces that new business opportunities repeatedly emerged, and the cognoscenti had opportunities to create their own firms.

[2] For a discussion of the relationship between the IBM Laboratory and the electrical engineering department at UC Berkeley, see Kenney et al. 2014.

This fecundity is illustrated by the fact that Fairchild and its successor firms experienced 134 spin-offs by 1986 (SEMI 1986), and there have been more since then; almost always founded by someone that could trace their employment experience back to a firm that descended from Fairchild. The doubling of processing power was accompanied by another dynamic, namely the ever increasing cost of a fabrication facility (Leachman and Leachman 2004). When Fairchild began producing chips, converted pizza ovens were used for the baking process. By 1975, a fabrication facility cost approximately $50 million (OhUuallachain 1997: 220), while in 2016 the cost of an Intel state-of-the-art fab is $8.5 billion (Chafkin and King 2016). As the costs of fabrication increased, it was no longer possible for startups to establish a firm and manufacture their chips, so new startups began contracting out to firms that specialized in manufacturing chips – by the end of the 1980s, these contract fabs were offshore in Taiwan. Silicon Valley firms now only designed and marketed the ICs. At roughly the same time ICs became so complex that hand designing was no long possible and engineers began developing design software. The UC Berkeley electrical engineering and computer science department, funded by the Department of Defense and NSF did much of the early research. They created an open source design software program that was commercialized by students and professors (see **Figure 2** to illustrate this relationship). This software was critical for the relationship between SV designers and offshore contract fabrication operations as the data could be directly transmitted to the contract fabrication facility.

Figure 2: UC Berkeley Professors and Their Relationships to the Semiconductor Design Software Industry



Source: Kenney et al. 2014

SV became not only the center of the semiconductor industry, but the center of the semiconductor equipment and software industries as well. Through an intensive interaction with the local industry, UC Berkeley and Stanford became elite electrical engineering and computer science research centers. While significant design and headquarters functions remain in the region, no semiconductor fabrication remains. The semiconductor industry was important for reasons beyond its technological centrality. First, the culture of spinoffs and raising venture capital was cultivated in semiconductors, but soon spread to other ICT industries. Second, the semiconductor industry provided significant investment opportunities for venture capital. Third, the industry attracted attention to the region and some of the IC industry entrepreneurs such as Robert Noyce, Gordon Moore, and Jerry Sanders achieved fame and became models for other entrepreneurs. Fourth, proximity to the semiconductor industry allowed venture capitalists and entrepreneurs in other industries to glimpse the future, or, as the futurist, William Gibson, once said, “the future is already here — it's just not very evenly distributed.” The semiconductor’s progress trajectory meant the future was often there in SV before being in other places.

2.2. Computers

The true breakthrough in terms of computers came when the microprocessor made possible the creation of desktop computers, both personal computers and work stations. Two SV university spinoffs, Sun Microsystems and Silicon Graphics, became enormously successful work station firms. While successful in developing work stations, with the exception of Apple Computers, the other Silicon Valley micro-computer firms soon failed when IBM introduced the personal computer. However, SV, with its entrepreneurial ethos, came to be the home of numerous startups that would supply components including microprocessors (Intel and AMD), BIOS chips (AMI, Phoenix Technologies, and Chips and Technologies), graphics chips (S3, Nvidia, and Cirrus Logic), hard disk drives (Seagate, Quantum, and Conner Peripherals), printers (Daisy Systems), and even computer mice (Logitech and Kensington) to PC assemblers that were not located in the region. In PC software, Microsoft soon became dominant and, by 1990, it appeared to many that SV might no longer be the future of the ICT industry. However, with the desktop computer came the desire to link computers to one another, i.e., to network them.

2.3. Computer Networking Equipment[3]

Much of the impetus for connecting separate computers together came from the Department of Defense (Abbate 1999). Heavily supported by DARPA, time-sharing of computer capacity was one of the earliest forms of computer networking (a wide area network), and a number of startups were established in Silicon Valley and other regions to exploit it. In 1969, DARPA launched the Arpanet (the precursor to today's Internet). Also, with the adoption of the minicomputer, departments and divisions in corporations and on campuses also installed computers and there was increasing interest in linking them together locally (LANs) and the dial-up connections used for WANs seemed unnecessary and inefficient. Thus, simultaneously there was demand for WANs and LANs.

One proximate cause for dramatically increased interest in computer networking was an effort that began in the early 1970s to automate the office. This "office of the future" required a network to share files between computers and expensive peripherals such as printers and data storage devices. A pioneer in this quest was Palo Alto-based Xerox PARC, which in the mid 1970s created a system of small computers, laser printers, and data storage devices networked by what would be called "Ethernet." PARC was not alone in this effort; minicomputer firms such as Boston-based Wang Computers were also experimenting with the dedicated office automation computers.

In the early 1980s, desktop computers were proliferating and entrepreneurs began forming firms to network these computers and the most successful of these were located in Silicon Valley (von Burg 2001). The proliferation of networks running different protocols, created an opportunity for an interconnection solution. The most successful communications interconnection firm would be Cisco Systems, a Stanford University spin-off that introduced a multiprotocol router. With the volume of data being communicated rising exponentially, there was a proliferation of opportunities to establish new firms with better data communications technologies (essentially data handling computers) and there were waves of new entrants started

[3] This section is largely drawn from von Burg (2001).

by engineers in existing firms and funded by venture capitalists. In fact, the incumbent networking firms, and especially Cisco, developed a strategy of acquiring the fledgling startups, but at enormous multiples making investors and the firm founders extremely wealthy (Mayer and Kenney 2004). Not surprisingly this encouraged a further proliferation of networking startups.

The key to these new firms was not the equipment they built, but rather the software that they developed to handle the data – production would be outsourced to specialized assembly firms. While SV was not initially a center for optical fiber technology development, during the 1990s optical components for data transmission also grew remarkably due to venture capital-financed technology development. Even more important, as the network became more complicated, it provided yet more entrepreneurial opportunities for network management, security, and other software and hardware such as specialized ICs (designed with the semiconductor design software described earlier). By the mid-1990s computer networking had become one of the core Silicon Valley industries. With the increasing dominance of digital networking technology, nearly all the incumbent telecommunications networking firms (Alcatel, Fujitsu, Lucent, NEC, Siemens Networking, and Northern Telecom) would be destroyed or dramatically weakened.[4]

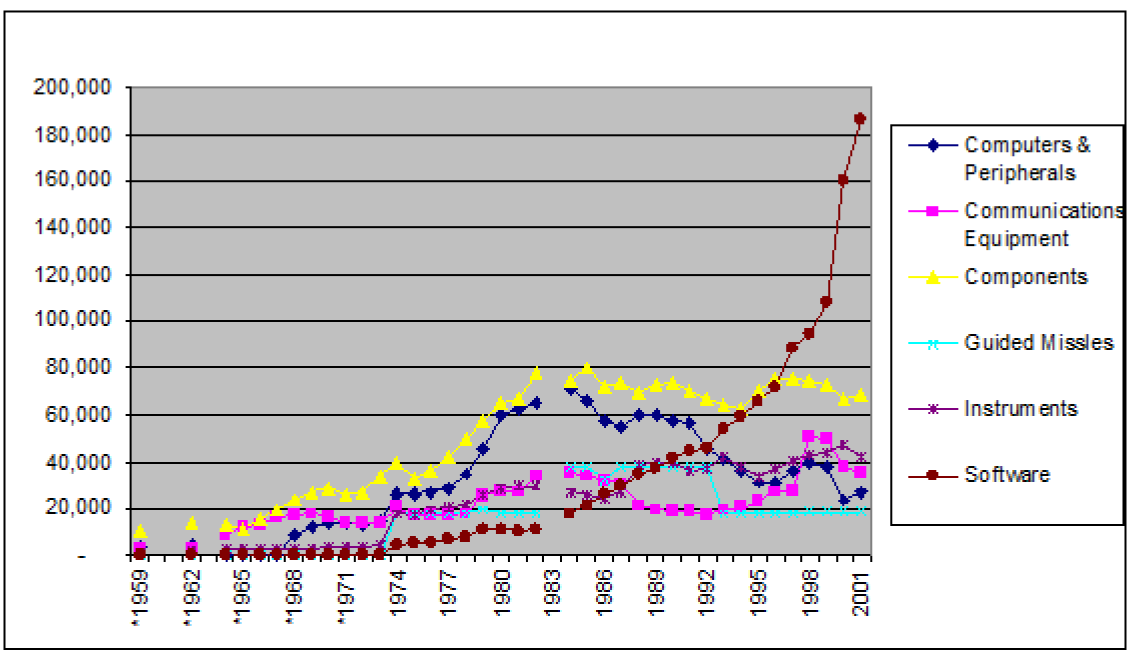
2.4. Software

The creation of a freestanding software industry is often traced to the IBM-US government consent decree in which IBM agreed to unbundle its hardware and software. This

