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Geographical Proximity and the Transmission of Tacit Knowledge

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Abstract. Since at least the publication of Pigou's "The Economics of Welfare" (Pigou 1932) and Arrow's seminal article on "Economic Welfare and the Allocation of Resources of Invention" (Arrow 1962), most economic theorists have argued that "knowledge is expensive to produce but cheap to reproduce." Following Hayek (1948) and Polanyi (1958), scholars working in the tradition of Austrian economists have dissented from that view by pointing out that if a good deal of knowledge, such as the price of gold, can be easily codified and transmitted, much important knowledge is tacit and dependent on the "particular circumstances of time and place." One line of work that supports the Austrian view can be found in economic geography and neighboring disciplines where the geographic concentration of economic activity is explained, among other factors, by the importance of geographical proximity between individuals in the transmission of tacit knowledge.This paper therefore argues that the spatial agglomeration of economic activities constitutes a powerful vindication of Austrian insights.

Key Words: tacit knowledge, agglomeration, economies, knowledge spillovers

JEL classification: O18, R11.

> An art which cannot be specified in detail cannot be transmitted by prescription, since no prescription for it exists. It can be passed on only by example from master to apprentice. This restricts the range of diffusion to that of personal contacts, and we find accordingly that craftsmanship tends to survive in closely circumscribed local traditions.
> —Michael Polanyi (1958, p. 52)

Since the publication of Pigou's "The Economic of Welfare" (Pigou, 1932) and Arrow's seminal article on "Economic Welfare and the Allocation of Resources of Invention" (Arrow 1962), most economic theorists have argued that knowledge is expensive to produce but cheap to reproduce. Following Hayek (1948) and Polanyi (1958), scholars working in the tradition of Austrian economists have dissented from that view by pointing out that if a good deal of knowledge, such as the price of gold, can be easily codified and transmitted, much important knowledge is tacit and dependent on the "particular circumstances of time and place," and therefore cannot be acquired by traditional market research procedures or transmitted by advertising or long-distance learning. Austrians have therefore always emphasized the importance of non-material components to goods, such as ease of availability, quality of service and the reputation of a supplier; and that the "know-how" used in problem

solving is often of a "personal" nature and is costly to acquire, transfer and use (Boettke 1994).

One line of work that supports the Austrian view is found in economic geography and neighboring disciplines,[1] where many authors explain the regional agglomeration of firms by, among other factors, the fact that some knowledge is expensive to acquire, to reproduce, or to transmit over long distances. Learning and innovation are thus held to be interactive and non routine processes requiring a good deal of face-to-face communication because such contact is the richest and most multidimensional available to humans. And even though experienced people can be relocated and modern transportation makes it easier than ever to carry people from one location to another, there is still no better way to have frequent interaction between individuals than by close geographical proximity (Cornish 1997, Gertler 1995, Graham 1997, Saxenian 1994, Von Hippel 1994).

The purpose of this article is twofold. First, the reason that the localization of firms over geographical space has always exhibited recurring patterns will be explained by providing, albeit very briefly, a number of explanations for these patterns that are not related to the communication of tacit knowledge. The second is to illustrate how the geographical concentration of economic activities, by allowing certain individuals better opportunities to tap into tacit knowledge than individuals located elsewhere, can provide an economical advantage. Even though this essay will borrow heavily from case study material that can be found in the recent "regional clustering of innovation" literature, it is written from the point of view of a methodological individualist rather than from more traditional geographical perspectives, such as can be found in the "regional innovation systems" literature for example (Malmberg 1996, 1997, Storper 1995). The concept of an "industrial district" will therefore be used as a generic term for the description of the spatial clustering of related economic activities, but it should not be inferred that the conclusions and main policy recommendations of the proponents of this literature are shared by this author. In essence, the position taken here is similar to that of Macdonald (1992:55): "Individuals work for firms and much of their value to their employers is related to network membership, but membership is fundamentally a personal matter transcending firm boundaries and even firm loyalties." In this perspective, Silicon Valley is no different than any other unplanned geographical concentration of industries, whether in manufacturing, financial services, entertainment, etc. (There will nonetheless be a number of references to Silicon Valley in this essay to illustrate that even in the industries most likely to use sophisticated means of communication, physical proximity still has some important benefits.) What has come to be known as the "regional knowledge-complex" (i.e. universities, research institutions and other science-based knowledge supply) will also not be singled out, for some recent research has shown that, contrary to the argumentation found in much of the theoretical literature, university-type research does *not* constitute a significant factor in the innovation processes of firms (Gordon 1993, Larsson and Malmberg 1999).[2]

1. Traditional Economic Analysis of Geographical Space

The location of industries is a topic of obvious practical importance (Parks 1982). For more than a century, many geographers and economists have developed theories relating to the

spatial agglomeration of economic activity in response to three empirical observations: 1) a large portion of world output is produced in a limited number of highly concentrated core regions; 2) firms in similar or related industries tend to co-locate in particular places; 3) both of these patterns seem to be sustainable over time (Malmberg 1996). Probably the most ancient written source on the topic is a book published in the middle of the thirteenth century that described such geographical concentrations of producers all over medieval England (Marshall 1986 [1920]:223). Some contemporary American examples of regional clustering include Massachusetts' Route 128; New York's diamond, financial, advertising and multimedia districts; Minneapolis' medical equipment industry; Detroit's car industry; Hartford's insurance industry; North Carolina's and West Michigan's furniture making industry; Chicago's future industries, etc. The most well-known and studied case is, however, California's Silicon Valley.

Such geographic concentration of related firms is usually explained by positive externalities known as "agglomeration economies," i.e. the notion that firms can achieve greater efficiency and flexibility when they operate in the context of a local economy where they can draw on larger pools of labor, materials and services. Agglomeration economies are of two types, those relating to the agglomeration of firms of the same industry in one area (localization economies) and those relating to the agglomeration of various industries in one location (urbanization economies).

Localization Economies

The geographical concentration of related firms is in no way new or limited to "high-tech" industries, for one can still observe industrial districts made up of printing, jewelry and cutlery firms, among others (Figures 1 and 2).

Such geographical agglomerations of firms can be found at the city, neighborhood, or street level, usually depending upon the capital requirements of each industry. Thus one can find automobile design studios located all over South California, although mostly in incipient agglomeration in Orange county and (to a lesser extent) Ventura county (Scott 1996),[3] whereas the fur districts of Montréal, New York, London and (to a lesser extent) Frankfurt are located in the heart of their cities (Julien 1991).

