# LOCAL KNOWLEDGE:
# INNOVATION IN THE NETWORKED AGE

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The ubiquity of information makes it easy to overlook the local character of innovative knowledge. Nowhere is this local character more overlooked yet paradoxically more evident than in Silicon Valley. The Valley persists as a densely interconnected innovative region though its inhabitants loudly proclaim that the information technology they develop renders distance dead and place insignificant. It persists, we argue, because of the local character of innovative knowledge, which flows in social rather than digital networks. The locality of innovative knowledge highlights the challenge of developing other regions for the modern economy. Should these abandon traditional local strengths and strive to become another Silicon Valley? Or should they concentrate on their traditional strengths and rely on Silicon Valley and the other established high-tech regions to provide the necessary technology to survive in the digital age? We argue that they should do neither, but instead develop new technologies in service of their existing competencies and needs. Finding new ways to address indigenous problems is the right way, we believe, to tie to the region expertise, talent, and capital that might otherwise be lost to the lure of existing high-tech clusters.

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## They come

Intriguingly, a book written at the height of the dot com boom and claiming to be the "defining portrait of young people in the whirl of an information revolution" (Bronson, , 1999: 1) begins:

> By car, by plane, they come.

Where did "they come" to? To Silicon Valley—the ill-defined area that stretches from north of San Francisco to south of San José, California. Even though if the rent for a garage, the mythical site to locate a startup, cost more than for a luxury apartment in most towns, even when $1 million for a house only bought a "tear down", even while dot com was turning to dot crash, "they" continued to pour in.

Who came? Young hackers, engineers, evangelists of new media, MBAs, and other digital economy hopefuls. These came to stay. Other more sober figures came to visit. Heads of state, ministers of economics, prime ministers, and whole chambers of commerce came. These came not to stay. But, just as the young hopefuls came looking for the source of personal wealth, the dignitaries came looking for the secret of civic, regional, or national wealth.

And why did they come? Because Silicon Valley is still, if not the absolute center, then one of the most significant nodes in the "wired," the "digital," the "networked," or most simply the "new" economy, a concentration of inspired ideas, astounding wealth, and the means to turn the former into the latter. Even as it shakes off the excesses of the dot com boom, the Valley, which is once again surviving a downturn

and outliving rumors of its death, endures as a robust powerhouse for knowledge and wealth generation.

Is it surprising that they came? Perhaps not. Almost century ago, the great British economist Alfred Marshall (Marshall, 1916) explained how this sort of "localization" happens, tracing examples back to the Norman Conquest of England in 1066. He noted that, though logic might tell competitors to stay away from one another, people involved in similar trades set up their workshops, factories, and outlets side by side. A particular city would specialize in steel. A particular town would host rival carpet weavers. A particular street would hold all of a town's flower shops. More recently, the U.S. economist Michael Porter (1998) has shown how such "industrial clusters" still thrive—for everything from furniture, golf clubs, and leather fashions to formula-1 engines.

And yet, there is a surprise. For, if Marshall was right in his analysis, he was wrong in his predictions. He argued that "Every cheapening of the means of communication alters the action of the forces that tend to localize industries" (Marshall, 1916:273). Drive down the costs of communication, Marshall assumed, and the reason to congregate will disappear. Others have reached similar conclusions. The futurist Alvin Toffler (1980) predicted that new communications technologies would doom the inner city and promote the rural "electronic cottage." With better communication, everyone would leave office buildings and factories to work at home and leave cities to work in the country. Similarly, Marshall McLuhan (1962) famously foresaw the global village, where new media would make not only cities but also countries irrelevant. The business journalist George Gilder (1989, 2000) likewise argued that digital technologies would produce a society of self-employed entrepreneurs working alone. Sweeping all such arguments into a single grand claim, Frances Cairncross (1997), an editor of London's

*Economist*, announced that, with modern communications technologies, distance was effectively "dead." No longer would people have to get together to work together.