[4] The most successful of these firms, Ericsson and Nokia, survived based upon their strengths in wireless communications. The threat to these networking equipment firms and, in particular, Cisco would come from the Chinese networking equipment maker, Huawei.

decision meant that innovators could develop products that would operate with the IBM products, which at the time dominated the entire market. Even, as IBM was unbundling, minicomputers that allowed independent third-party software vendors to write programs for them were introduced. The importance of software, of course, is that it directs the computational power to produce a desired outcome, i.e., what the user wants. Over time, the entrepreneurship in Silicon Valley would become software-centric, as can be seen both in terms of employment and venture capital investment (see **Figures 3 and 4**) and, in fact, the SV hardware firms also became increasingly software-centric as the value in their products increasingly was based on the software. The growth in the importance of software occurs in approximately 1980, roughly coinciding with the introduction of desktop computers, which were more modular and open, as both the Microsoft and Apple operating systems operated as platforms with interfaces so that software from third-party vendors could operate on them. Further, the proliferation of desktop computers would create an ever larger market for software programs.

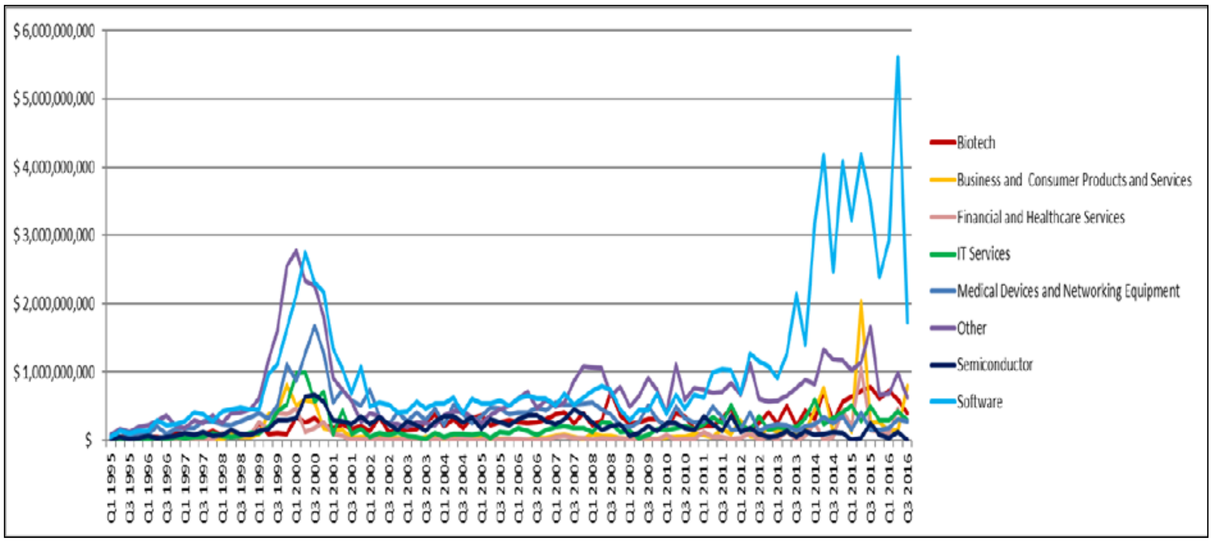
Figure 3: Employment in Four Bay Area Countries, 1959–2001



Note: Data before 1998 was collected by SIC code. For 1998 - 2001 data was not available in SIC codes. Therefore, data was collected in NAICS codes that approximate SIC codes.

The change can also be seen in venture capital investment. Importantly, during this entire period SV received between 30-40% of all investment in the United States. The unusually large spike in the "Other" category in the Dot.com Bubble was driven by media and entertainment investments. [5] What is most important is that during both the Dot.com Bubble and the recent period VC investment in software expanded immensely.

Figure 4: Venture Capital Investment in San Francisco Bay Area by Sector and Quarter, 1995-2016



Source: Pricewaterhouse Coopers Moneytree 2016

In software, as has been the case with other industries, Silicon Valley has pioneered various software sectors; some of which would be extremely important for the transition of the region to one that is software-centric. Microsoft's PC software monopoly resulted in the demise of Silicon Valley firms such as VisiCalc and Borland Computer. Even when new PC software such as the Netscape browser was commercialized in Silicon Valley, Microsoft used its

[5] Included in the other category in order of importance Media and Entertainment, Retailing/Distribution, Electronics/Instrumentation, Industrial/Energy, Telecommunications, and Computers and Peripherals.

monopoly power to destroy them. Two of the most important SV survivors of this onslaught were Adobe Systems and the tax software producer, Intuit.

Silicon Valley firms have been far more successful in business productivity software. The most significant of these was relational database software, which was pioneered roughly contemporaneously at IBM's San Jose Laboratories and UC Berkeley. All of the key independent relational database firms (with the exception of Microsoft, a late entrant) are located in Silicon Valley. The largest of these is Oracle which, after Microsoft, is the second largest independent software firm in the world. Other important firms include Sybase, Informix (purchased by IBM), and IBM. Oracle, in particular, spawned other important business software firms including PeopleSoft and Seibel, which pioneered other niches in business software.

Silicon Valley also experienced success in entertainment software. Here, the Silicon Valley pioneer was Atari, which later collapsed. Atari's demise in the 1970s permitted the control over the game boxes to move to Japan, and today Japan is the major competitor for the U.S. game software makers. The largest entertainment software firm in Silicon Valley is Electronic Arts, which used to be a developer and today not only produces games but also distributes them for other producers. These game software firms are intimately connected to the cutting-edge PC graphics chipmakers also located in the region.

Though Silicon Valley did not prove to be as dominant in software as in some other industries, it did become one of the key global software centers. The remaining software firms in the region have integrated Indian software production capabilities into their global footprint, in the same way, as the semiconductor design firms integrated Taiwanese fabs. In the PC era, the locus of the consumer software industry was, of course, Microsoft.

2.5. The Worldwide Web – Silicon Valley Becomes the Center

The Internet was a national defense project, but the real key to commercialization was the introduction of the WWW protocols that were developed in 1991–92 at CERN in Geneva (Abbate 1999; Kenney 2003). In 1993 entrepreneurs had not yet comprehended the opportunities that the Internet represented and there was also a delay in convincing venture capitalists that the WWW presented an investment opportunity (Ferguson 1999). However, the lag in comprehension did not last long, especially in Silicon Valley, and by early 1994 venture capitalists were receiving business plans from entrepreneurs with ideas for the commercial exploitation of the WWW. The first easy-to-use web browser Mosaic formed the basis of one of the earliest Internet startups, Netscape, which was established in April 1994 by Marc Andreesen, a recent University of Illinois, and Jim Clark, an ex-Stanford professor and founder of Silicon Graphics Inc. Less than one and one-half years later, Netscape had an initial stock offering in August 1995 at a valuation of nearly $1 billion. Netscape's remarkable increase in value alerted every venture capitalist and entrepreneur that the WWW was a new opportunity. Given the greater venture capital resources and large numbers of entrepreneurs, the Bay Area quickly became the center for WWW startups (Kenney 2003; Zook 2002).