It has also been noted that metropolis are typically patch works of such "industrial districts." Thus citizens of Los Angeles can boast of districts specializing in the production of film and television programs, recording, advertising, printing and publishing, textiles and clothing, furniture, jewels, processed food, and biomedical products (The Economist 1997, Scott 1996) (Figure 3).

The scale of an industrial district is, of course, subjective. It can thus be argued that Los Angeles' entertainment district is made up of a number of sub-clusters, such as animated films, special effects, photographic processing, sound recording, television programming, video production, film editing, and many others (Scott 1996:312). One the latest districts to have appeared in the Los Angeles area is "Toytown," located next to the garment district. Home to more than 100 businesses, most of them owned by Chinese immigrants, its emergence has been attributed to the head of MegaToys, Charles Woo, who is said to have encouraged other toy companies to move close to him in the early 1980s in order to share suppliers and meet sudden market demand (The Economist 1997).

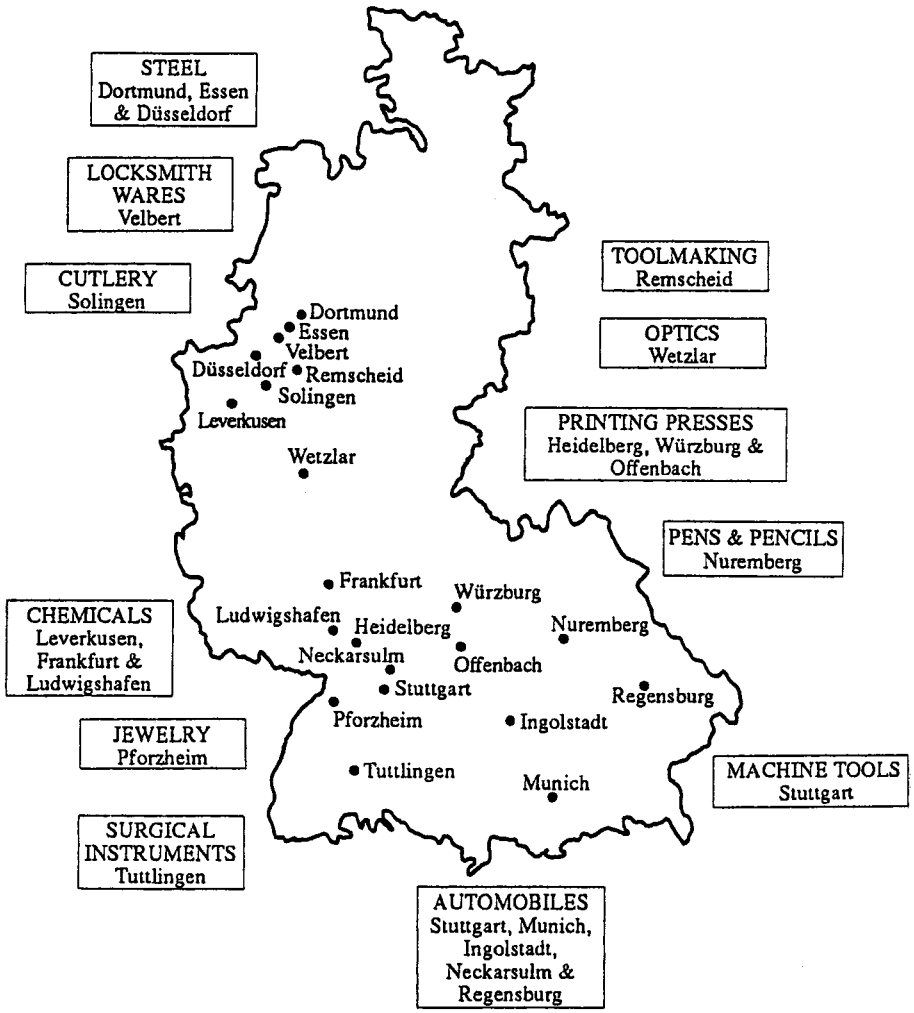

Figure 1. Some German industrial district. Porter (1990:156)

Following Marshall (1986 [1920]), most analysts usually highlight the fact that firms benefit from their location in such "industrial districts" by sharing the fixed costs of common resources such as a pooled market for workers with specialized skills, the development of specialized inputs and services, and technological spillovers. As Marshall's contemporary Charles S. Devas wrote:

> This kind of concentration is what is called *localisation of industry* in the strict sense. The grounds for it are manifold. There can be better technical training where many of the same trade are congregated together, more mutual help, greater likelihood of inventions, more use in common of markets, means of carriage, and machinery, and

Figure 2. Some Italian industrial districts. Porter (1990:155)

> greater growth of *subsidiary industries*, such namely as supply materials and utilise refuse, to do which for a single factory would not be worth while.
>
> And in modern industry, especially where machinery is elaborate, it is a great gain to have close at hand those who can at once repair or replace any damage or loss of that machinery. Hence, although localisation is conspicuous in past economic history, different villages or towns having each as their specialty some particular trade, it is more conspicuous now when not merely thousands but millions of customers are supplied from one center (Devas 1901:98–99).

It has also been emphasized by many writers that the geographical concentration of related firms balance cooperative and competitive forms of economic activity, leading to greater innovation and flexibility, while also facilitating new business formation, the development