The means of communication have been cheapened beyond Marshall's wildest imaginings. The media and their technological infrastructure have gone far beyond what Toffler and McLuhan ever conceived when they spoke of "electronic cottages" and "global villages." The glass-fiber Gilder used as his crystal ball is mostly in place. Yet still "they come." Not just anyone. Many of those that come are the very people responsible for dramatically cheapening the means of communication. These are the people who, more than anyone, know how to master the distance-killing technologies and so, presumably, distance itself. And yet, it seems, to assert that distance is irrelevant, they need to congregate. So, while chanting that distance is dead, they process from the corners of the world to one small, ever more crowded, ever more polluted spot between San Francisco and San José.

**Information paradoxes**

Most of the claims that distance is dead assume not only the ubiquity, but also the centrality of information. Information is seen not only as a necessary, but also as a sufficient condition for learning, work, and life itself. So, the argument goes, if you can get information anywhere, then you can learn, work, and live anywhere. In this view, the information age, unlike the industrial age, gives no advantage to proximity. The marginal cost of the reproduction of information is almost zero: once the initial piece of information has been produced, further copies cost next to nothing. Its marginal costs of distribution are also close to zero: once the infrastructure is in place, a "bit" travels around the globe for much the same cost as it crosses town. And as it a non-rivalrous public good, for someone to acquire information, nobody else has to give anything up.

Given these characteristics, information technologies undoubtedly do contribute to globalization. Managers can find the necessary information to control production, oversee distribution, and affect consumption regardless of where or how far apart these processes occur—particularly if what is produced, distributed, and consumed is itself information. People on one side of the globe can, in principle, work closely with those on the other side. Customers can chose among competing products from around the world. Theoretically, then, the case for the death of distance is strong. And yet, downtowns grow denser, self-employment falls, digerati cluster, consumption remains surprisingly local, and high-tech locales thrive. Indeed, in the second edition of her book *The Death of Distance*, Cairncross (2001) concedes that in fact "distance is far from dead."

Why not? Those who make the sort of arguments we have outlined implicitly embrace the information theory that was famously laid out by Claude Shannon and Warren Weaver (1964). But theirs is a mathematical and engineering theory—a theory that, as its authors explicitly note, is indifferent to matters of meaning. But information is not indifferent. Or rather, all information is not. The word *information* stretches all the way from Shannon and Weaver's interests—the stuff of bits, bytes, and computers—to human knowledge, the stuff of human understanding. The former interests may conveniently ignore meaning, judgement, and interpretation. To the latter, they are essential.

Unlike machine information, human knowledge shows some paradoxical features. It can resemble computer information, travelling easily and quickly. Hence corporate "knowledge officers" suffer nightmares worrying about proprietary research leaking out of their corporation. Yet human knowledge can drive knowledge officers just as crazy for the opposite reason. Some important information can prove quite difficult to move even within the corporation. A former CEO of Hewlett-Packard (HP) once ruefully

remarked, "If only HP knew what HP knows." There was, he felt, significant useful knowledge in the company, but too often the people who needed it either failed to find it or, if they did, were unable to make use of it.

Furthermore, sometimes the same knowledge appears both "leaky" and "sticky" simultaneously (Brown & Duguid, 2001). The knowledge necessary for the development of the personal computer, for example, developed at the Xerox research centre in Silicon Valley but would not travel into the rest of the corporation. It simply stuck. Yet the same knowledge leaked out of the company, providing a highly lucrative resource for Apple, Adobe, 3Com, other Silicon Valley firms, and eventually Microsoft. Distance was undoubtedly a factor. While Xerox's research center was in the Valley, its engineering and manufacturing plants were elsewhere in the United States. This radically new knowledge wouldn't travel that far. It was intelligible to close-knit groups in the Valley, even groups outside Xerox. But it was contrastingly unintelligible to people far from the Valley's milieu, even people inside Xerox.

Simultaneous stickiness and leakiness is probably a defining characteristic of emerging knowledge (the sort of knowledge that is critical to innovation). Once such knowledge is standardized, embedded in products (such as the personal computer), and part of widely acknowledged practices (such as desktop publishing), it can travel as far as those practices are spread. But until then, while it reflects little more than imagined uses, it is intelligible only among close groups who are all pushing at the same frontier and imagining the same inchoate practices.