As the number of WWW users exploded, new business ideas and opportunities proliferated. This expansion provided opportunities for yet other startups to develop new software and Web-based services. Businesses were built around searching and cataloging other sites (Yahoo!, Excite), selling products online (eBay and Amazon), software tools, building new communications networks (Exodus) and Web-hosting services among many others. Investors were willing to fund entrepreneurs experimenting with an amazing proliferation of business models. By mid-1999 there was a full-scale investment panic as public investors drove stock prices skyward. By the time the Bubble ended in 2000, more than 370 self-identified Internet-related firms had gone public and their total valuation had reached $1.5 trillion, though they had only $40 billion in sales (Perkins 2000). The returns for the most successful VC funds were astronomical—many had annual returns of 100 percent and one even had a 400 percent annualized return. The amount of venture capital invested in Internet-related firms grew from a nearly negligible $12 million in the first quarter of 1995 to $31 billion in 1999 (NVCA 2000). Approximately, 50 percent of all the new Internet firms were headquartered in the Bay Area. Faster than anywhere else, Silicon Valley entrepreneurs glimpsed the potential of the WWW as a commercial opportunity and then mobilized the resources necessary to try to realize that future.

The dot.com bubble, as **Figure Four** also shows, was the largest VC bubble in SV history. This was driven by a torrid IPO market, where it was possible to raise enormous amount of capital for new firms with extremely weak business models. A prime example of this is the $1.2 billion in capital lost on Webvan, a firm established in 1996, had an IPO in November 1999, and collapsed in 2001 (Aspray et al. 2013). In the case of Webvan, two factors contributed to its collapse. The first was a business model that was so uneconomical that the firm could not survive even with an enormous capital endowment. The second was the collapse of the stock market that meant it was unable to raise even more capital. However, another firm with a money losing business model, Amazon.com, was able to continue to raise capital despite making very little money. The ability to raise capital while continuing to lose money is vital when expanding and competing against incumbents that must make a profit. The incumbents can be driven from the market by an inferior business model (i.e., one that does not make a profit). When competitors, such as bookstores in the Amazon case, are driven from the market a monopoly can be the outcome. This capture of the node in a value chain also means that other nodes become vulnerable. In the case of Amazon, the next node in the value chain it threatened were publishers (for this struggle, see Gessen 2014), as Amazon began encouraging self-publishing.

In 2000, the Bubble collapsed and hundreds of startups went bankrupt. Though, what is important to remember is that many of them survived and, as important, a new set of skills related to managing data centers, big data, and a fledgling cloud computing capability emerged. This would become vitally important in the next wave of SV firms that would form what Kenney and Zysman (2016) have termed a "Platform Economy."

2.6. Social Media and the Platform Economy

After the collapse of the dot.com bubble in 2000 funding for new firms dropped dramatically, but there were exceptions to the relatively negative environment. For example, Google established in 1998 went public in 2004. During this relatively depressed period, firms such as Facebook, Instagram, LinkedIn, Pinterest, Twitter, and YouTube were formed based on providing a "platform" on which users could communicate. These firms were built upon monetizing user-generated content.

For Silicon Valley, yet again, there would be a dramatic technical change, with the introduction and rapid adoption of the smartphone. This would mark a profound shift in the global ICT industry, as the two dominant operating systems, Apple's iOS and Google's Android, belonged to SV. These two operating systems would begin a displacement of Microsoft and the personal computer as the core computing device. It would be SV firms that would drive the movement of the heavy-duty computing to the cloud (though, of course, Amazon and Microsoft, remain powerful firms). New transformative firms such as Uber/Lyft and Airbnb are predicated upon the functionality of the smartphone.[6]

There also was an ideological shift, which was already inherent in the SV culture, but has become dominant recently – namely the philosophy of "doing something first, and asking regulators forgiveness later." This has combined with a technophilia, libertarian philosophy, and an emphasis on disrupting existing industries and arrangements by whatever means possible. Fueled by an enormous influx of finance capital, a global-class technical work force, a number of the global ICT pace-setting firms, and benign neglect upon the part of regulators, SV appears more central and successful than ever. But, may also, once again, be in one of its periodic bubbles. At this time, the only country that has remained largely immune to the strength of SV's platform firms is China (see Jia and Kenney 2016).

3. Entrepreneurial Support Networks and Culture

Cluster studies have shown that successful regions develop an infrastructure including public goods, rich supplies of specialized labor and input providers, strong local competitors, and industry-specific information (Porter 1998). What most observers do not fully appreciate is that the product of SV is new firms that embody a perceived new technology/business opportunity (TBO). The adjective "perceived" is vitally important because a priori no one can judge whether the TBO will be successful. For all involved, "success" is defined as the ability to sell the firm formed to exploit the TBO for a significant multiple of the initial investment. In fact, for the successful TBO firms the multiple should be so great as to cover the losses on the unsuccessful

[6] This not to suggest that Uber/Lyft or Airbnb are guaranteed to be successful, however they certainly are threatening existing industries.

investment. The fundamental point to make here is that not all TBOs need to be successful, only a sufficient number, so that the returns from the few winners outweigh the losers by a large margin.[7]

While Porter correctly suggests that this is an advantage for all types of regions, in SV one other element should be added to this infrastructure; a network of actors whose goal is to find the new TBO embedded in a new firm. We have termed this an "entrepreneurial support network (ESN)." The goal of ESN actors is to participate in the capital gains that accrue when one of the startups is successfully sold either to the public in an initial public stock offering or through an acquisition (Kenney and Patton 2005). The ESN in SV has become so resource-rich that the various actors in the network will fund emerging ideas in other fields as was the case in biotechnology, nanotechnology, and, most recently, Cleantech. If these investments fail as was the case in Cleantech, only a relatively small proportion of the total venture capital resources and, perhaps, a few venture capitalists will be lost (for further discussion of Cleantech and VC, see Hargadon and Kenney 2012). If the investments succeed as was the case of biotechnology, a new investment field emerges, if they do not, then the investors simply move on. Ultimately, the actors are agnostic as to what constitutes a suitable field for support, they experiment with the TBO, and if there is a market for the firms they supported, then there will be further investment.

The case of Uber, in many respects, best illustrates the ability of VC-funded firms to continue losing money, while gaining market share and thereby destroying incumbents. It is widely believed that Uber continues to lose money in operations (Horan 2016). It is able to fund these money-losing dynamics as it has VC investments that allow it to continue to subsidize its

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[7] To illustrate, Kleiner Perkins and Sequoia Capital paid $25 million for 20% of Google 1999, when Google went public in 2004 and these stakes were worth $2.03billion each. This was a roughly 2000x return in 5 years.

losses while taxis lose market share, become uneconomical and leave the business. This could lead to a monopoly. When the monopoly is in place, Uber might be able to raise prices once again – what it clearly could do in such a situation is set price to maximize its income. Seen from another perspective, VC's role as capital was to assist a firm in overcoming the "Valley of Death," i.e., when it was losing money faster than it was making money, but also was growing very quickly. As the sheer volume of VC available grew, VCs could finance the loss of money for longer periods of time in situations where the VCs believed there was an opportunity.

The entrepreneurial environment benefits from interaction in many venues that contributes to cross-disciplinary information sharing and synthesis. With so many technologists, investors, and others interacting and trying to peer over the horizon to identify the new opportunities, a consensus can form leading to enormous waves of investment and a rush of entrepreneurs into the supposed profitable new field. The repeated successes in establishing new firms and then being able to garner large capital gains on a significant number of them creates a culture of entrepreneuring. Interestingly, this culture differs remarkably from other entrepreneurial cultures that are based upon the idea of establishing, managing, and controlling one's own firm. The Silicon Valley culture is based on establishing and then selling a company to either the public or a corporate acquirer.