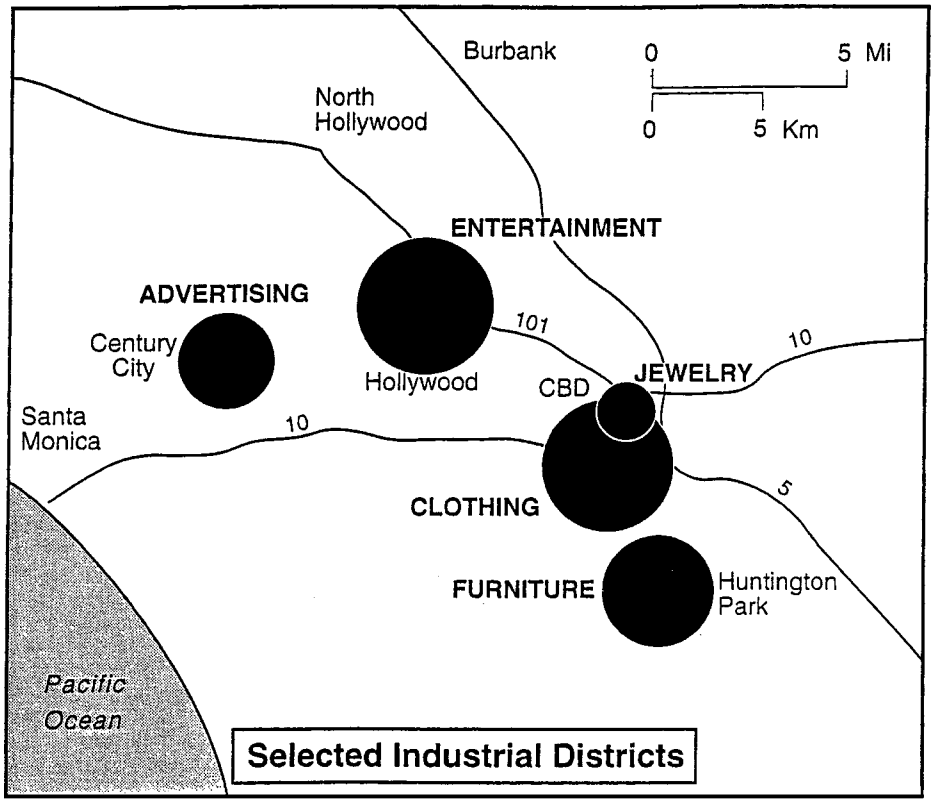

Figure 3. Some of Los Angeles' industrial districts. Scott (1996:312)

of trust relationships and easier access to start-up capital[4] (Desrochers 1998, Malmberg 1996, 1997, McEvily and Zaheer 1997, Patchell 1996).

Urbanization Economies

Each firm faces concerns whether to make or to buy some inputs, but in a modern economy no firm can avoid buying inputs from diverse suppliers. Cities are therefore the hosts to many businesses supplying various pieces of equipment or services to diverse industries. The spatial agglomeration of various activities will, for example, allow the operation of airports, hospitals or cultural activities, as well as law, accounting and various consulting firms of the first order. If the benefits of a greater division of labor between firms are well understood, geographical proximity between a supplier and its customers further increases the speed of delivery while allowing the possibility to make daily deliveries, to save the buyer warehousing space and to reduce the risk of running out of a needed item while it is being shipped from a long distance.

On the Persistence of Geographical Agglomeration

The geographic concentration of economic activity has existed since at least the Neolithic period (Mellaart 1967) and cities have never stopped getting larger in size ever since. But like today's "telecommunications revolution" prophets of the "Death of Distance" and the "End of Geography" (Cairncross 1997, O'Brien 1992), most commentators have always tended to believe that recent advances in transportation and communication technologies are rapidly making agglomeration economies obsolete. Thus even Alfred Marshall believed that the railway, the printing-press and the telegraph were working against geographic concentration. As he wrote: "Every cheapening of the means of communication, every new facility for the free interchange of ideas between distant places alters the action of the forces which tend to localize industries" (Marshall 1986 [1920]:227). Another contemporary of Marshall, S. J. Hall (1900), wrote that the use of modern machinery tends to lessen the importance of a specially skilled labor supply and that the more an industry becomes automated, the more its location is likely to become independent of its supply of labor.

Economic history indeed teaches us that as an industry expands and becomes ever more sophisticated, the standardized production of geographically concentrated industries tends to be relocated elsewhere, either closer to consumers or to cheaper input sources (Haig 1926). But history also teaches us that as long as firms in an industry remain innovative, the forces of economic concentration usually remain much stronger than anticipated. And the overwhelming fact about past trends is that a general reduction in the transportation costs of both goods and information has always tended to encourage geographical concentration rather than discourage it. As Devas observed at the turn of the century:

> [The nineteenth century] revolution in transport by the introduction of steamships, and above all of railways, has ... produced as a portentous effect the concentration of population in large towns instead of being scattered in villages or homesteads over the country. This disproportionate growth of towns is one of the most striking features of the nineteenth century, and is seen in every country where the new methods of transport are much used... The reason for the modern growth of great towns is simple. It is not that cities are much more attractive than before, but that the new means of communication have removed the obstacles to the operation of that attraction (Devas 1901:100).

The tale of a modern Hong Kong entrepreneur, Patrick Wang, illustrates the current relevance of this observation. Wang's family business, Johnson Electric, makes tiny motors that go into electric toothbrushes, CD players and many other things. As his business grew, he relocated most of its production facilities out of Hong Kong, but in the nearby Pearl River Delta so that its staff of about 200 Hong Kong design engineers could keep in close contact with the factories. This did not prove satisfactory, however, for the problem of distance loomed larger every day. As Mr. Wang said: "Two weeks in a container on the sea was bad enough in the days of telex response times... It is no use now" (The Economist 1998:16). He therefore had no choice but to invest in a new factory in a Mexican *maquiladora* to be closer to his biggest market, the United States. There he pays wages about three times

those he would be paying in China, but this is part of the price to be close enough to his customers.

There are thus a number of reasons for the persistence of geographical concentration of economic activities. The case for the continued importance of static factors such as agglomeration economies, transportation costs and timeliness is even stronger if one looks at service-based firms.[5] After all, trading foreign exchange over telephones and computer terminals can theoretically be done anywhere in the world—and is indeed done throughout the world. And yet, as the financial district of New York and the City of London can attest, the most innovative service firms are more than willing to pay some of the highest office rents in the world in order to be based in particular locations. What is it then? The unique feature of geographical proximity that is usually pointed out as the main reason for this is the possibility of frequent face-to-face communication between individuals. One therefore needs to move from static explanations that are based upon the reduction of transaction costs owing to geographical proximity to more dynamic accounts that emphasize processes of learning and innovation.

2. Geographical Proximity and the Communication of Tacit Knowledge

Geographical Agglomeration and Service-Based Firms

Modern economies are, by any account, based on services ranging from activities requiring no particular know-how to others demanding constant innovation. Contrary to the assertions of some authors who identify as new trends the relocation of standardized services (O'Brien 1992), service firms have always exhibited locational patterns similar to manufacturing firms (Haig 1926). The more specialized and up-to-date a service activity is, the more likely it is to be concentrated in large cities. The more standardized it becomes, the more it tends to migrate toward customers or inputs (Coffey 1992, Coffey and Shearmur 1997, Coe and Townsend 1998). But as traditional transportation costs/supply explanations cannot be invoked in the case of service activity, most contemporary writers stress another important dimension of urbanization. As Coffey (1992:142) writes: "In particular, it is the cost of maintaining face-to-face contact between the producers, on the one hand, and their inputs and markets, on the other hand, that is potentially the most expensive element of intermediate-demand service production: this expense can be significantly reduced by spatial agglomeration." Similar comments were made in 1926 by the economist Robert Haig on service firms concerned "with matters of great import, not with petty transactions" in the financial district of New York.