So, unlike digital information, the sort of knowledge that has fuelled growth and wealth in the modern economy neither spreads nor scales very easily at its most productive stage. Consequently, innovative knowledge and knowledge-based growth, like industrial growth, still cluster. They cluster because innovative people tend to cluster, staying close to those who share their visions, understand their insights, and

advance their ideas. Moreover, around such clusters what Marshall (1916) called "subsidiary trades" cluster, too. Silicon Valley doesn't only contain technology gurus on the frontier of their trades. It contains intellectual property lawyers, venture capitalists, product designers, and so forth, each at the frontier of their "trades." These, too, are innovative. But they also reinforce the localness of innovative knowledge.

If you want to start an innovative company in the Valley, you don't have to look far to find the complementary expertise to help you. The lawyers are used to working with emerging intellectual property issues, the venture capitalists with untried business plans. Try to start such a venture in a "green field site" or rural "electronic cottage" and you can no doubt find lawyers and bankers. But they too are likely to be green as to the challenges and demands of radical innovation. They may know how to work with established ventures, but not how to establish new ones. (Even regions that have a venture capitalist industry in place often find there is little appetite for the important but risky, first-round, seed funding.) Instead, you will probably find yourself on daily flights to places like the Valley. Here professions develop in tandem with other innovators. Here lawyers and venture capitalists provide more than legal advice and money. They act as mentors and even as instigators, distributing expertise gained from working with the last startup to those trying to build the next one.

So innovation still has geography. And that geography still has consequences. Not only knowledge and people cluster. The wealth generated by that knowledge clusters, too. Hence countries show steep differences between poor and increasingly disempowered regions and rich and increasingly powerful ones. Silicon Valley and Redmond, Route 128, the M4 corridor outside London, Helsinki, Paris, and Tokyo form a far-flung global network. But each of these regions is in many ways closer to these other far-flung clusters than to regions that are geographically their neighbors. Indeed, in this regard, geography remains powerfully stubborn, marking persistent difference not only

between rich and poor countries, but also within rich countries, between rich and poor regions. Worldwide and even nationwide data about dramatic, growing Internet access often only help to obscure equally dramatic growth in regional disparities.

Nonetheless, even if these new regions do not cure old problems of disparity, in the new economy, as in the old, innovative clusters remain important engines for productivity growth and wealth creation. Countries and regions that cannot imitate them in some form will undoubtedly fall behind, whether in regional, national, or global terms. Consequently, as we noted above, politicians come to the Valley to try to discover its secret.

**What is the there there?**

What should these visitors look for?

First, they need to see that the inputs to the Valley's success are highly diverse and yet the outcomes highly systemic. The region's strength, that is, comes not simply from new entrepreneurs, but from the new and the established together. The former include the volatile dot coms, such as Netscape, Yahoo!, Google, or Ebay. And the latter include large corporations such as Hewlett-Packard, Varian, Intel, 3Com, Sun, or Cisco. The two work in tandem. For example, established companies will initiate start-ups (sometimes directly, sometimes indirectly by seeding ideas with entrepreneurs or venture capitalists) to test new possibilities. If the test works, they may later acquire back what they started up or spun off. The established also provide a springboard where entrepreneurs hone their skills before going out alone. And they provide a safety net. Silicon Valley thinks of itself as a culture of high-wire risk. But as the dot com world has shrunk, it has been noticeable that established firms have provided a safe haven to which those who left to make their fortune but returned when they lost one.

Second, besides the firms in the valley, the major research universities, Stanford and Berkeley make major contributions. Hewlett-Packard, Sun, and Yahoo, among many others, were spawned principally from Stanford, while BIND and the TCP/IP stack (essential to the running of the Internet) and BSD Unix (now essential to the Macintosh) were developed at Berkeley. Both universities continue to provide much of the regions intellectual creativity and to bridge the conventional gap between town and gown. And more than the research universities contribute. Versatile educational centers—Santa Clara University, San José State University, San Mateo Community College—adapt themselves quickly to the demands of their local region in ways that institutions outside the milieu find impossible.

The electrical engineering, computer science, or business schools of these schools are staffed with teachers who also work in the companies of the region. But other departments also make valuable contributions. The tie between arts and the Valley is both direct and indirect. Directly, Hewlett-Packard and Pixar provide examples of enduring links. Hewlett-Packard was transformed into a major technology company when Disney used its oscillators to make the movie *Fantasia* in 1940. Fifty years later, Disney has again turned to the Valley, forming a partnership with Pixar, who have blended technological and creative skills in highly acclaimed animated movies. Indirectly, the humanities and social sciences as well as the arts have added significant creative spark to and analytical insight into how people in the Valley think.

