DANISH RESEARCH UNIT FOR INDUSTRIAL DYNAMICS

DRUID Working Paper No 01-03

Dynamics of High-Technology Firms in the Silicon Valley

by

Adolfo Nemirovsky & Gabriel Yoguel
May, 2001

Dynamics of High-Technology Firms in the Silicon Valley

Adolfo Nemirovsky
Founder, XStream Logic Inc, Los Gatos, Santa Clara, California, USA. E-mail: adolfo@acm.org

&

Gabriel Yoguel
Professor, LITTEC, Instituto de la Industria, Universidad Nacional de Sarmiento, Argentina. E-mail: yoguel@mail.retina.ar

Abstract

The pace of technological innovation since World War II is dramatically accelerating following the commercial exploitation of the Internet. Since the mid 90's fiber optics capacity (infrastructure for transmission of information including voice and data) has incremented over one hundred times thanks to a new technology, dense wave division multiplexing, and Internet traffic has increased over 1.000 times. The dramatic advances in information technology provide excellent examples of the critical relevance of the knowledge in the development of competitive advantages. The Silicon Valley (SV) that about fifty years ago was an agricultural region became the center of dramatic technological and organizational transformations. In fact, most of the present high-tech companies did not exist twenty years ago. Venture capital contribution to the local economy is quite important not only due to the magnitude of the financial investment (venture investment in SV during 2000 surpassed 25.000 millions of dollars) but also because the extent and quality of networks (management teams, senior employees, customers, providers, etc.) that bring to emerging companies. How do new technologies develop? What is the role of private and public investment in the financing of R&D? Which are the most dynamical agents and how do they interact? How are new companies created and how do they evolve? The discussion of these questions is the focus of the current work.

Keywords: Technological development, R&D, networks
JEL: 031, C24, L63

ISBN 87-7873-101-1

Introduction: Local Environment, Innovation and Learning Processes.

The dramatic advances in information technology (IT) bring sharp reductions of the time for generating and implementing technological innovations into new products and generate a sharp increase in competitive pressures and strategic uncertainties. Competitiveness is not longer a macroeconomic phenomena determined by static comparative advantages and industrial infrastructure. In contrast, advantages are dynamically created and must be carefully preserved or are quickly lost. The capability of agents to generate comparative advantages depends on how knowledge is generated, processed and transmitted, and on the (economic and social) environment where agents reside (Lundvall 1992, Lall 1995).

The capability to innovate becomes increasingly important for generating comparative advantages and for reducing strategic uncertainties. Innovations may help designing new products or improving existing ones. In addition, they may bring organizational transformations and/or establish new relationships with the market. The capacity of organizations to learn and adapt to take advantage of innovations is of vital importance. High-tech firms usually generate both formal and informal knowledge as they evolve. The potential of organizations for transforming generic knowledge into specific (applicable to the production process) is vital for generating competitive advantages. On the other hand, not every agent is capable of providing adequate responses to rapidly changing technologies and business conditions. Learning processes require a minimum threshold of capacities and competencies. As we discuss below, these requirement are less critical in certain positive *local environments* such as the Silicon Valley (SV).

The local institutions, agents and the interrelation among them compose a *local environment.* The creation of competitive advantages by agents strongly influences the degree of development of the local environment in which these agents act. A local environment can be considered as a "public space" (social capital) which, when highly positive, gives rise to processes of collective efficiency (Camagni 1991, Bianchi y Miller 1994, Morgan 1995). In the SV the positive environment manifest itself in a dynamics with a diversity of agents who cooperate and compete. Interactions among these agents generate a collective tension that i) favors the development of strategies of innovation, ii) minimizes the difference between agents, iii) reduces strategic uncertainties, iv) reduces weakness of organizational cultures v) reinforces learning processes vi) provides missing competencies vii) contributes to the process of diffusion of knowledge (Camagni 1991).

In the new international scenario local environment and global economy are not opposite. The strength of globalization resides in the complexity of knowledge and in the synergy that results from competitive confrontations of different geographical areas with their own networks of agents. To measure the value of their specificities (knowledge, capabilities, etc.) local and national spaces need to be compared to others at a global scale. This confrontation may serve as catalysis for accelerating processes of conversion of knowledge from tacit to codified[1], and for generating new knowledge (Lundvall 1992,

[1] Codified knowledge includes technological and organizational knowledge that can be transferred in the market. In turn, tacit knowledge includes: i) knowledge not codified in books or

Ernst y Lundvall 1997, Rullani 1997, Ducatel 1998, Poma 1998). For example, tacit elements have a strong empirical component, thus the geographical localization has importance in the generation of this type of knowledge. The experimental, empirical and conceptual nature of learning processes helps to create tacit knowledge and also to codify it for transforming, processing and transferring it. In this way, knowledge can circulate from a context to another assuming a more universal form. On the other hand, for knowledge to be effectively applied in another context it must be de-codified (Becattini y Rullani 1997, Poma 2000, Boscherini y Yoguel 2000). This process of codification and de-codification of knowledge that relates the local and global environments is usually known as versatile integration. The Silicon Valley constitutes an example of local system of versatile integration that additionally presents two positive aspects: constitutes an advanced local system and specializes in information technology.