> The Wall Street district, filled with high buildings, is dedicated to "finance"..."Finance," as here used, includes the exchanges, the banks, the insurance offices, as well as various professional groups, such as lawyers and accountants. Largely through the control of loanable funds, there is centralized here the function of coordinating the business activities of a very wide area.
>
> The exercise of this managerial function of coordination and control is at first glance singularly independent of transportation. It does not require the transfer of huge

> quantities of materials. It deals almost exclusively with information. What is all-important is transportation of intelligence. The mail, the cable, the telegraph, and the telephone bring in its raw material and carry out its finished product. Internally easy contact of man with man is essential. The telephone is prodigally used, of course, but the personal conference remains, after all, the method by which most of the important work is done. Conferences with corporation officers, with bankers, with lawyers and accountants, with partners, with fellow directors, fill the day. The work is facilitated when the time of the men whose time is most valuable is conserved. The district must be conveniently accessible and must be at the heart of the system of communication. It must be arranged so as to give the greatest possible ease of contact among men whose presence is desired in arriving at decisions... The closely interrelated and inter-dependent group in Wall Street find their functions sufficiently facilitated by a central location to make it worth their while to outbid all others for the spot they want (Haig 1926:427–428).

The point here is that the crucial knowledge in any innovative industry is not standardized information, routine patterns or the public knowledge of science. It is also often not the kind of data that can be obtained through quantitative market research involving the analysis of secondary data or statistical survey research, nor from qualitative methods such as focus groups and interviews. What is really useful is what is new, what are the latest changes and the specialized know-how that individuals have acquired through practice and mistakes. There have not been, however, detailed studies of the processes by which geographical proximity is useful for innovation in services. One has therefore to go back to manufacturing, where many analysts have documented how much economic actors need to interact with other people to obtain both approval and useful information that is tacit and has not yet been published or documented anywhere (Senker 1995, Von Hippel 1988, 1994, 1996). As Cornish (1997:147) writes: “Alternatives to market research are the norm for complex and costly products with small and specialized markets, particularly products sold to industrial buyers. Here personal contact between producers and users is most prevalent, and secondary or statistical data is least likely to be available.” And again, much information that could be amenable to non-personalized modes of communication is usually not available without the establishment of trust relationships between individuals. As a Silicon Valley executive pointed out: “If I developed something that I thought was key to my business growth, the last thing I would do is give a paper on it ”(Rogers 1982:116). It will now be argued that being located in one area instead of another can often make a difference, at least over time, in acquiring significant amounts of uncodified knowledge.

Geographical Proximity and the “Particular Circumstances of Time and Place”

Even though most of the suppliers and customers of a firm might be located outside of its regional setting, being located in the middle of an industrial district typically allows creative and entrepreneurial individuals to absorb thinking processes, ways of talking and ways of doing things by interacting closely with other knowledgeable people. It also makes it easier for entrepreneurs, managers and technicians to avoid being caught off guard by

unanticipated breakthroughs by allowing them to monitor emerging technologies closely and to find answers to their questions more rapidly. This phenomenon explains at least partly why large companies often have a number of "listening posts" or branch offices in places like Silicon Valley, Boston or Manhattan. In a famous passage of his Principles of Economics, Alfred Marshall described the nature of this "industrial atmosphere:"

> When an industry has thus chosen a locality for itself, it is likely to stay there long: so great are the advantages which people following the same skilled trade get from near neighbourhood to one another. The mysteries of the trade become no mystery; but are as it were in the air, and children learn many of them unconsciously. Good work is rightly appreciated, inventions and improvements in machinery, in processes and the general organization of the business have their merits promptly discussed: if one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the source of further new ideas (Marshall 1986 [1920]:225).

To compete effectively in many industries, it is therefore not enough to look at trade journals or computer screens, to communicate via telephone conferences or to monitor plants in remote locations via modern communication means, for even though new information technologies sometimes improve long-distance interactions, they are still far from being an adequate substitute (Graham 1996). Being where your partners and competitors are is still an important asset. Socializing with them allows the opportunity to ask for advice or for a specific bit of information that has not been formalized ("Could this device be modified to do this?," "How does it react under such and such conditions?," "Have you ever tried something like this?," "Do you know somebody who could do that?," "Did you ever do business with them?", "What is going on over there?, " What kind of technologies are they using?," "Why are they no longer doing business with them?," "Why did he quit his job?," etc.). And even though it is true that a firm's personnel might initially seek to limit the diffusion of its know-how, individuals often have to communicate some of this knowledge to potential users and even to competitors if they want to see their products reach the market. One of the earliest students of Silicon Valley has given the following illustration to make this point.

> An example was furnished to us by participants in the annual meetings of semiconductor engineers that were held in the early days of the industry [in the early 1960's]. During the informal exchanges that occurred at coffee breaks, over drinks, and during meals at these meetings, an engineer might learn of a new development by a competing firm. That night he would telephone an executive in his company headquarters to relay the new information and to request permission to disclose additional details about his own company's work (which would usually be granted) (Rogers 1982:114–115).

Geographical proximity also increases the possibility of useful informal encounters where one person says to a second, "What are you working on?" and where a third jumps in and adds "I know somebody you've got to talk to; I'll call you with the number." Although exchanges of this kind might happen in a pub and last less than two minutes, they may

prove to be the most productive encounter of the entire day for everybody involved.[6] It was true in Marshall's and Devas' time and earlier and it is still true today.