Though we focus on identifiable institutions in this paper, it is important to note that the entrepreneurial culture developed in Silicon Valley can be characterized as extreme entrepreneurism. During the economic boom periods changing jobs is a given part of the labor market in Silicon Valley. Over time, participating in a startup became a career path. This acceptance of startups as normal has reduced the career risk to becoming an entrepreneur. Moreover, whereas thirty years ago the entrepreneur was expected to use credit card debt and even mortgage their home as part of the process, in the last twenty years such measures are no longer necessary prior to receiving angel investments and/or venture capital. It is not in the interest in investors to raise the barriers to entrepreneurship and increase the concerns of the entrepreneur. This lowering of entry barriers has culminated in the belief that failure should not necessarily preclude an entrepreneur from being funded to undertake another startup. What is clear is that there is no interest or advantage in punishing failure, that the monies lost will not be recovered, and being seen punishing entrepreneurs would discourage other venturers from taking investments from the vindictive VC. Given that the Silicon Valley economy is based on capital gains, a culture and ideology encouraging entrepreneurship is a prerequisite and a logical outcome.

In keeping with the capital gains-driven economy, one of the primary cultural and economic goals is to secure stock options or equity. This has led to an environment in which equity is extended to a large number of persons in the corporate hierarchy. The ownership of options elicits extraordinary effort from the employees. If the startup firm is successful, it creates many wealthy managers and engineers. Often, these experienced individuals invest in other entrepreneurs or even launch their own startup, thereby perpetuating the entrepreneurial cycle.

There are many aspects of the SV culture that are difficult to reproduce. The first is the startup work culture. This work culture is remarkable in many respects. First it is male-dominated, though our previous research has shown that women, while dramatically underrepresented, are more prevalent in Silicon Valley startup IPOs than in startups from the rest of the US (Kenney and Patton 2015). Second, for startup firms the work hours are remarkably long with 70, 80, or 90-hour work weeks, often for months on end, the norm. For nations where such work weeks are either not acceptable or illegal, competing with SV firms will be difficult.

Because of the ferocious nature of the competition, especially in ICT fields that are characterized by winner-take-all markets and breathtakingly rapid technical change, being late equates with failure. Third, it is a corporate environment within which new technologies, a great "hack," and huge capital gains are the reigning myths. In this environment, a hot new firm or technology attracts attention and floods of resumes. The opportunity to commercialize the "hottest" new technologies attracts many of the best engineers and elite managers in that field. Fourth, there is a belief, whether justified or not, that a "great" programmer is worth far more than large numbers of good programmers. This does not encourage egalitarianism, but rather brutal competition and "us-versus-the rest" mentality. Such an ethos is difficult to replicate in other locations.[8] Moreover, firms in other fledgling regions considering entering the ICT industry in competition with SV must deal with the fact that their SV competitors will be ferocious. However, the firms that survive the SV competition may find their global competitors much less driven. As a result, many young firms from Europe and Asia decide to move to SV very early in their life cycle to be able to compete and learn from the global leaders.

The importance of this access is greatest for fast-growing startups. Consider the pressure that a fledgling rapidly growing firm experiences. Google, for example, was incorporated in 1998 and, at the time, was composed of the two founders, in August 2004 when it went public it had 2,292 employees. Google's compound annual growth rate was in excess 30% meaning that it was hiring large numbers of employees every month, and nearly all of them were local.

The young firm needs top-quality personnel, and, in particular, managers with the ability to manage such growth. In the case of Google, in 2001, less than three years after it incorporated, it

[8] Somewhat similar ideologies likely exist in other high-risk, high-pace trading environments such as Wall Street or the City of London.

hired Eric Schmidt, a Berkeley Ph.D. in electrical engineering and computer science, the ex-Chief Technology Officer at Sun Microsystems, and ex-CEO of Novell – in other words, a three-year old firm was able to hire a top-flight manager and engineer.

Effectively, SV has developed an ecosystem optimized from establishing new firms to exploiting new TBOs. A labor force, a set of institutions, and a culture/ideology; all of these were predicated upon the enormous financial success that investments in the region generated. What is remarkable is that, if we date the formation of SV to 1958 when Fairchild was founded, the dramatic growth and ability to discover large new financial opportunities has now continued for nearly sixty years – a remarkable run in its own right – and a testament to how powerful the ESN is.

3.1. Cluster Management?

When confronted with an ecosystem that has repeatedly generated a number of the richest and most powerful firms in the world, it is natural to search for some overarching plan or management. Certainly, there were leaders such as Frederick Terman, Bill Hewlett, David Packard, Bob Noyce, and others that worked for the overall good of the local industry. Michael Storper et al. (2015) judges that there were more civic organizations in the region than Los Angeles and attributes SV success to their roles. Though this may be the case, as compared to the more dispersed LA region, it is not civic organizations or a planning agency that drove the technological revolution or created the Bay Area venture capital community (Kenney 2011).

It would be convenient to attribute the development of Silicon Valley cluster to some strategic considerations by central actors. However, as our history has shown the evolution was an unfolding that was an interplay between individuals (or, more properly, in most cases, teams of entrepreneurs) and institutions (again made up of individuals) whose goal is to assist entrepreneurs in building firms on the TBOs. There is no central management, as the cluster is predicated upon entrepreneurs doing new things. To illustrate, many of the most successful firms have been denied funding by large number of venture capitalists. What is important is that they did get funding from other VCs and then succeeded. In fact, even elite venture capitalists decline or even fail. Fifteen years ago, Kleiner Perkins was the elite VC firm, today it is among the top firms, but no longer in the elite. There can be no "top-down" strategy as there is no "top," but also because the future is inherently unknowable – or, put correctly, with the technical changes underway in the ICT industry it is clear that new things will become possible – it is just unclear what they are and whether an existing firm or a startup will develop them. Consider the Internet giant Google. Its three most important offerings after Search are advertising, for which it purchased AdSense, the offering YouTube that it purchased, and the offering Android that it also purchased. The ecosystem itself generates the new opportunities.

The ultimate strategy for all of the organizations in the ecosystem are capital gains and survival. Complexity theory can help us understand the environment in the sense that organizations are constantly self-organizing in the rich "soup" of technologies, capital, and skilled labor comprised of technologists, managers, venture capitalists, consultants, specialized lawyers, etc. The startups are the outcomes of self-organization. If they fail, they are purchased by larger organizations, so that many of the human resources are released back into the environment – often to establish or join yet another startup. There is no way to centralize or manage this process; it is self-generating and self-sustaining. However, public goods institutions such as universities do feed technology and highly trained personnel into the ecosystem. While personnel are clearly important, critical new ideas from universities can be vital (e.g., reduced instruction set computing, semiconductor design software, relational databases, search engines, computer graphics, internet, etc.)

Effectively, it is difficult to discern any over-arching strategy at the cluster level, but obviously, the actors all operated with individual strategies to produce economic success. Similarly, as we turn to internationalization, there was no overarching strategy, but simply firms and individuals acting under pressure to cut costs (offshoring assembly activities) or access facilities that would enable them to operationalize their business plans (semiconductor fabrication facilities in Taiwan).

3.2. Internationalization

Internationalization has had an impact on many aspects of SV, including the work force, manufacturing and supply chains, markets, and venture capital; all four of which are discussed below.

Workforce:

The Silicon Valley workforce is composed of technical and managerial personnel from throughout the US and abroad. The exact number and percentage of foreign born employees and entrepreneurs is unknown, but certainly it is significant (see, for example, Kenney and Patton 2015; Saxenian 2007).[9] The ability to attract such personnel to the region is a vital component of the region's success. Ultimately, the SV ecosystem is predicated upon having access to the largest number of extremely talented ICT-knowledgeable personnel.