This work discusses the economic relevance of the SV in the West Coast of the United States, and shows the strong relation between the performance of the local firms with their previous history and with the evolution of the local system of innovation. Firms, universities, federal laboratories strongly interact among themselves and with groups of agents. In turn, agents act as connectors and catalyze the generation and circulation of tacit and codified knowledge. This work also shows the critical importance of learning processes, which become the most important competitive advantage of the area. The first section focuses on the importance of knowledge as enabler of competitive advantages. Section II discusses Silicon Valley as a virtuous local environment. Section IIII focuses on innovation and the learning process in the SV. Finally conclusions are presented.

1. Knowledge as Enabler of Competitive Advantages

The tremendous advances in information technology (IT) since World War II originated from rapid progress in three IT components: transportation (bandwidth), capacity of processing (computational power) and storage capacity (memory technology). During the last 30 years (since the invention of the integrated circuit) the processing power and storage capacity have dramatically increased giving rise to sharp reductions in the price for processing and storing of data [2]/[3]/. Moreover, in the last six years we have witness revolutionary advances in fiber optics that have increased the information transported via fiber by two orders of magnitude (a factor of one hundred).

---

manuals ii) empirical knowledge, iii) capacity of solving problems not codified iv) capacity to relate problems to analog situations. While the codified elements of the knowledge process are transable, the tacit component is firm specific, and cannot be bought in the market. It constitutes a technological/organizational competitive advantage of a firm, region or country.

[2] In the middle 60's and shortly after the invention of the integrated circuit, Gordon Moore, one of the founders of Intel proposed the following empirical law (later known as Moore's law): the number of transistors per processor duplicates every 18 months. For example, the number of transistors of an Intel X86 chip, the most common chip used by a PC goes from 29 thousand in 1978 to 7.5 millions in 1997.This number gives a good idea of the processing capacity of a chip (or the storing capacity of a memory). This empirical law has worked for over 35 years, although more recently the duplication occurs every 24 months.

[3] The ratio price vs. performance for microprocessors and memories has been improving about 50% per year during the last 30 years.

Since the mid 90's there has been an accelerated replacement of the telephone infrastructure (circuit-switched technology) for that of the Internet (packet-switching[4] technology). The explosive growth of the Internet in the last few years, and the deregulation of markets in the telecom industry significantly accelerated these changes[5] and the following trends have emerged a) convergence of the telecom (voice) with the datacom (data) infrastructures using Internet technology, b) creation of large number of start-ups that generated most of the technological innovations, c) development of strategic alliances, and d) process of acquisition, fusion and consolidation of the industry towards one-stop shopping.

The arrival of the Internet has broken the previous status quo in the telecom and information[6] markets, led respectively by AT&T for almost 100 years, and by IBM for over 50 years. In every segment new actors have emerged producing a much larger and segmented market. In fact, most of the high-tech companies that now dominate the US economy did not exist twenty years ago.[7] This dynamics takes place in an environment of high uncertainty, such that the one that "hit the target" first has a much higher reward (and risk) that those that did it in the past in a much more stable environment with a "linear" innovation processes. Agents now need to make decisions in an uncertain environment with imperfect information and limited rationality, as the neoschumpeterian framework shows.

Some of these profound transformations have highly affected the telecom industry modifying price structures and business models. For example, just a few years ago (with circuit-switched technology) the price of long distance phone calls was determined in function of duration, time of the day and distance. In contrast, in the future (with packet-switched technology) time of the day and distance may not be as relevant anymore. The phone companies, either alone or as part of a chain of providers will offer a variety of options (prices) for use of their infrastructure based on quality of service which will have as one of their components regular phone calls with the costs of calls only weakly dependent of distance. In addition, they will include other services such as interactive TV, videoconference, internet access, e-commerce infrastructure, video rental, interactive education, games via Internet, etc.

---

[4] While the circuit-switched technology establishes an exclusive communication between emitter and receptor, in the packet-switched technology the transmitted information is segmented in small packets that travel independently towards the receptor. The packet-switched technology is much more efficient for short and highly interactive communications typical of internet sessions.