The story of Apple Computers is another illustration of the importance of Silicon Valley's "industrial atmosphere." Thus Steve Wozniak, the technical brain behind the early Apple computers, has often stressed the importance in his development of the Homebrew Computer Club, an information-exchange group for people interested in computers which was founded in 1975 in a Menlo Park garage. As he put it: "Getting good feedback is... important. I had the best in the world when I was developing the Apple II. When I had something, I would just take it down to the Homebrew Computer Club" (Brown 1988:228). But the Club was also a valuable source of inputs, as Wozniak also remembers:

> In the early days of microcomputers, the only two products to come out with color were the "Color Dazzler" from Cromenco and the Apple II. And it turns out that we both came out of the Homebrew Computer Club... The same day I bought my first 6502 processor at the Wescon computer show in San Francisco, we had a club meeting in Palo Alto. Everybody came to that meeting. Some people from a company called Sphere brought a minicomputer connected to a color TV. They showed the first color graphics that probably most of us in that room had ever seen or only imagined that a computer could produce.
>
> I just sat there thinking, I can't believe I'm seeing something like this. Probably, those people from Cromenco were sitting there just as I was: thinking what an unbelievable thing it was. For about two minutes everyone sat quietly, watching this TV draw color circles. It was just one of those things. It's hard to explain. But if that hadn't happened to me, the Apple II probably never would have had color—or even been an Apple II (Brown 1988:224).

The story of how the windows-and-mouse interface "migrated" from Xerox Palo Alto Research Center (PARC)[7] to Apple computers is also illustrative. As is notorious in digital circles, Xerox's executives failed to capitalize on the innovation created by some of their employees. The mouse rather became an important commercial asset when Steve Jobs, the marketing brain of Apple, saw it demonstrated on a tour of PARC in 1979. He borrowed the idea, hired some of its creators, and went on developing the Macintosh (Mann 1998:59).

Another advantage of being located in an industrial district is that it is often easier to identify general problems in an industry and to offer innovative solutions to a host of firms instead of a single one. High-speed wireless Internet connectivity's pioneer Kenneth Jackson is illustrative of a more general phenomenon. After having made a lot of money in the cellular phone industry and moving out of the industry, Jackson then adopted a very innovative way of finding entrepreneurial opportunities. He produced and hosted his own cable access TV program ("Internet TV") and took copious notes as he interviewed high-tech movers and shakers throughout Silicon Valley. As he put it: "One of the common denominators that kept coming up in the conversations was [a shortage of] bandswitch. I figured I could solve that problem: If the wire are congested, let's just do it wirelessly" (Teague 1998:121). Jackson therefore developed his own technology that ended up costing his customers only about

half of what they were used to pay for the alternative ISP while also drastically reducing setting up time from 60 to 90 days down to 48 hours. After having found some customers, Jackson says his business really took off after a year. “Instead of going out and [talking to] people and doing the whole cold-calling thing, the relationships that I’d built [over time in Silicon Valley] started bringing referrals. [Now] people are calling us and saying “Hey, sign me up.” (Teague 1998:121).

Uncodified knowledge is also important in terms of human relationships. Knowing the name of a customer’s secretary or the best way to deal with a truculent supplier can often make a difference in a business partnership or in a producer supplier relationship. And again, it can be reasonably believed that geographical proximity facilitates the absorption of this kind of knowledge, for it can hardly been obtained in ways other than face-to-face communication.

Geographical Proximity and the Transmission of Personal Knowledge

Geographical Proximity and Creative Work. While every business keeps blueprints, log entries, productivity charts, manuals, operating instruction, statistics, product specifications and a host of other documents that are more dependable than human memories, much of the creative thought and know-how of workers is not easily reducible to words, either because it is hard to codify or simply too expensive compared to the expected returns. This usually means that “knowledge creation” does not equate setting up computer databases because the critical information about a business is lodged in the head of its employees. Information systems and databases are enabling tools, but successful, creative work still requires personal contact with those possessing the effective know-how. As engineer turned historian of technology Eugene Ferguson has noted:

> I was fortunate to learn early that an engineer’s intelligent first response to a problem that a worker brings in from the field is “Let’s go see.” It is not enough to sit at one’s desk and listen to an explanation of a difficulty. Nor should the engineer refer immediately to drawings or specifications to see what the authorities say. The engineer and the worker must go together to the site of the difficulty if they expect to see the problem in the same light. There and only there can the complexities of the real world, the stuff that drawings and formulas ignore, be appreciated (Ferguson 1992:56).

Geographical deconcentration can therefore not be accomplished easily for activities dealing with creative work, mainly because long-distance communication is still inadequate for the continuous and detailed engineering or technical adjustments that are needed in the course of technological creation. If physical proximity can usually be achieved quite easily within a firm by moving some employees to the same production facility, it often has more drastic geographical implications for interfirm collaboration. And as a number of studies have pointed out (Senker 1995, Von Hippel 1988), because in-house development is always time-consuming and expensive, technical people developing a new product usually have a high incentive to rely on people working in other firms to diagnose and respond to situations because relevant know-how is usually not available in-house or in publication. But although engineers and technologists meet other technical people at various meetings, trade shows

and conferences, and despite the fact that the cost of air transportation has been going down in recent years, it is usually much more convenient to ask for help in the staff of nearby firms. As a former manager of DEC's workstation group in Silicon Valley pointed out:

> Physical proximity is important to just about everything we do. I have better relationships with Silicon Valley companies that I have even with my own company [DEC] because I can just get in the car and go see them. The level of communication is much higher when you can see each other regularly. You never work on the same level if you do it by telephone and airplane. It's very hard to work together long distance. You don't have a feel for who the people are, they are just disembodied voice...
>
> An engineering team simply cannot work with another engineering team that is three thousand miles away, unless the task is incredibly explicit and well defined—which they rarely are. If you're not tripping over the guy, you're not working with him, or not working at the level that you optimally could if you co-located. (Saxenian 1994:157).

Of course, any information exchange process between possibly rival firms demands a high degree of reciprocity. Geographical proximity often greatly facilitates the building of bonds of trust between people, because of the frequent interactions and long-term contracts or commitments between people that it allows in both working environments and social activities.