After studying together, students from these different schools pass out into Valley businesses to work in different firms. In so doing, they form dense social networks that that may span corporate boundaries. It is along these boundary-spanning, interfirm networks that ideas often leak. If one firm cannot make something out of promising ideas (as Xerox failed to do with the PC), these networks will take them to others where they will be used (as a fledgling network of PC designers did with Xerox's ideas). Though

individual companies may lose in such transactions, the region gains, with these networks acting as effective conduits to both inventive producers and efficient consumers of ideas.

So third, as this leakiness may suggest, visiting dignitaries should look on Silicon Valley as an "emergent property." It needs to be understood not at the level of the individual participants, but at the level of their joint interactions. In effect, the Valley is not a collection of isolated organisms, but an interdependent ecology built around a particularly responsive kind of knowledge. As in all robust ecologies, there is a base that provides widespread nourishment for established organisms and niches for new ones to develop. And as in ecologies, in the Valley too failure at the level of individual species may nonetheless be beneficial to the ecology as a whole. It can be important to rate success at the level of the Valley collectively rather than simply firm by firm.

But fourth, visitors should realize that this is not an entirely self-organized ecology of micro-organisms running wild. Some parts are. Other parts are more purposefully farmed. In particular, the valley has benefited from visible hands of government and economic organization as well as from the invisible hand of the market. The Department of Defense, NASA, the National Science Foundation, the Small Business Administration, and fiscal policy have all contributed to making the Valley what it currently is, even if their presence is less strongly felt today than in the past. Most other successful regions have found the helping hand of government important for getting under way.

And fifth, as the changing role of government intervention reminds us, visitors should also understand that, like all ecologies, the Valley has a history. It did not spring to life with a bunch of bright young technicians working on silicon processors. It grew over time, from the development of radio telegraph technology with Federal Telegraph Company before the First World War, the loud-speaker technology of Magnavox, and the pioneering precision instruments of Hewlett-Packard, through the transformation of

silicon at Intel, the personal computer industry developed by Xerox PARC, IBM, Apple, and the networking innovations of 3Com and Cisco, to current cutting-edge developments in optical communication, biotechnology, micro-electrico mechanical systems (MEMS), and the dot com successes (and failures) of recent years. Over time, the Valley wove together related firms, formal institutions, informal networks, ancillary services, and different technologies into a dense resilient environment.

**Finding a silicon goose**

All this makes it hard to talk about imitating Silicon Valley. Do you start at the beginning and hope to develop quickly along a similar, lucrative path? Or do you try to leap to the end of the path? Both seem futile. If Silicon Valley began to emerge in the shadow of the First World War, then the path is some 90 years long. On the other hand, to leap to the end entails producing research universities, entrepreneurs, venture capitalists, primary and subsidiary trades, large and small firms, and dense interconnections all at once. And both cases assume that an ecology can be uprooted and transplanted without problems.

So perhaps the critical question to ask first is should other regions seek to develop into Silicon Valley? Some critics argue that seeking a silicon goose to lay your region a golden egg is a mistake. Regions should develop their own competencies rather than try to acquire alien skills. If some make plastics and others silicon, the two can trade to mutual advantage. Comparative advantage can get you ahead if silicon skills do not.

There's clearly a lot of good sense in this argument. It is folly to drop what your region's skills to clutch at silicon straws that will only take you into direct competition with far more robust and experienced Silicon Valley. But there are also problems with trusting to comparative advantage. The classic discussion of the concept comes from the Anglo-Portuguese economist David Ricardo (1971, first published 1816), who based his

ideas on Anglo-Portuguese trade. If the English developed their industry (particularly textiles) and the Portuguese their agriculture (particularly wine), Ricardo argued, then the two could trade with one another and both would gain. History suggests, however, that the English gained far more from the benefits of industrialization than the Portuguese did from the benefits of agriculture. The English ended up with both industry and agriculture (and industry in service of agriculture), while the Portuguese had only their agriculture. In the long run, the Portuguese were both comparatively and absolutely disadvantaged.