[5] Notice that in standard phone technology there are two methods for establishing connections. In the inband signaling, the cable used for transmission of voice is the same as that for establishing the connection. In contrast, in the outband signaling packet-switched technology is used to establish connections.

[6] The information industry (and IBM in particular) were already disrupted by (and speed of innovation that heavily accelerated since) the introduction of the personal computer (PC) in the early 80's.

[7] These companies include Microsoft, Cisco, Intel, Oracle, America Online, Qwest among others.

Work is now related to projects that appear/disappear in the context of a dramatic reduction of the life-cycle of products, which in the area of information technology has gone from 5-7 years a decade ago to 7-8 months today. In this direction, lifetime jobs at a given company are almost gone. This is due to the fact that natural unit of work for companies are 2-3 years projects that require certain technical expertise. Team members are usually recruited both, in-house and from outside. Companies can now satisfy their critical needs with specialized personnel, who are not necessarily local, and/or take advantage of differences in workers' salaries with similar competencies but at different geographical locations. A consequence of this process is the externalization (outsourcing) extended to the entire world. Companies of the SV and a few countries such as Israel, Taiwan, India, and Ireland take advantage of these tendencies. These countries have developed highly trained personnel that participate in the dynamics of the SV (and others high-tech centers) in certain areas such as software, hardware, communications as contractors or employees of local companies, or through their own companies as providers to local companies. Also alternative forms of engagement are encouraged such as part-time contractors and telecommuting workers. Internet technology, in fact, is allowing collaboration at distance (geographical de-localization) with workers around the globe working on a single project.

The rapid transition towards an economy of information (services, software, communication, etc.) has important technological, social and legal impact. This generates challenging problems as there is not yet a well-established methodology for measuring the "value" of emerging technologies and of new products that are already dominating the USA economy. Moreover, it is not even clear yet how to profit from the Internet (e.g., Amazon.com). Finally, there is not a well-defined framework to determine the ownership of knowledge (e.g., Napster). The new information economy suffers from deficiencies of the educational system that cannot satisfy current demands nor provide training required by the industry. Finally, society is slow to adapt to changes, and although IT can potentially reduce the gap between rich and poor and provide tools for a more open and democratic society, in short term it appears that the gap is growing. These enormous challenges that must be resolved in a near future are unlikely to stop the long-term grow tendency fueled by the Internet but surely they will generate crisis and uncertainty.

2. Silicon Valley (SV) as a Virtuous Local Environment

2.1 Basic Data

The Silicon Valley (SV) is located in Santa Clara County, about 70 kilometers south of San Francisco and 670 kilometers north of Los Angeles and occupies an area of about 1.300 square kilometers. The SV's population grew almost 300% from about 0.6 million in 1960 to about 1.7 million in 1999. The cities of San José, Sunnyvale and Santa Clara concentrate almost 60% of the county. The rest of the population lives in smaller towns including Mountain View, Palo Alto (where the University de Stanford is located), Milpitas, Cupertino, Campbell, Saratoga and Los Gatos. The city of San José with a population of over 0.9 million is already the 11th largest city of the country, and the third most populated center of California. Over 25% of the population of the SV comes from other countries, in particular from Asia (China, India, Vietnam, Philippines, etc.), Mexico and Central America.

At the beginning of the 90's - before the internet boom of the last decade - the SV concentrated 13% (1.5%) of all industrial jobs of California (USA), and similar proportion of sales. These were very high percentages considering that the local population represented 6.2% of California's and 0.7% of that of the country. The local share of the US industrial jobs has increased even further in the 90's due to a much faster local growth than that of the State and of the country propelled by the Internet revolution. (The rate of growth has slowed down in 2000.) This is validated by the fact that the number of industrial jobs per 1000 inhabitants in SV duplicates that of the California and US. The economic activity of SV is outstanding not only for the development of information technology, but also because of a highly dynamical internal market. For example, per capita annual retail sales has increased by a factor of 8 in the last 30 years. In addition, job productivity was over 120 thousand dollars per worker, 50% above the US ratio.

Below we present some charts with information on the performance of the top 150 companies in the Silicon Valley at the end of the 90's. This only includes companies whose headquarters are located in the area, so it does not consider a large number of others (such as IBM, Microsoft, etc.) with large operations in SV but headquarters elsewhere. As it can be seen from Table 1, the 20 largest companies concentrated most of the sales (76%). In average, sales of the top 150 companies were about 1.265 million dollars, with large differences between the first 20 companies (7.439 millions) and the remaining ones. In spite of this strong concentration, there were over 120 local companies with sales above 100 million, giving rise to a critical mass of important agents. This concentration trends are weakened by the continuous and rapid incorporation of start-ups to the local economy.