[9] The definition of foreign-born and immigrants, at first glance, appears to be simple. However, upon further examination becomes quite complex. For example, Jerry Yang, one of Yahoo!'s founders, immigrated from Taiwan with his mother at the age of 10. He is a different class of immigrants than someone who comes with an undergraduate degree from a foreign university to become a graduate student.

Manufacturing:

In 2016, ICT manufacturing in Silicon Valley is limited to prototyping and other such high value-added activities. This was not always the case, as the pioneering firms had manufacturing facilities in the region. However, as land, labor and other costs and the scale of production increased firms beginning in the 1960s, SV firms began relocating certain parts of the production process and assembly out of the region (Borrus et al. 2003; Brown et al. 2005).[10] In the 1980s, as semiconductor fabrication (the most capital-intensive portion of the production process) became increasingly expensive, small start-ups could no longer afford to undertake the entire production process. The Silicon Valley solution was "fabless" semiconductor startups that contracted for production with offshore fabrication facilities in Taiwan (Mathews 1997). In terms of manufacturing, by the 1990s, little manufacturing by SV firms remained in SV, though some leading firms, such as Intel, continued fabrication in the US. By the 1990s, offshoring also began to extend to programming and services. Here again, Silicon Valley firms (such as Hewlett Packard, but also non-SV firms such as Texas Instruments) led the way, in particular to Bangalore (Dossani and Kenney 2003). In 2016, all major SV firms had some combination of production, R&D, programming, and service provision facilities globally.

Markets:

Silicon Valley startups benefit from the large US domestic market, which provides a large initial market. Because startups are built with the goal of rapidly growing large, this by definition means creating goods and services appealing to global markets.

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[10] Only slightly later, the Silicon Valley hard disk drive industry also began offshoring work to Asia (McKendrick et al. 2000).

Until the mid-1990s, with the exception of Apple, Silicon Valley firms for the most part sold to other firms, not directly to consumers. Effectively, again with the exception of Apple, consumers only knew SV giants such as Applied Materials, Cadence, Cisco, Oracle, 3Com, Rolm, Seagate Technology, Silicon Graphics, Sun Microsystems, Sybase, Synopsys, and even Intel through financial news or stock analysts' reports.[11] While recognized as investments, the preponderance of the most important SV firms produced inputs to production processes or products of other firms.

In the 1990s, the visibility of the region and its new entrepreneurial firms changed with the mass adoption of the Internet. While the fundamental Internet technologies, for the most part, were not developed in SV, startups located in the region were rapid to exploit the commercial opportunities the technologies offered. Key early firms were Yahoo!, formed at Stanford University, and Netscape, one of whose founders, Marc Andreessen, commercialized technology he had helped develop at the University of Illinois. Both firms were deliberately focused on the consumer market and these products were adopted globally -- almost as rapidly as they were adopted in the US. In only a few years, Silicon Valley-based internet firms became dominant globally, with the partial exception of North Asia (China, Japan, and Korea).

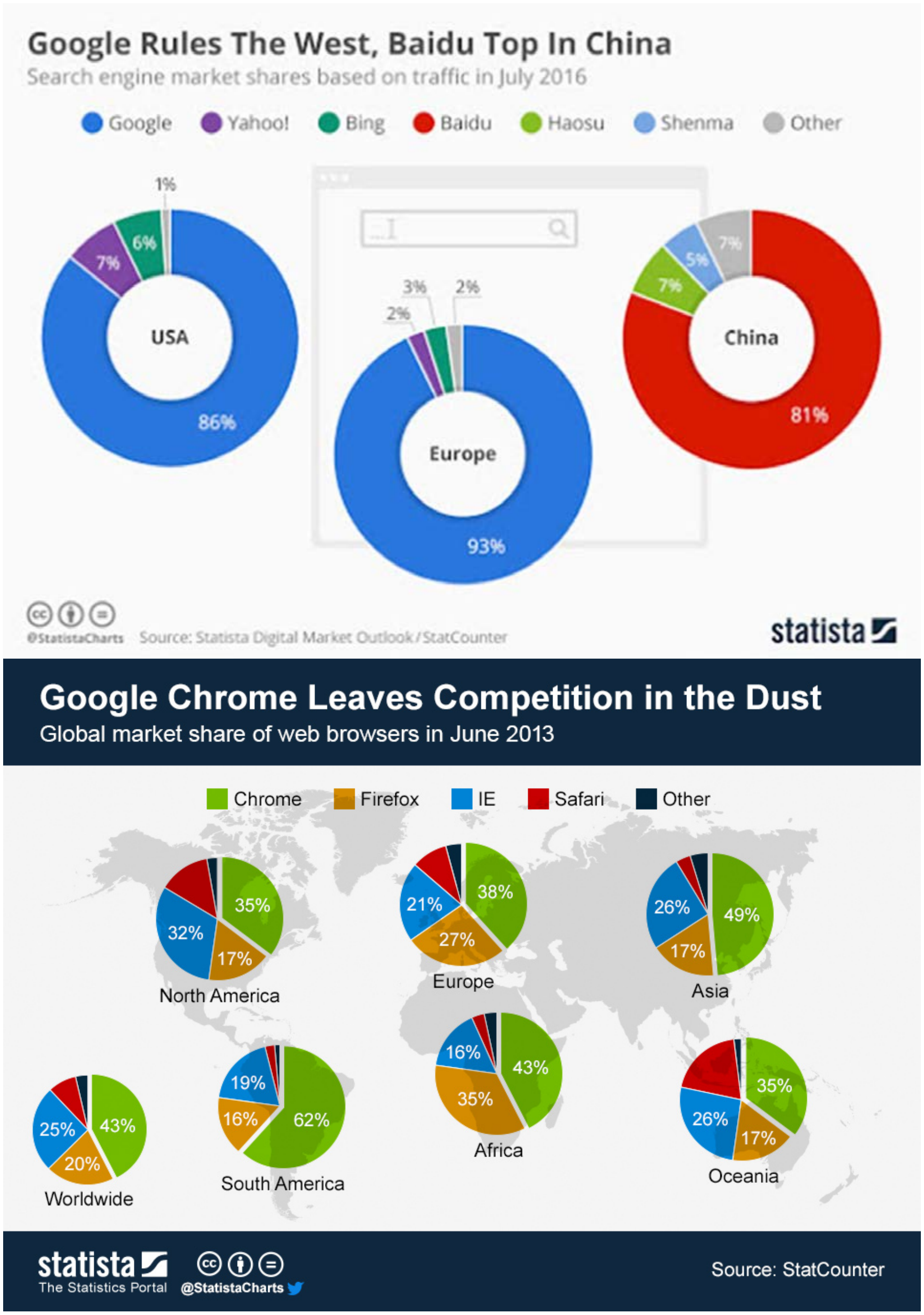
In 2016 Silicon Valley firms, particularly those based on Internet technologies, are globally dominant (with the exception of China). In 2016, the only globally significant European internet firm is Spotify.[12] The global dominance of SV firms is remarkable in terms of search, browsers, and social media (see **Figure Five**. In terms of social media all of the dominant firms,

[11] Another early consumer software firm was Intuit, which was established in 1983.
[12] Skype was a European startup, but was purchased by Microsoft.

Facebook (Instagram and WhatsApp acquired), LinkedIn, Twitter, and YouTube (acquired by Google), with the exception of Snapchat (based in Los Angeles), are Silicon Valley firms.

In addition to social media firms, firms such as Uber, Lyft, and Airbnb, are from SV. For Internet firms, given the very nature of the technology, the market is, by definition, global.