Geographical Proximity and User—Producer Interactions. The importance of product users in the innovative process, as opposed to producers, has been well documented in recent years. Thus in most industries, users and not manufacturers, create most innovations (Slaughter 1993, Von Hippel 1988). They are also in a unique position to tell producers what is wrong with their products or to make suggestions as to what they should be working on (Gordon 1993, Macdonald 1992, Von Hippel and Tyre 1996). At any rate, carrying all the useful knowledge from a user's production facility to a producer's development lab is simply too expensive to be undertaken in most cases (Von Hippel 1994). As Cornish (1997:147) writes, valuable knowledge is therefore usually acquired "through the day-to-day activities of the firm's management, R&D, marketing, and production personnel when they communicate directly with customers or learn about market needs indirectly through other parties (distributors, R&D alliances, and the like)." Motorola's CEO Robert Galvin describes the importance of user-producer interactions in a most convincing way:

> Some years ago, an associate prompted me to visit with our customers more regularly. I decided that I would spend one day each month with a different customer. Our representatives arranged it so that I could talk in detail to the people who engineered our product into theirs and who bought, expedited, assembled, inventoried, repaired, installed, serviced, and paid our invoice... The most evident organization/authority factor we discovered was that every deficiency I discovered and reported had been known by our sales and applications representatives for months and even years. The field people had communicated these deficiencies and cajoled their bosses, laboratories, and factories [but to no avail]... Second, my example was a role model to other officers,

> many of whom had never made a customer call. Some of them returned from their initial experience virtually born again as they integrated the customers' expectation into their departments. It is inconceivable to me that a scientist, engineer, personal manager, senior accountant, or officer of any kind can achieve total customer satisfaction without understanding and having a feel for customers firsthand. The quality, effectiveness, and productivity of customer/supplier communication—people to people—can be doubled and even tripled (Galvin 1996:141–2).

Once again, if a truly interactive and widespread relation between producers and users' employees seems desirable, a strong case can be made that physical proximity can only facilitate this process. And indeed it seems to have been the case historically that physical proximity between the producer and user of machinery has often been indispensable (Rosenberg 1970). Reporting the results of a survey he conducted among Silicon Valley firms, Gordon notes that:

> The primary role of client linkages in innovation is reinforced by the emphasis firms gave the contributions of marketing personnel to innovation *within* the firm. Although the entrepreneur, R&D staff, and to a lesser extent, technical employees were predictably central to in-house product conception and development, two-fifths of firms went out of their way to emphasize the impact of actors not mentioned explicitly in the survey's list of potential contributors to innovation: almost universally, marketing constituted the source emphasized (Gordon 1993:42).

Gordon (1993:47) also adds that "in the hierarchy of material and information outputs connected with innovation, clients are considered in a league virtually by themselves as the most important source of extra-firm knowledge for product conception and development by Silicon Valley high technology SMEs..." One interesting result from Gordon's survey was that even though local markets are relatively insignificant for most of the firms surveyed from the standpoint of sales volume, local customers appear to play in many cases a more important qualitative role in the process of conceptualizing the new product and in the development phase. Size and sectoral differences in the salience of customers within the Silicon Valley region were negligible in that respect. Gordon also notes, however, that the importance of local clients varies directly with a firm's experience with innovation, for firms developing a new product for the first time strongly emphasize the input of local clients to product conception, whereas firms with a lot more previous experience with innovation were much less dependent upon input from local clients. Larsson and Malmberg (1999) report similar findings among Swedish machinery producers, and so does Cornish (1997) for Canadian software producers. Cornish (1997) also provides a more detailed review of the literature where it is pointed out that most authors writing on this topic seem to agree that greater distance between producer and market usually reduces the quantity and quality of information acquired, while entailing much greater amounts of money in terms of knowledge acquisition. The importance of geographical proximity is, however, not limited to advanced and complex manufacturing operations. Gertler (1995) and Desrochers (2000), among others, report similar results for seemingly simpler technologies. Some evidence thus indicates that, unless the information transmitted is relatively standardized, new telecommunication

technologies still cannot be substituted adequately for face-to-face contact between users and producers of new technologies.

Geographical Proximity, Job Mobility and Information Exchange

One of the most important factors behind the spread of technical knowledge is workers' mobility between firms (Taylor and Silberston 1973:211). It is beyond any doubt that an urban setting greatly facilitates this process, if only because workers do not have to move their families and lose their friends between jobs. Again, the phenomenon is in no way new, for as Long (1991:874) tells us, the practice was common among 15th century Venetian glass makers where "secret knowledge of craft processes provided significant advantages." As one story goes, Giorgio Ballarin, employed by a long-established glass making family, broke into the place where his employers kept their secret formulas one day in their absence. He stole the formulas and brought them to a rival glass maker. He thereby was able to marry that glass maker's daughter and acquire a furnace of his own.

Once again, Silicon Valley is the most studied case of workers mobility in an industrial district. As Saxenian (1994) has noted in much detail, these networks defy sectoral barriers, for some individuals move easily from semiconductor to disk-drive firms or from computer to network makers, while others move from established firms to start-ups (or vice-versa) and to market research or consulting firms. As a result, secrets and staff have always been hard to keep in Silicon Valley since the "traitorous eight" walked out of Shockley Laboratories in 1957 to found Fairchild Semiconductor, which itself eventually spawned 37 different firms, including Intel. Reminiscing on that period, Gordon Moore, the founder and current chairman of Intel Corporation, wrote in 1996:

> During [the late 1960's], some top management problems developed at Fairchild Camera and Instrument Corporation, the parent company of Fairchild Semiconductor. Two chief executive officers left within a six month period in 1967, and the board of directors established a three-man committee to manage the company while they were searching for a new CEO outside the company. Bob Noyce, a vice president and the most logical internal candidate for the position, was clearly being passed over. Given the circumstances, Bob decided that he would leave Fairchild. At the time, I was director of research and development, running the laboratory at Fairchild. I had become increasingly frustrated with the difficulty involved in transferring new products and technology into the manufacturing organization of the company as the semiconductor division grew and became more successful. It seemed that it was much easier to get new technology picked up by groups that would spin off and start a new company than it was to transfer it to our sister operations... The areas of technology that we were working in offered a wide variety of product opportunities. This, combined with the development of the venture capital industry, led to a large number of new companies being formed out of Fairchild...
>
> When I heard that Bob Noyce was leaving, I considered my own situation and decided that it would be best for me to make a move before the new management arrived than after. I told Bob that I, too, would leave and that we should try to find something to

> pursue together. When I told Dr. Andrew Grove, the assistant director of the laboratory, that I was leaving, he indicated that he too would like to join any operation that we were starting. After leaving Fairchild, Bob Noyce informed Arthur Rock, a venture capitalist friend from the days of the formation of Fairchild Semiconductor Corporation, that we were planning to start a new company. Bob asked if Arthur would take on the task of raising the necessary capital... Arthur undertook the task. He called several of his friends and on the basis of his recommendation got immediate commitments for the start-up financing (Moore 1996:58–60).