Table 1. Distribution of sales of the 150 largest SV companies (in millions, 1998 US dollars)

Range	Number of companies	% of total companies	Volume of sales	% of total sales	Average sale per firm
Over 1500	20	12.9	148.788	75.9	7.439
1000-1499	9	5.8	10.805	5.5	1.201
500-999	26	16.8	17.562	9.0	675
300-499	18	11.6	6.526	3.3	363
100-299	76	49.0	12.041	6.1	158
less than 100	6	3.9	368	0.2	61
Total	155	100.0	196.090	100.0	1.265

Source: Own, based on Mercury News data.

Currently, SV industry is highly diversified. Main areas of activity include datacom, semiconductors and software. Semiconductors (Intel, AMD, National Semiconductors, Linear Technologies, etc.) and related equipment (KLA Tencor, Lam Research, Applied Materials, etc.) account for over 25% of the sales. Software (Oracle, Adobe, Intuit, etc.) represents about 15% and datacom (Cisco, 3Com, Juniper, etc.) accounts for over 10%. The remainder includes computers (e.g., Hewlett-Packard and Sun), memories (e.g., Seagate), Medical equipment and biotechnology (e.g., Agilent, Genetech, Chiron, Alza) and Internet (e.g., Netscape/AOL and Yahoo) among other sectors. Market segments are highly interrelated and with high variations in their scale of operations. For example average sale per firm ranges from just above 100 million (e.g., biotechnology) to over 10.000 (e.g., computers). Table 2 gives the sale distribution per sector of the top 150 SV companies at the end of the 90's.

Table 2. Distribution of sales per sector of the 150 largest SV companies (average sale in millions, 1998 US dollars)

Sector	% total firms	% total sales	Average sale per firm
Semiconductors	7.8	19.2	536
Software	19.2	14.1	1.811
Others	8.2	10.3	1.056
Telecom	1.4	10.3	182
Semiconductor Equipment	4.0	7.1	760
Others High-Tech	2.5	6.4	511
Computers	32.0	3.8	11.028
Disks/Memories	8.0	3.8	2.753
Medical Equipment	0.8	3.8	259
Internet	0.7	3.8	248
Manufacturing Services	3.6	3.2	1.504
Networking	7.0	2.6	3.611
Electronic Design Automation	1.1	2.6	566
Software Edutainment	0.5	1.3	473
High-Tech Services	0.6	1.3	630
Medicinal Labs	0.3	1.3	330
Biotechnology	0.1	0.6	135

Source: Own, based on Mercury News data.

2.2 Origin of The Local Environment

The SV was an agricultural region, with a small agro-industrial activity that processed and distributed food until the 30’s. Frederick Terman, an engineering professor from Stanford University had a big impact in the creation and development of the earliest high-tech firms in the area. In fact, Terman is known as the "father of the Silicon Valley" as he actively worked for the creation of networks involving private firms, Stanford University and the Government.

The creation of Litton Industries in 1932, of Hewlett-Packard in 1937 and of Varian Associates in 1948, all of them with strong relationship to Stanford signaled a dramatic change in the evolution of the local economy then moving toward a high-tech future and also marking the beginning of the end of the agricultural economy. This emerging high-tech industry greatly benefited from the World War II demand of electronic equipment (radar, electronic systems, electronic devices, etc.). The new companies established an informal business environment that contrasted with that of the East. Main characteristics included a strong reliance in technological innovations, minimization of bureaucracies and emphasis on community outreach. In addition to local firms the SV benefited from the installation of large laboratories by leading companies headquartered in the East such as IBM, Westinghouse, Philco-Ford and Sylvania in the 50's and 60's.

It is of paramount importance the creation of Fairchild Semiconductor, the first semiconductor plant to produce transistors. The main impact of Fairchild has not only been the technological innovation of producing transistors, but the generation of a large number of "Fairchildren", high caliber engineers that left the company to start their own companies. Many of the largest semiconductor companies in the SV today had "Fairchildren" as founders. This flourishing activity generated a very high demand for engineers stopping the "brain drain" towards the East, and later on inverting the flow. In the history of the SV, Fairchild is seen as a university that formed hundreds of engineers that later established their own companies [8]/. This role of Fairchild in the 70's is replicated by Apple in the 80's and early 90's, with the Apple children founding several multimedia and Internet companies.