Figure 5: Global Dominance of Silicon Valley Firms in Search and Browsers



Source: Statista Charts 2016

3.3. Venture Capital

Venture capital was a uniquely US creation (Kenney 2011), but in the 1980, a few SV venture capitalists established foreign operations, particularly in East Asia (Kenney et al. 2007). In the 1990s, a number of SV venture capitalists established operations in Israel (Avnimelech and Teubal 2006). In the 1990s, particularly during and after the dot.com bubble, SV venture capitalists established operations in China, and also to a lesser degree in India (on China see, for example, Fuller 2010; on India, see Dossani and Kenney 2002). Over the last three decades Silicon Valley venture capitalists have globalized their practice as they search for entrepreneurial clusters capable of gestating startups that can generate VC-like returns. Having said this, SV remains by far the most attractive location for investment, so even as some SV firms have globalized operations, other equally successful SV VC firms only invest locally.

3.4. Summary

While the Silicon Valley cluster has intensely local characteristics, it has become increasingly globalized. While foreign immigrants have always played a role in Silicon Valley, their role has grown. Very early on, SV firms offshored lower value-added assembly manufacturing, then the fabless semiconductor firms offshored fabrication, later low-end services and some aspects of software production were also offshored. In fact, SV firms were leaders in utilizing offshoring, in particular to Asia. It could even be argued that SV firms played an important part in the building of the non-Japanese electronics industry. Finally, SV firms have always targeted global markets, but more recently with the rise of the Internet, the speed with which SV firms are able to penetrate global markets has accelerated. It is no exaggeration to say that the wealth being generated in SV would not be nearly as great without firms being able to exploit global markets. To illustrate, in 2016 only 13.3 percent of Facebook users were in the North America (Internet World Stats 2016).

Globalization continues to concern some, especially workers that are displaced and government officials concerned that offshoring could lead to the loss of technology. However, for firms and venture capitalists this is viewed simply as the nature of competition. Further, as SV firms are absolutely predicated upon conquering global markets, any barriers are seen as problematic. Earlier scholars were extremely concerned about the offshoring of manufacturing (Cohen and Zysman 1987; Florida and Kenney 1990). While offshoring and the disconnection of the US high-technology economy from the rest of the economy is seen as a concern nationally, there is little evidence that it has adversely impacted SV businesses.

To conclude, globalization and the offshoring can be seen from a wide variety of perspectives. For the last now four decades, observers have been concerned about the impacts of offshoring on Silicon Valley. If we are specifically addressing the impacts of offshoring on the ability of Silicon Valley to create new firms and be the center for developing cutting-edge, new-to-the-world businesses and industries, and possibly disrupt old industries, then offshoring has not had a significant impact on the Silicon Valley new technology/firm creation machine. This is, on purpose, a deliberately narrow definition. This is because Silicon Valley entrepreneurs and venture capitalists are NOT driven by some social purpose such as creating jobs, making the US the global technological leader, or helping US society become better in some way. The system is driven by commercializing new technologies that can lead to out-size capital gains – all these other social or political benefits are unintended by-products of entrepreneurial success – they are not goals. Silicon Valley has a single focus – creating new firms that can be sold for enormous capital gains.

In this context, globalization is first and foremost about access to global markets for the technology. US firms are so powerful because they CONTROL markets in much of the world except China. Entire US industries pioneered by Silicon Valley (and some non-Silicon Valley firms such as Microsoft) suffer from copy-cats. For example, in PCs the US is entirely dependent upon Asia (except of course Intel and Microsoft) for assembly. The US is essentially out of the disk drive industry pioneered by IBM and Silicon Valley firms. This does not matter to Silicon Valley, these are low-margin businesses with insufficient innovation to allow new entrants. Therefore, Silicon Valley firms and entrepreneurs do not care. This also means that the jobs in those industries have disappeared along with thousands of peoples' livelihoods -- this is simply a "natural" outcome of the Silicon Valley business model. For the US government, this can be a concern as it means a set of capabilities may have moved offshore – this is a regrettable outcome of the industrial and business dynamics of the Silicon Valley model. Existing Silicon Valley firms compete by driving costs down by offshoring many activities to lower-cost environments, while trying to retain the highest value-added activities.

Another outcome of the model is that foreign firms can purchase small US startups to get access to their technologies. From the national government perspective, this may be of great concern as the technology would then be owned by a firm domiciled in another nation. However, not allowing firms from other nations to buy Silicon Valley firms would limit the market, thereby decreasing the potential value of Silicon Valley firms – remember the goal for the venture capitalists and entrepreneurs is capital gains upon sale of the firm to the market or a larger acquiring firm. In other words, the potential pool of customers wanting to but the firm would shrink, thereby decreasing the firm's value to remaining customers. This might decrease the willingness to back new ventures. The flows of capital into the region from around the world are vitally important to its vibrancy.

Ultimately, Silicon Valley is predicated upon globalization in all its forms and this explains its constant push for more open global markets, migration rules, etc. Of course, this general tendency toward openness does not prevent sectors of Silicon Valley industry experiencing foreign competition for asking for federal government protection as occurred in the semiconductor industry in the 1980s and computer networking equipment, when Huawei was found copying Cisco software, more recently. Further, many times, the US government has moved to protect the US ICT market in particular from foreign, in most cases, earlier Japanese and, more recently, Chinese competition. Depending upon how one views patent protection, Silicon Valley firms may also be getting protection from foreign competition through increasingly draconian US intellectual property enforcement.

The next section addresses the vital role of the public sector in making SV possible.

3.5. The Role of the Public Sector

Silicon Valley is not the direct result of public sector funding, however indirectly government and public sector action has been vitally important. Prior to addressing the all-important indirect action, it is important to note that neither federal nor state actions were directed toward creating an ICT cluster in the San Francisco Bay Area – SV was the result of entrepreneurial action. In this sense, there are few lessons for other regions and countries.

In contrast, the indirect role of the government has been central to success of Silicon Valley. The following list of policies have all been powerful accelerators for U.S. technology, in general, and the Silicon Valley ICT cluster was, perhaps, the biggest beneficiary:

1) R&D -- Since World War Two, and particularly from the inception of the Cold War, the U.S. government through defense, NSF, and NASA funding of electronics R&D developed many of the technologies that were later commercialized by Silicon Valley (and other) firms (Benhamou et al. 2009). Until the mid-1960s, the US government was also a vital early customer for the new technologies, particularly as it was willing to give firms cost-plus contracts that essentially funded the research. After delivering the new technology or artifact to the Department of Defense, a firm was free to commercialize the technology. Many of the early firms, including Fairchild, were initially dependent upon military purchases.

After the 1960s and the end of cost-plus contracting government investment in R&D, particularly at research universities, remained vital. It was through federal funding that the inventions and implementations that ranged from the internet (then Arpanet) and BSD Unix, to semiconductor design software and reduced instruction set computing, were made at U.S. universities. Two of the most important of these were UC Berkeley and Stanford University (the other one of greatest importance was MIT) (on UC Berkeley ICT inventions, federal funding, and Silicon Valley, see Kenney et al 2014). While these inventions were foundational, probably of even greater importance was the funding for graduate students. To illustrate, William Joy (BSD Unix/TCP-IP, Sun Microsystems) and Eric Schmidt (Sun Microsystems, Novell, and Google) were funded on federal grants while graduate students at UC Berkeley in the 1980s. In the late 1990s, Sergei Brin and Larry Page (Google founders) were funded as graduate students at Stanford University. These are just examples to illustrate the point that it was the creation of human capital, particularly graduate students whose studies and research was funded by the Federal government, that was likely of even greater importance than the inventions themselves. This was not a geographically targeted policy, but rather a general national policy.

2) Immigration Policy – While US immigration policy is remarkably complicated, convoluted and difficult to explain, visas for top-tier students wanting to do graduate studies in US universities have been easy to get. This has allowed US universities to select and attract many of the best students in the world. After completing their graduate degrees, many of these students choose to stay in the US and joined firms and academe. This, quite simply, provided the US ICT industry with the very best technologists in the world. There were other visa programs that encouraged the immigration of skilled technologists, though likely none were as important as student visas.