Even though there is much to be said on behalf of spin-offs, some commentators have argued that the resulting high turnover rates might create significant continuity problems for innovation because much of the knowledge possessed by an innovation team is not coded in ways that permits easy transfer of information to newcomers. As one innovation student puts it: "Telling about it is not only time-consuming: it is indeed no substitute for having been there" (Angle and Van de Ven 1989:674–675). It has also been argued that workers' mobility impedes innovation, for innovators realize that some of their ideas will be imitated without compensation, a situation that will slow down their investment geared toward generating new products and processes. In short, as some authors have argued, "personnel raiding" and spin-offs lead to a vicious circle of under investment and depreciation in the value of labor (Florida and Kenney 1990).

Despite some corporate grievances, there is no strong evidence that the high worker mobility of Silicon Valley has been counterproductive, for strong competition and available labor resources seem to have made up for it. As Gordon (1993:41) inferred from a survey and follow-up interviews he conducted, firms that don't innovate simply go bankrupt for "competitive pressures are felt keenly on all sides" and "the overwhelming majority of firms considered innovation imperative for survival in rapidly changing information technology economies." There are also many reasons to believe that firms competing with each other are more likely to generate a business climate where people are more willing to try new things or alternative ways of doing old things to differentiate themselves from their competitors than would be the case in an isolated firm (Porter 1990). It is also usually agreed upon that this high worker mobility is a good thing for the workers. Thus when asked about that topic, Marcian Hoff, the inventor of the microprocessor, answered that "moving around from company to company very definitely helps put things in perspective. You don't want to move too much, but it can help. I think one of the pluses is this spirit of trying new things and the willingness on the part of venture capitalists to back new products" (Brown 1988:305).

It has also been pointed out that firms losing competent workers have a ready-made counter strategy: to hire back their departing employees. Leaving a firm does not preclude a later return. After six months or a year in the laboratory of a competing firm, a microprocessor engineer may be even more valuable to his previous employer than when he left; and so he may be rehired by the original firm, in part to gain what he has learned from the competition. In fact, his original firm may have previously allowed the professional to go in order to rehire him later. As Rogers (1982:116–117) writes, "Head hunting in the Silicon Valley can be a Machiavellian game of Byzantine strategies and counter strategies, with the exchange of technical information as one of its purposes."

Of course, hiring a competent employee from a competing firm is usually motivated by the desire to obtain technical information. Things may not always be that simple, however, as modern economies are characterized by countless forms of nondisclosure agreements stipulating that employees leaving a firm will not transfer any secret information. Yet, as Taylor and Silberston (1973:116) have noted, absolute secrecy where know-how is of the sort that can be carried in the memory is usually not insisted on. Rogers (1982) has also noted that hiring employees from competing Silicon Valley's firms that have signed such agreements is nonetheless quite helpful, for even though the former employee cannot disclose specific product information to his new co–workers, this does not prevent him from transferring valuable information that surrounds the product or process he previously worked on. Rogers (1982:116) thus writes that there might be, for instance, 100 different ways to approach the technological solution to an important problem. A departing employee might know that 20 of them were tried during the previous 12 months in his former firm and found to be unsuccessful. Information about paths not to take therefore becomes extremely valuable to his new firm.

Geographical Proximity and the Combination of Previously Unrelated Knowledge

There is much evidence indicating that geographical proximity is an important asset for the transmission of tacit knowledge within a particular industry. Yet the essence of innovation is the combination of previously unrelated pieces of knowledge. As Ayres (1943:113) puts it: "The history of every material is the same. It is one of novel combinations of existing devices and materials in such a fashion as to constitute a new device or a new material or both." Innovation therefore often involves the collaboration of individuals possessing previously unrelated types of knowledge. Because most of the time these individuals do not even share key concepts, there is typically a need to develop a common language in order to coordinate search and development procedures. As Feldman (1994:21) points out: "Individuals, especially those with different expertise from diverse backgrounds have different cognitive schemata. Interpreting and synthesizing this information... involves questioning and interpretation. This is a process of trial, feedback, and evaluation that is facilitated by face-to-face communication." A speech-recognition expert gives the following illustration:

> In speech recognition, for example, some of the technologists involved include linguists, signal-processing experts, VLSI [very large scale integration] designers, psycho-acoustic experts, speech scientists, computer scientists, human-factor designers, experts in artificial intelligence and pattern recognition, and so on... Each one of these fields has very different methodologies and different terminologies. Very often a term in one field means something else entirely in another field. Sometimes we even create our own terminology for a particular project. So, enabling a team like that to communicate and solve a problem is a significant challenge. If you look at the entire company, you bring in even more disciplines: manufacturing, material-resources planning, purchasing, marketing, finance, and so on. Each of these areas has also developed sophisticated methodologies of their own that are as complex as those in engineering. My challenge is to provide a climate in which people with different

> expertise can work together toward a common goal and communicate clearly with one another (Brown 1988:243–244)

In a recent work, Desrochers (2000) provides qualitative evidence on more than 50 instances of resource combinations between individuals with different backgrounds, illustrating that the importance of this phenomenon is just as great in "low-tech" industries as in more complex endeavors. If there is thus much evidence pointing toward the importance of geographical proximity for communication between people sharing a "common cognitive ground," it seems obvious that its importance is even greater for people possessing diverse backgrounds.

A Cautionary Note on the Importance of Geographical Proximity

The case on behalf of the geographical base of innovation is strong, but it should be handled more cautiously than it often is. Other considerations, such as the fact that the owner of a business was born in or likes a particular location ("non-rational causes" as the economist Edward Ross (1896) dubbed them more than a century ago) often play a crucial role in many location decisions. Besides, it is often the case that traditional "static" localization externalities are judged more important by firm owners and employees than "knowledge" externalities. As a number of studies have also shown, the clustering of related firms in a given area is not always a sufficient condition to create decentralized processes of collective learning and continual innovation. In particular, people in industrial districts are also part of much larger national and international networks which are often significant for information flows and innovations (Cornish 1997, Hansen 1995, Malmberg 1996, 1997). Gordon's work (1993) reminds us that Silicon Valley's firms are powerfully oriented to national and international markets and that clients located outside the region are often of the utmost importance for the process of technological change. In a survey of small manufacturing firms located in North Florida, but not in a geographically concentrated industry, Malecki (1997) found that impersonal and nonlocal sources such as trade shows and trade publications stood as much more important sources of information than local business meetings and social gatherings, a finding echoed in other rural areas by Rallet (1993), Julien et al. (1994) and Joyal (1996). It therefore seems reasonable to postulate that producers will always look for the best quality/price ratio in terms of goods of services, and that the transmission of tacit knowledge relative to those goods and services is but one asset. If people in a firm are looking for the best technology available on the market, then geographical proximity is not likely to be the most important factor. Nonetheless, it is fair to postulate that, other things being equal, buyers of goods and services will tend to favor suppliers that are located closer to them for reasons that have been exposed in this essay.