After contributing to the World War II effort from Harvard, Terman returned to the West Coast in 1946 as a dean of the School of Engineering and actively continued his unfinished project to transform the now SV in a center of excellence initially trying to catch up with the East Coast. As before he emphasized the interconnection between business and high technology, and the role of university research to solve technological problems. To accomplish these goals he contributed to the creation of several institutions for strengthening the interaction between academia and industry including: i) *Stanford Research Institute*, which focused in applied research and very close collaboration with local industry, ii) *Honors Cooperative Programme*, that established a bridge between academia and industry, and among other activities provided a program to train employees of local companies in new technological advances and, iii) *Stanford Industrial Park*, one of the first industrial parks of the country encouraging local companies to place their facilities in a large area own by the university and rented to local companies. Military contracts during the 50's contributed to the expansion of the park. Already in the 50's Stanford had a number of Ph.D. students in Electrical Engineering comparable with that of MIT. At the end of the 60's the SV was already known as an important center of electronic and aero-spatial industry

At the beginning of the 70's and due to the large impact of the semiconductor industry in the local economy, the region began to be known as the Silicon Valley. In fact, SV hosted 40 out of the 45 semiconductor plants installed in the US between the end of the 50's and the mid-70's. This large concentration of high-tech firms favored the development of spin-off and start-ups, and the emergence of an important market for venture capitalists. In the mid 70's there were about 150 high-tech companies in the region and over 100 thousand people working in the high-tech industry. The local dynamism generated an environment where companies were created independent of military contracts as source of financing. The excellence of this environment was only equated by that of the Boston area (around Highway 128). There, the most dynamic company and engine of the region was Digital Equipment (DEC) which focused in minicomputers. On the other hand, there was a very important cultural different between the East and West Coast firms [9]

[8] Among the best-known companies founded by "Fairchildren" one must mention Intel, National Semiconductors, AMD and LSI Logic.
[9] These differences are the focus of an excellent book of Saxenian (1994). See references.

While the East coast companies were mainly financed with military funds promoting secrecy and relative isolation of the firms, the SV received a much smaller fraction of military and government spending. Survival skills in rapidly changing technologies and assurance of private funds required strong interaction and collaboration among local firms. In addition, the local geography and the physical proximity of firms helped to develop both a formal and informal communication among companies and other local organizations.

During the early 80's several semiconductor products manufactured in the SV (memory chips in particular) became commodities, and Japanese companies began dominating large fraction of the market. This started a deep recession both, in the East Coast (Highway 128) and in the SV. The worst point of the recession in the SV was reached in 1984. At this point many analysts compared the destiny of the semiconductor industry with that of the automobile industry, which, at that time, had been aggressively taken by Japanese firms.[10] The widespread opinion then was that the network system of the SV was not strong enough to resist Japanese competition. The initial response of the local companies was to associate the Japanese comparative advantages with the lower relative salaries paid by Japanese firms. It later become clear that the advantage was not in lower salaries nor in government protection but in the synergy of the collective action of enterprises and other private and public organizations, and to the reduced cost of credit that the Japanese firms enjoyed.

How did the SV react to this serious crisis? The semiconductor industry at that time consisted not only of the production of semiconductor memories but other semiconductor technologies were emerging. Engineers from large companies (Intel, National, AMD, etc.) reacting to bureaucracies in their organizations that slowed or stopped the development of these new technologies began to abandon their companies to start their own firms. These events together with the restructuring of large companies are the basic elements that helped the SV to recuperate from the crisis and begin a very sustained growth that continued til the end of the 90’s. By the end of the 80's the SV had already surpassed Highway 128 as the center for innovation in information technology.

In 1976 Apple Computers is created and then delivers two revolutionary products: i) Apple II introduced in 1977 is the first personal computer (PC) that receives massive acceptation giving rise to the highly dynamic PC industry, and ii) the Apple Macintosh in 1984 that brought the technological advances that PCs are utilizing still today (graphical interface, mouse, icons, menus, windows, etc.). Steve Jobs and Steve Wozniak founders of Apple quickly became folk heroes in the valley (and later the rest of the world). This is the origin of a culture of admiration of young entrepreneurs and new technologies and that inspired many young people to consider technology as an exciting career. Probably the biggest revolution of Apple Computers has been to convert the PC in a tool of massive use. In turn, Apple introduced a new philosophy in the valley combining

[10] In this period Japanese investors acquired the Rockefeller Center. This event was considered by many as a symbol of US decadence.

engineering elements with a strong artistic flavor, and creating a culture with hippies/yuppies ingredients.