Today, comparative advantage would most likely turn on the distinction between digital informational products, on the one hand, and material goods, on the other. The comparative argument would then suggest that those regions good at making material goods should simply trade with those with digital expertise. Yet, like industrialization, the digital side of this pair has clear advantages over the material, and the gap between the two in terms of productivity and wealth creation is likely to widen. The digital side can expect significant increasing returns—here costs fall and profits rise with every unit sold. In isolation, the material side, however, is likely to face decreasing returns, which produces the opposite effects.

**Taking knowledge for granted**

Moreover, this easy division between informational products and material goods is perhaps becoming as problematic as the one between industry and agriculture. People working with material goods need informational support, just as agriculture needs industry. And the gap between the two is not as easily spanned as some on the informational side assume. Indeed, some of the problems that beset the dot com world arose because people trivialized the challenge of responding to the local knowledge that is deployed on the "other side." (Unable to see the local character of their own

knowledge, it is not surprising that the digerati could not appreciate the local knowledge of others.)

A *Wall Street Journal* article of March 2001 (Gomes, 2001) presents the example of Mr Hunt, a produce (fruit and vegetable) broker in Oakland. He stood as an intermediary between farmers in California's rich agricultural sector and California stores. In terms of information and economics, what intermediaries do appears relatively simple—and ripe for disintermediation. Web-based exchange, it was assumed, could do what Hunt's firm did with ease. If Hunt did not join such an exchange, he was warned, he would become obsolete. What the theorists overlooked was the density of local knowledge involved in good brokering. Produce brokering isn't, as the experts assumed from a safe distance, simply a matter of coordinating information. It involves working with complex, situated knowledge. What counts as "fresh," "ripe," or "firm" depends not on any fixed definition, but on the season, the varietal, the supplier, and the customer. Hunt's job was to bring suppliers and customers together despite their different perspectives. Any system that ignored those differences would have problems. Despite trying various Web-based exchanges that were offered, Hunt finally went back to his old ways. His firm survives. Most of the exchanges do not. The moral of the story is not, however, that Hunt returned to being an anti-technology "Luddite." Far from it. Both before and after the exchanges, Hunt was a heavy user of technologies—computers, phones, faxes, and so on. The moral of the story, rather, is that making technology that allows people like Hunt to do his job involves looking at his job not with an abstract understanding of information, but with Hunt's understanding.

**Use it or lose it**

Consequently, the right strategy for the informated economy may be neither trying to develop a Silicon Valley and relying on competitive advantage, nor trying to ignore those

skills and relying on comparative advantage, but in the challenging task of straddling the gap between the two. This will involve bringing together abstract information and situated knowledge and balancing the rising forces of increasing returns and the sinking forces of decreasing returns. No easy task. And yet there are two reasons that this may be a productive way to respond.

First, historically innovation has always been significantly "recombinant." That is, innovators do not simply exist in blank space conjuring up new, unprecedented ideas. Rather, many innovators do their best work bringing together old problems and new solutions, existing technologies and unexpected applications, or different types of technology. Indeed, one of the most popular software programs today developed by matching new technological possibilities with a detailed understanding of practices that date back at least to the middle ages. Quicken developed from a detailed investigation of how people keep accounts and how they may be supported in doing so.

Second, the economy seems to be developing beyond the current focus on information technologies in isolation to informated materials in use. Smart materials—physical objects that have embedded information-processing capabilities are likely to become increasingly important. Consequently, combinations of materials science, biotechnology, and computer science are pushing Silicon Valley itself in new directions. The underlying insight that innovation is not a pure and abstract art, but a combinatorial one, opens new possibilities for more conventional regions, too. Here it is possible to bring together new and old, the unprecedented and the established, into promising new combinations. To make "smart" buildings, cars, clothes, or furniture that people can actually use will take as much knowledge about the way the conventional objects are used in everyday life as it will about the abstract processing of information. Consequently, the sorts of skills that have kept regions producing cars or furniture or plastics firmly in the old economy may give them particular advantages in the developing

hybrid economy—neither all digital nor all material. "Old" regions can bring to this hybridization process their understanding of materials and their markets.