Conclusion

Interaction with customers and suppliers, along with information about new technologies and ways to deal with non routine situations, is critical to business success. Even though many people maintain that such knowledge can be conveyed over screens and telephone calls, the fact remains that much useful economic information and technical know-how still

remain in a tacit, rather than explicit, form. As such, most valuable knowledge is embodied in people and is not amenable to any formalized mode of communication. One of the ways that firms' owners and employees can tap into the tacit knowledge of other people is by being located in close geographical proximity to them. As was argued, such industrial concentration favors the mobility of skilled personnel from one firm to another, makes interactions between producers and users much easier, enforces reputation effects, lessens the risks of opportunistic behavior and therefore facilitates exchange of information between competitors. In short, the localization of a firm within a relevant industrial district can enhance the capability of its employees to generate, diffuse and absorb tacit knowledge, thereby facilitating day-to-day problem solving. There is enough evidence available to argue that being exposed face-to-face and on a regular basis to demanding customers, to competitors at the cutting edge of technology, and to competent consultants increases the likelihood that economic actors will pay more attention to changing technological, community, and customer needs. Because the actions of regional rivals are highly visible and because it is usually more difficult for firms to lobby against domestic than foreign competitors, the geographical concentration of related firms often provides a better setting for permanent innovation. As Angle and Van de Ven (1989:670) have argued: "In general we suggest that *placing people in direct confrontations with sources of problems and opportunities is needed to reach the threshold of concern and appreciation required to motivate people to act*." There is thus little truth in the belief that information is expensive to produce but can be replicated at little cost, for using information from others is always much more difficult than using your own information. If geographic concentration is not a sufficient condition for innovation, it nonetheless remains a great facilitator in the transmission of tacit knowledge and a powerful vindication of Austrian insights.

Notes

1. The study of regional agglomerations of economic activities has captured the attention of a diverse array of social scientists outside of the disciplines of economic geography and regional science, such as political scientists, sociologists, strategic and international management experts, economists and public policy analysts. For recent reviews of this literature, see Malmberg (1996, 1997) and Storper (1995). For additional references, see Cornish (1997), Desrochers (1998), Feldman (2000), McEvily and Zaheer (1997), Patchell (1996) and Scott (1996).
2. The most plausible explanation for this state of affairs is that the signaling of a problem to be solved is more significant for innovative activity than the generation of new theoretical knowledge. One of the few exceptions seems to be the biotechnology industry (Zucker et al. 1998). It must be pointed out, however, that even though academic research is usually considered by firm managers to be much less significant in the creation of useful knowledge than the employees of other firms and private consultants, some firms do nonetheless maintain some ties with research institutions, but usually in the hope of attracting the best students or in some cases, as one commentator has put it, "specifically to exploit the sweat-shop contracts they would never impose on their own employees" (Kealey 1996:327). It is also worth noting that Mansfield (1995) has found that holding the research quality of a collaborating university department constant, the probability that a firm will support research at a college or university 5 miles away tends to be 50% higher than that it will support this research at a college or university 100 miles away.
3. Southern California is now a major world center in that area with close to two dozen design studios belonging to American, European, and Japanese firms. According to Scott (1996:313): "These studios draw on the two-fold advantages of Southern California as a center of skilled labor and as a post for observing the latest in car styling and fashions-another of the region's peculiar cultural obsessions."

4. It has often been said that the availability of start-up capital played an important role in the success of Silicon Valley (Saxenian 1994) and Route 128 (Jacobs 1969), but the argument is much older and is in essence that some local lenders, be they banks, venture capitalists or individuals, will get a better feel for the regionally concentrated industry than other investors. Chinitz (1961:286) made a more general statement on this topic: "Are banks in one area more receptive than banks in another area to the demands of new business and, if so, are these differences in attitude shaped by the industrial traditions of the area? I say yes, on both counts. My conviction on this point is based less on deductive than on inductive reasoning. I have been told that this is the case. Having been told, I can think of some fairly good reasons why this might be the case. When banks cater to a competitively organized industry, they are more likely to accept the insurance principle of making money, not on each customer, but on the average customer. If you have U.S. Steel or Westinghouse on your rolls, you do not have to learn to make money on the insurance principle."
5. Although, of course, the distinction between "manufacturing" and "service" firms is often arbitrary or lost in the statistical analysis of the location of activities. One of the first authors that described what would plague generations of economic geographers, urban economists and regional scientists was Robert Haig (1926:415–416): "When one begins to seek the reason for growth and decline in the center [of a metropolis], he is immediately impressed by the inadequacy of the terminology ordinarily used in discussing the problem. Broad terms such as "industry," "manufacture," "commerce," and "trade" are not well adapted to the tasks in hand. If, for example, a silk mill, formerly located on Manhattan, moves to Pennsylvania but keeps its head office and salesroom in New York, it is not accurate to say that this "industry" has left New York. What has actually happened is that there has been a territorial subdivision of functions which were formerly united in the same place, certain activities being sent to Pennsylvania and certain others kept in the metropolis. Fabrication and certain other functions have gone, but selling and many of the other functions remain. Fourth Avenue is full of establishments bearing the names of manufacturing plants, but no fabrication is in evidence. Though it is the center of the silk industry, not a loom is to be found there."
6. Macdonald (1992:54) makes interesting remarks on governmental policies toward information flows based on similar observations: "The programmes by which government policy is implemented tend to be concerned with formal information flow through institutional channels; it is difficult to devise a formal programme for informal information flow. Put crudely, governments may promote conferences and the presentation of conference papers from which relatively little information flows, but they would be reluctant to subsidise the beer to stimulate the conversations at the bar in which a great deal of information flows. Governments are generally ill at ease with information programmes anyway, preferring to deal with the tangible, and to treat information almost as if it were a tangible good."
7. PARC has often been labeled as the "fumbler of the future" because its parent company chose not to exploit many of the technologies that were developed there that were ripe for commercialization, while other companies did. Graham (1996), however, maintains that such a characterization is unfair and that despite the mouse and other similar episodes, Xerox realized great value from PARC.

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