The effects of the crisis of the 80's were harsh and lasting. This affected the confidence of the SV about its potential for growth (which before the crisis was thought to be unbounded). In addition, it generated a critique to the excessive bureaucratic tendencies in the large firms. On the other hand, this did not affect the open culture, the practices of cooperation among diverse agents and the notion that not success is a learning opportunity rather than a failure. In 1994 Netscape Communications is created to commercialize the web browser. This created the industry of the Internet launching the SV and then the rest of the world into the most dramatic revolution. In the 90's the Internet economy began to dominate the valley economy providing a recovery of the spirit of the 60's and 70's that had been lost for almost a decade. The new industrial structure that has been generated is much more diverse than that of 2 decades before, and includes not only semiconductors but other industries such as software (databases, CAD tools, games, etc.), internet, biotechnology and communication (see Table 2).

Progress (of the SV and of the high-tech industry) is not linear. In fact, crisis and restructuring are integral part of their dynamics. Several factors explain the new crisis that started in the year 2000. Main factors include very high valuation of high-tech companies with price to earning (P/E) ratios sometimes more than 10 times above typical values before 1994, doubts about the capacity of dot-coms to earn money (e.g., Amazon.com) and, more generally, uncertainty about how to commercially exploit Internet's huge potential. The 2000-2001 crisis initially affected dot-coms (which are just the most visible but small component of the Internet, a very complex system) but later propagated to other high-tech sectors. This crisis should not be understood as the end of the growing cycle fueled by the Internet revolution, which is dramatically transforming the economy and society. Instead, it should be viewed as (a short-term) restructuring of the industry to better adjust to dramatic and little understood changes brought by revolutionary technologies with yet to be defined business models.

2.3. Main Characteristics of the SV as a Virtuous Local Environment

What is the dynamics of the SV? How can firms quickly adapt to frenetic changes in technologies and business conditions? A positive environment that promotes collective learning, discussion and confrontation of ideas without respecting company boundaries plays a critical role in the creation and development of local firms. A positive environment encourages collaboration not only among firms related through the production chain (suppliers and providers), but also among competitors developing new technologies and opening new markets. Moreover, a positive environment promotes flexibility and adaptation to fast changing market conditions.

In first place, there is in the SV an important critical mass of firms with heterogeneous modes of production and little vertical integration with a wide range of high-tech specialization including internet, semiconductors, semiconductor equipment, computers, memories, software, telecommunication, network equipment and biotechnology. Companies compete and collaborate, learning from each other about changes in market conditions and the state of art of relevant technologies. There are both, formal and informal channels of communications within a firm and among firms. Also there is usually a strong interaction with other agents some of which may be outside the regional system (such as other non-local firms, universities and research laboratories, venture capital, etc.).

In the 60's and 70's most large companies of the SV (e.g., National Semiconductors, …) had a high-degree of vertical integration. This promoted isolation inside companies and inside departments within companies and, of course, even more among firms. In spite of that temporary "deviation" the SV has been an "open" system, it could even be thought as a "single company" with a very strong interaction among various agents. The cooperation among agents may be, for example, to guarantee interoperability among various competing technologies to enable exchange of parts/products and usually to open new markets that require a critical mass of consumers. Because of specialization and high interdependencies of a firm with its suppliers and clients, strong collaboration among these parties is a must in an economic environment where time to market is so critical that being late a couple of months could kill a product or even a company.

The flexibility of the system, standardization of sub-assembly and parts and the non-vertical nature of organizations enable the creation of modules of hardware and software produced by large number of agents. These conditions allow for design and manufacturing of new products at very fast pace and creation of new markets supported by fast learning curve. Learning processes are based on data from a large variety of new product offerings targeting similar needs, and on responses of the market to various alternatives. This "quick experimentation" of the system to test different emerging technologies, assembling a variety of products based on these technologies and rapidly bringing these products to market provides critical input to guide flexible firms (and the local system) in a highly uncertain environment.

We must note that although there are common cultural characteristics shared by agents in the local system (which make the SV valley an open, flexible and fast learning local system), there are also cultural peculiarities associated to different firms and groups (ethnical, professional, etc.). Thus, we could distinguish several "company subcultures" which differ in a) hierarchical structure of organizations b) human resource policies for retention, job rotation, etc. c) degree of "patriotism" or involvement in company's principle or doctrine.

Some companies have a strong engineering culture and place a strong emphasis in gaining employee's fidelity in spite of their large size (Hewlett-Packard, Linear Technologies). Others mix artistic ingredients with engineering excellence and tend to have a hippie-yuppie culture (Apple). Some companies have many descendents (Fairchild, Apple) which, in some cases, preserve "parent's religion" (such as anti-Gates culture of earlier Apple children). Some firms combine engineering culture with strong defense of their secrets and some control elements (such as cards registering employee's arrival and departure time, e.g., Intel). Other firms combine the "religious struggle" in the market with "political" alliances with other smaller parties (Oracle). In contrast, another companies resemble a "Roman Empire" absorbing large number of start-ups and smaller companies, but respect, to some degree, their internal cultures (Cisco) thus keeping not only their technology and IP (intellectual property) but also most of their people. This is in contrast to other more painful absorption of start-ups that retains only IP but “accelerates” the departure of critical people of the incorporated firm (such as earlier IBM acquisition policies). In most companies (if not all) in the SV, it is common that as the company reaches some critical size or stage, some of the leading technical and/or business people leave to start new companies. Some independent wealthy people may remain in their alma-matter (either in the management team or as a technical fellow) but invest money in start-ups of friends as angels or contribute to VC funds. Some of these people also become venture capitalist.