This vision of the future suggests less a polarization of society than a symbiosis. It does not turn around a simple distinction between old and new economy jobs (any more than around a distinction between material and informational products). Rather, the two may continue to merge into one, combining each other's strengths, rather than one trying to supersede the other.

Such combinations have significant advantages over attempts simply to imitate Silicon Valley. As we suggested earlier, leading high-tech regions form a global network of equals. Less powerful high-tech regions tend to join as subordinates—less like links in a network than like spokes around a hub. As a result, they revolve at the will (and mercy) of the leading regions, working on problems delegated from the hub but which have little or no local significance, losing jobs when the hub slows down, and so forth. Such delegated work can be as mind-numbingly dull as it is precarious. This dullness marks a sharp contrast with Silicon Valley, where excitement drives many people to do what they do. Unsurprisingly, then, such subordinate regions lose their brightest prospects, whose skills give them mobility, to the more powerful regions. Silicon Valley, which as first mover didn't face this problem, continues to draw people from subsequently developing regions to the excitement it has created.

So the problem for developing regions is profound. Train a highly skilled workforce without the rest of the ecology and you may find (as India has done) Silicon Valley siphoning your workers off with higher pay, more interesting work, stock options, and all the attractions of an established ecology. (Silicon Valley firms have a large appetite for workers that they don't have to train themselves and that, because of their temporary visas, can send back home if they make difficulties.) Similarly, develop a venture capital industry and you may find (as Taiwan has done) that the capital raised is

invested in regions like the Valley with an established record rather than in their own nascent high-tech sectors.

Regions, however, that develop their high-tech skills in service of their own needs and interests, by contrast, may avoid these problems. They offer challenges of intrinsic interest to technologists and intrinsic worth to local capital funds. Brazil, for example, has developed a biotech sector around its particular needs as a major agricultural exporter. It recently managed to decode the genome of the fruit fly borne bacterium that has plagued fruit growers around the world (including California). As a result of this and other successes in genetics research, Brazilian labs are now being invited into partnerships with labs in North America and Europe. No longer are they subordinate, deputed to carry out tedious tasks of no indigenous interest. Instead they are equals and as a consequence, the Brazilian biotech sector is starting to develop its own momentum.

Ideally, of course, countries need more than a single national center of excellence and the hope that its local growth will, over time, spread benefits more widely. A country needs several, rival clusters from the regional economies within a country, thereby creating rival poles for capital, skills, and knowledge—poles that, while creating competition, nonetheless help keep the benefits in the country. Brazil, for example, has also created a rival cluster around its remarkably successful aircraft industry. With work of such high standard and intrinsic merit, Brazil has developed a rate of retention of its best scholars that is the envy of all developing countries. Even those who go overseas to study return to Brazil, rather than stay in the United States or Europe. Local problems and local skills are thus helping to develop robust regions not around distant hubs but around local knowledge.

**The lure of the local**

In sum, the idea that information is global can be seriously misleading. Its local features have significant implications for regional development. Training workers for the nebulous global economy may be counterproductive. They may easily become fodder for the better-developed regions to pick up and discard at will. Watching brains drain to other countries is the painful way to become aware that information, after all, does have geography. But the drain can perhaps become a fountain by encouraging the best brains to address the informational needs of the local economy—from entertainment to infrastructure, from agriculture to manufacturing, from private enterprise to public works. These may tie the material and the informational, the old economy and the new, decreasing and increasing returns, and people and capital into local, rather than global networks in regionally productive ways.

This sanguine view entails first recognizing that in a knowledge economy, just as in an industrial economy, distance is not dead. And it is not dead because, in the development of innovative knowledge, social networks play a major role. These may include the informal networks of workers in similar companies. They may also include the networks of academic cadres that bind scholars as much to their discipline as to their companies. They may include the arts, the social sciences, and the humanities as well as science and technology. They may include networks of "subsidiary trades": lawyers, venture capitalists, and designers. In some economies, they may include unions. (These are not a feature of Silicon Valley, which has proved highly resistant to them. They are, though, a feature of the high-technology economies of northern Europe. Scandinavian unions, like guilds of old, play significant part in raising skills, spreading knowledge, and in directing government intervention.) In all, the networked economy is not just a technological network carrying digital information, but a social network supporting the creation of human knowledge.

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