3) Financial Regulation – For entrepreneurial, high-risk, fledgling Silicon Valley firms whose intention is to grow rapidly, an institution capable of providing capital to fuel that growth is necessary. In the US, a new organization for financing these young firms, venture capital, was born (for a history, see Kenney 2011). The US legal system had the limited partnership that proved to be amenable to the practice of venture capital. Over time, as venture capital increased in importance, a variety of other rules and regulations evolved to facilitate venture capital investing.

   The other vital financial institution was US equity markets, which after the reforms of the 1930s, were among the largest and most transparent in the world. Until the formation of the Nasdaq in 1971, while it was not easy for fledgling firms to list stock, it was possible through the relatively illiquid over-the-counter markets. The willingness of the US Securities and Exchange Commission to allow firms with minimal revenues and profits to list made it possible for small firms to obtain far greater sums of capital than they could in private markets and use the capital to fund growth. The other benefit of allowing young firms to list was that venture capitalists could liquidate their investments and thus finish what Gompers and Lerner (2004) term the "venture capital cycle." In terms of financial regulation, there was no particular dispensation for Silicon Valley firms.

There have been other financial regulatory changes that have occurred over the last thirty years. For example, there has been constant pressure by investment banks and venture capitalists to weaken financial regulation by easing listing requirements, weakening the ability of investors to bring law suits for fraudulent disclosures, reporting, or practices. These efforts culminated in the repeal of 1934 Glass-Steagall Act separating consumer and investment banking, and the decreasing willingness of the Securities and Exchange Commission to pursue financial misconduct. When taken as a whole, these developments encouraged financial risk-taking across the entire economy, and thus increased the capital available for risky investment including venture capital.

The most recent major easing of restrictions was the Jumpstart Our Business Startups (JOBS) Act signed into law in 2012. The JOBS Act was a response to critics, largely from industry or industry-funded organizations, that the requirements for listing young firms on US stock exchanges was too difficult and thus handicapped newly formed firms.[13] The JOBS Act had many provisions that included reducing the disclosure requirements for listing firms and increasing their safe harbor from law suits concerning the violations of the Depression Era rules regarding public statements by management prior to the IPO. In many respects these were probably more favorable to small biotechnology firms that needed to raise money to fund research and clinical trials for an unproven drug. Weakening these provisions created more opportunity for them to "hype" an unproven drug without being subject to investor lawsuits if it later failed. For the ICT sector, probably more important was the relaxation of the rule that any firm that had more than 100 stockholders had to begin making SEC filings. The JOBS Act changed the number to 1,000 and allowed investment entities such as mutual funds to be considered as a single holder. This allowed "hot" firms to remain private longer and raise ever increasing amounts of capital (for example, Uber has raised over $12 billion in private capital and Airbnb has raised approximately $3 billion in private capital). While the JOBS Act was not targeted specifically and solely at SV firm and investors, they were substantial beneficiaries of its provisions. The hopes of this legislation, largely unrealized, were that it would create more SV-like startups throughout the US.

4) Taxation – There were a number of taxation decisions that were important for the rise of Silicon Valley, but two have received the greatest attention. First, the lowering of capital gains taxes in 1980, while not directly affecting venture capitalists, did affect the willingness of managers and executives to accept stock options as compensation, because they would be taxed at the lower capital gains rates. The second tax decision benefitted

[13] For a more critical evaluation of this claim, see Ritter (2014).

venture capitalists, whose most important gains are from carried interest. This decision allowed for carried interest to be taxed at capital gains rates and not at the higher regular income rates. These taxation policies were not targeted only at Silicon Valley or venture capital, but greatly increased the returns to venture investing and new firm formation.

U.S. taxation rules had other benefits for the rise of sales platforms such as eBay (SV firm) and Amazon (SV firm), namely the rule that as long as shipments were across state lines, due to the federal commerce clause, the selling firm did not have to pay sales tax (the customer was supposed to declare and pay the sales taxes on their taxes, which they did not do and there was no enforcement). More recently, Amazon has made agreements with some states to collect sales taxes. The importance of this law was that it provided the online firms an advantage over bricks-and-mortar stores (essentially the uncollected taxes offset the cost of shipping).

5) Antitrust Enforcement – Antitrust enforcement was one of the environmental conditions that provided opportunity and, at times, protection for the startup environment. On the communications side, it was the gradual opening up of the AT&T system that provided a flow of new opportunities for startups; many but not all of which were in SV (Kenney 2003). The final breakup of AT&T into the Regional Bell Operating Companies and Lucent then offered even more opportunities to reconfigure the telecommunications network for digital communications – an area where SV firms excelled. On the computer side, the requirement that IBM unbundle hardware and software made it possible for new entrants to create products that would be compatible with IBM equipment (Baldwin and

Clark 2000). Nearly constant antitrust scrutiny may also have inhibited IBM's ability to react to new technologies or even to fully exploit the technologies it developed in its laboratories (see, e.g., Campbell-Kelly 1995). Later, the US government would prosecute Microsoft for antitrust violations and, once again, this may have provided some protection for small SV firms. The application of antitrust law was not explicitly meant to protect SV firms, but rather was a part of a general antitrust enforcement. This contrasts with Europe where both the government telecommunications monopoly and most of the national computer champions were, for the most part, protected and sustained by government policy.

6) Intellectual Property (IP) Law – The US, often lobbied by ICT firms, has aggressively promoted increased patent protection during the last three decades including extending patent protection to software and even business models. Increased patent protection has had contradictory impacts, as SV firms have increasingly complained about law suits from non-practicing entities, often termed "trolls" (Merges 2010; Jeruss et al. 2012), while firms such as Apple, in particular, have constantly litigated against their domestic rivals such as Google, and foreign competitors such as Samsung (Cusumano 2013). In this respect, the US government has legislated to protect US high-technology firms. The conundrum for the ICT industry, in contrast to the biotechnology and pharmaceutical industries, is that ICT firms are far more promiscuous in the use of technologies. One partial solution to the IP litigation is the increasing open source software development and usage by SV firms.

While the role of increased patent protection continues to be debated, Chander (2014) argues that the US government took a relatively benign perspective on copyright law allowing Internet firms to reproduce copyrighted material with permissive intermediary liability rules. Thus, in the U.S. online firms were not liable for the transmission or posting of copyrighted materials, they only needed to remove offending material. While in Europe and Asia, the state sanctioned far more severe responses. As a result, US online firms could expand far more rapidly on the basis of copyrighted material.

Effectively, European and Asian governments have a higher priority on protecting existing media firms. Their apparent goal was to protect the existing firms and technologies, while in the US the leverage was largely with the new entrants. In the case of data privacy, which can be seen as another type of IP, the data provider was given significantly greater protection in the US. While clearly handicapping an online firm's ability to be profitable and thus handicapping the growth of such firms in Europe, it is uncertain whether any significant actual protection was created. Chander goes even further arguing that in the 1990s, the US government went even further passing a wide variety of the laws protecting Internet industries and thus thereby dramatically eased the ability of venture capitalists to invest in Internet startups thereby paving the way for their rapid growth. Again, these were not SV-specific laws, but SV was perhaps the greatest beneficiary.

7) Bankruptcy Law – The US has a long history of relatively lenient bankruptcy laws, which Cumming and Armour (2006) show in a cross-national comparison, increases venture

capital investment. California has lenient bankruptcy laws, which allow debtors to easily discharge personal debts, often while protecting their home. Often, during particularly difficult periods, entrepreneurs will use their credit cards to tide a firm over. What is important here is that there is little punishment beyond the bankruptcy judgement and therefore the punishment for failure is relatively low.

8) Non-Compete Agreements – The well-known fact that non-compete agreements are unenforceable in California has been shown to increase entrepreneurship (Gilson 1999; Marx et al. 2015). This is a state law and has been in effect since the late 1800s. Effectively, this allows employees to leave for another firm taking the knowledge they learned while employed. They cannot take their employers intellectual property, but the learning they acquired by doing belongs to them and the employer cannot stop them from becoming a competitor.