In spite of all these peculiarities, the culture of the SV rewards risk-taking individuals, but make risk-taking much easier that elsewhere. This is because no success in an endeavor is not viewed as negative but as a good opportunity for learning. In essence the culture of SV is that change is permanent and it is necessary to adapt fast to survive. Thus, even when one "dies" moving in the "wrong" direction, one's capacity of learning is very valued.

One of the main ingredients to generate such virtuous local system in the SV is the presence of large number of agents who accelerate the flow of information. Usually they know each other because of sharing activities (attend same university, work at the same company, attend same church, meet at conferences, gyms or bars [11]/) and interact in multiple ways. These agents are either individuals (venture capitalists, engineers, business people, lawyers, etc.) or organizations (professional organizations such as IEEE, ACM and APS, ethnical organizations, universities, etc.). Agents generate and transform information that a) may influence decisions within a firm or relationship of the firm with others, b) generate relationships among agents, c) destroy relationships d) created interactions among agents with incomplete and contradictory information and e) connect different levels of abstractions. On the other hand, as the number of agents is large and the type of information they transmit is heterogeneous, the resultant is a collection of signals sent to the market. Although information is distorted as it propagates, many times purposely for opportunistic reasons, the overall effect of this dynamics is to accelerate diffusion of knowledge, generate networks that dynamically may reconfigure and adapt to very fast changes in the environment, and become the source of new businesses. Arno Penzias (see Box 1) is an example of an outstanding agent.

Box 1 Dr. Arno A. Penzias, Physics Nobel Prize and Venture Capitalist

He was born in Germany 1933 and was educated in US. Dr. Penzias began his scientific career in Bell Labs in 1961 working in the field of radio communications. He is best known for his work in radio astronomy that led to the Nobel Prize in Physics in 1978.

[11] Informal discussions help agents to understand current events in the SV and in the rest of the world. In these discussions they may get revealing information, say, about their customers, competition, emerging technologies and markets.

His found a very strong evidence to support the Big-Bang theory which explains the origin of the universe. Dr. Penzias held technical and managerial positions, and helped to transform Bell Labs from a organization centered around classical academic disciplines to one focused on strategic emerging technologies. In the late 90's, he moved to the Silicon Valley. Currently Dr. Penzias is a partner of the venture capital firm New Enterprise Associates (NEA).

He says that basic research is NOT the opposite of applied research, but non-applied is, instead. Thus, it is necessary to find a good synthesis between academic (basic) research and industry needs. To this purpose, one must avoid "non-applied" research centered around writing many papers that very few read, use or understand. On the other hand, it is important to change the short-sighted view of most corporate managers whose strategic views do not go beyond a trimester and who consider research (basic or applied) a waste of time/resources.

The interactions among agents and the implicit existence of an "engineers federation" breaks with the traditional individual firms, and generates a fuzzy boundary within and among firms. Engineers that belong to the "federation" or network have a stronger relationship among themselves (sometimes in competing organizations) than with colleagues of the same firm. Similarly, large companies are many time partitioned in autonomous units, then a given unit may have a weaker relationship with another unit than with the corresponding unit of a competitor.

Then, the Valley can be thought as a single modular and flexible company with many coordinators and with high mobility, strong connection among parts but quick morphological changes (some parts break down, others join together, some appear and others disappear). The dynamics of incremental innovation is insufficient to stay in the market for too long, and formal and informal networks play a critical role in the generation and diffusion of knowledge and in the creation and destruction of business opportunities.

Radical innovations may change the nature of businesses. These innovations are generated either in start-ups or within a small innovative group in a large firm. In the SV system dynamics, radical innovations in large firms are associated with either tendency to externalize (spin-off group with revolutionary technology) or absorb from the market (acquire start-ups or their technology). This (non-linear) dynamics manifests itself in the continuous process of fusion and/or acquisition of firms. In very few cases from the radical innovation processes new companies have emerged and quickly dominated new markets (such as Microsoft, Sun and Cisco). Usually new successful start-ups (with their technological innovations) are absorbed by large companies that dominate the market and are the de-facto coordinators of the system (e.g., Cisco).