9) Standards Setting – Standards were particularly important for the development of Silicon Valley. Standards had to be created for data communications, interfaces between components interfaces, materials, and innumerable other aspects of the ICT industry – quite literally, SV is not possible without standards. The federal government, in particular, played an important role in standard setting. It is important, at the outset, to state that the government did NOT play an all-important role, as there were de facto standards created, often by a dominant player. In other cases, IEEE and ACM committees created all-important standards. When we consider the government role, two standards will illustrate important government interventions, and two further examples will illustrate a lack of direct government significance.

As an illustration, an early important standard was the military specifications for semiconductor reliability, which forced process improvement and the production of reliable chips that could then be used in commercial applications. This was combined with the government's requirement that a second source for all parts in military procurement be available. This ensured that there be one other capable supplier and thereby forced some information sharing (Lecuyer 2006).

A second illustration is the adoption of the TCP/IP standard for data communications. In this case, the initial protocol was developed at DARPA and then implemented and improved in universities and a university spin-off BBN. This was all funded by DARPA, which then was declared by DARPA to be the standard for military-funded computer networks. When the Arpanet was turned over to the NSF in 1985, TCP/IP spread to all networks. However, this was not sufficient to make TCP/IP a standard in the civilian market. In Silicon Valley new startups, particularly university spinoffs, such as Sun Microsystems (Baldwin and Clark 1997) and Cisco, not only adopted, advocated to their business customers that they should use the open source, TCP/IP, protocol. Cisco, in particular, would sell multiprotocol routers that would use any standard on the market, but then say to their customers, "you know TCP/IP is really the best solution." The result was that increasingly TCP/IP became the de facto standard. In this case, the government funded the standard development and mandated the standard, which later would overwhelm all alternatives and become the standard. Notice, this was not a standard-setting process such as was used in the setting of wireless standards where international committees met in Geneva and made mutually acceptable decisions at the International

Telecommunication Union. The market eventually chose the standard, but the role of the federal government was critical (Abbate 1999).

The final example is that of the local area networking protocol, Ethernet, which is set in IEEE committees. These are known as the IEEE 802 standards, which now govern the all-important Wi-Fi standards. In the case of Ethernet, it was a coalition of Digital Equipment Corporation, Intel, and Xerox that went to the IEEE wireless committee and proposed a wireless communication protocol that they had already developed. Importantly, in this case, the coalition was willing to provide all of its patents freely to all vendors, while the competitor standard, Token Ring, advocated by IBM was more reluctant to share intellectual property (Burg 2001). The standard eventually won in the marketplace and, in particular, was driven by SV and, to a lesser degree, Boston VC-financed startups. In this case, the government was irrelevant. This was a market-driven standard.

The point is that, in certain cases, government standard setting was important and even crucial, while in other cases it was irrelevant. The question this brings up is, in what cases, can or should the government or governments make market-framing standards decisions. It is likely that in the case of TCP/IP a market-based solution would have emerged, while in the military specifications case, firms with powerful advantages may not have shared information. Likely, in cases where the ICT market is likely to force information sharing, government involvement may not be necessary, as a market-driven standard is likely to emerge.

These government policies were important for the formation and the subsequent growth of the Silicon Valley ecosystem, however none of them, outside perhaps intellectual property law, were deliberate policies to create or protect the region. This is one of the most important misinterpretations of the SV growth by scholars such as Mazzucato (2015). These arguments are correct in that they emphasize the state as a vital actor in funding the development of new technologies, and as an important customer (though for many of these technologies the state was not an important first customer). However, what Mazzucato does not explain is why there is an overwhelming concentration of ICT entrepreneurs in SV, rather than being more evenly spread among various regions in the US. The belief in the state as the defining variable in the entrepreneurial developments in SV cannot explain why the particular forces coalesced there, versus other locations, or why European investments at CERN would be commercialized 6,000 miles away in California.

4. Reflections

In 2016 the ICT industries in Silicon Valley appear to more dominant than ever before. Older-generation firms, such as, Adobe, Applied Materials, Cadence Design, Hewlett Packard, Intel, Intuit, Cisco, Oracle, and Synopsys are still successful and powerful in their respective industry segments. In the PC Era, while Silicon Valley firms, such as Intel and Seagate, were important component producers, the true locus of power was with Seattle-based Microsoft. At the beginning of the Internet era, Silicon Valley was the central location of startups, but Microsoft was able to out-flank Netscape and maintain its dominance through control of the PC operating system (and the Office suite). And yet, as the Internet became the locus of new firm formation and people's usage of computers, the new firms built on the internet were dominated by SV startups with the important exception of Seattle-based Amazon and, more recently, Los

Angeles-based Snapchat. It was the transition to the mobile phone combined with the rise of social media websites that cemented Silicon Valley's global dominance.

Today, the world's dominant operating systems are Apple iOS and Google's Android; Microsoft's Windows has been confined to the desktop. Before reflecting on the social media firms, it is vital to recognize that the mobile phone is central to the business models for firms such as Uber, Lyft, Airbnb, TaskRabbit and many more. The social media giants, Facebook, LinkedIn, Twitter, and others, are among the world's most visited websites. Effectively, SV firms dominate in an economy where internet platforms increasingly organize ever greater parts of global social and economic life (Kenney and Zysman 2016).

In 2016, the remarkable success of SV in spawning firms that have changed the world and the way people work, play and interact is remarkable – and even in 1996 was unimaginable. The wealth that it has created in the San Francisco Bay Area is surprising (see, for example, Storper et al. 2015). Pursuing these achievements has not been without costs at the local and national level. Capital gains tax rates are lower than those for ordinary income, thus favoring the returns to capital that Piketty (2014) found so disturbing and redistributing the burden for operating the state to the lower and middle classes whose income comes in the form of wages. The gradual loosening of restraints and safeguards on capital markets did help fund the creation of these startups, but there seems little doubt that it has also led to increasing volatility in US stock markets and greater inequality.

It is difficult to imagine a more "local" and global place on the planet. First and foremost, all of the leading firms (and, particularly startups) assume that they are developing products that in Steve Jobs' words "will change the world." SV's supply chains stretch across the Pacific into Asia, and if one traces the entire supply chain are clearly global in character, though the nexus of power is certainly Transpacific. And yet, the importance of being in the San Francisco Bay Area to understand the changes underway is remarkable. Today, old industry firms including Walmart, General Electric, and now Ford, General Motors, and Toyota have a regional presence, as they feel that being aware of the disruptions being transmitted from the region are critical. Other ICT firms ranging from Samsung and Lenovo to SAP and IBM have substantial regional operations as their business models are threatened by the TBOs being explored in the region. Effectively, these firms find it necessary to be there to understand the changes emanating from the region. For entrepreneurial firms, the region is even more attractive as there are so many assets in the region upon which small firms can draw. As result, young firms from around the world are drawn to the Bay Area.

The ultimate lesson of SV is that there is no single lesson, but rather its success was a remarkable confluence of serendipitous events, individual and collective locally embedded action, an accommodating and, at times, prescient state that made a number of decisions that had positive effects on the development of SV, but had, perhaps, less socially beneficial effects on the entire nation’s political economy, in terms of issues such as income inequality, privacy etc., global leadership in a number of particularly fecund technologies, a remarkable concentration of brilliant individuals, global-class research universities, and corporate R&D laboratories, a set of financiers whose success was dependent upon encouraging Schumpeterian innovation driven by opening and populating entire new economic spaces, a blind faith in the benefits to be derived from new technologies, a willingness to work extremely long hours sacrificing work and family life balance, and an ideology of valuing technical brilliance, monomaniacal pursuit of the new new thing and “going for it.” All of these together produced a particular configuration or regional recipe is likely not reproducible anywhere else, but which may have lessons for other regions especially as the ICT industries increasingly define the space of human and economic action.

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