In addition to individual agents, local organizations (educative, service, professional, …) have a very important role in the generation of a local system of excellence. [12]/. These institutions usually complement each other and may benefit from strong interrelationships between private firms with state and federal funded organizations. In particular, in the last few years there has been a special effort by local and federal government in encouraging and supporting the development of high-tech start-ups. In addition, the educational organizations strongly encourage the coordination of research problems with industrial needs (see Box 2).

Box 2 Dr. John L. Hennessy. Dean of Engineering at Stanford

Dr. Hennessy is the Dean of the School of Engineering of the University of Stanford. He is also a leading figure in computer architecture. During his sabbatical in 1984/5 he co-founded MIPS Computer System, currently known as MIPS Technologies Inc.
This company specializes in the production of chips and related intellectual property using technology based on the research of his group at Stanford. He encourages faculty and students to get involved with local industry. He says that "this is the way to approach Stanford researchers to the real-world ", and that "technology thrown over the wall in form of publications many times is sterile and dies without affecting the world".

As additional examples of the dynamics between Stanford and local start-ups one must mention Andreas Bechtolsheim, co-founder of Sun Microsystems (1982), and Sandra Lerner and Leonard Bosack, founders of Cisco Systems (1984). In the mid 90's Stanford graduate students created Yahoo. The market value of these 3 companies (Sun, Cisco and Yahoo) reached about 500 thousand millions of dollars at the end of the 90's.

The local system does not accept demand passively. On the contrary, it has an active role in the development or induction of demands, which allows it to escape from commodity

[12] Among institutions and agents that have significant role in the Silicon Valley one must mention **Journals:** Mercury News, The Business Journal of San Jose; **Museums and Bookstores:** Museum of Technology and Innovation, Intel Museum and Fatbrain, a bookstore with extension activities; **Universities and Laboratories:** University of Stanford, University of Santa Clara, University of San Jose, University of California at Berkeley and at Santa Cruz , Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, Stanford Linear Accelerator Center, NASA; Organizations: Bay Area Regional Technology Alliance (BARTA), Churchill Club, MIT/Stanford Venture Laboratory, Software Developer Forum, The Jewish High-Tech Community, Chinese Software Professionals Association, The IndUS Entrepreneurs, Silicon Valley Computer Society, Graphics Art Association, Silicon Valley Computer Society, Wireless Communication Alliance, California Venture Forum, Silicon Valley Association of Software Entrepreneurs (SVASE), Silicon Valley Indian Professionals Association (SIPA), The Berkeley Entrepreneurs Forum; Professional Organizations: Bay area chapters of Institute of Electrical and Electronics Engineers (IEEE), Association of Computer Machinery (ACM), American Institute of Physics, American Chemical Society; Incubators: The Enterprise Network, Center for Entrepreneurial Development, Communication Technology Cluster, Mountain View Multimedia Incubator, Tri-Valley Technology Enterprise Center, Digital Village; Conference Centers: Santa Clara Convention Center, San Jose Convention Center; and Service Providers: PricewaterhouseCooper LLP, Emerging Companies Services, Garage.com, HiTech Law, Band of Angels.

markets, and focuses on the most profitable phases of the productive cycle. In this regard, the role of the good VCs and other agents can be viewed as promoters of new demands and connectors of the various pieces of the puzzle to solve new problems opening new markets.

In the period 1996-1999 venture capitalist (VC) in the SV financed 3076 companies of high-tech, investing about 26.500 million of dollars. More than half of this amount has been invested just in 1999. Table 3 show that the number of companies created in 1999 is 86% superior to that of 1996. On the other hand, the amount invested grew at the much higher rate of 400%. Thus, the average amount invested per company increased from 6.7 millions in 1996 to 10.8 millions in 1999. There are two important tendencies: a) there has been a relative increase of the weight of the SV in the total amount invested by venture capital in the U.S. (from 28% in 1996 to 39% in 1999), and related the this, b) there have been a very strong investment on internet projects which have reached in 1999 about 66% of the total VC investment in SV.

Table 3. Venture Capital Investment in the Silicon Valley (base 1996=100)

Year	Number of Start-Ups (1996=100)	Investment (1996=100)	% Total U.S. VC investment
1996	100	100	28
1997	120	160	32
1998	143	200	31
1999	186	600	39
2000	230	1000	38
2001 *	150*	500 *	40.*

Source: Own, based on The Money Tree, Pricewaterhouse-Coopers

- *estimated*

This tendency reached its peak in the year 2000 when VC investment in the SV was about 25.000 million. This amount is a just a little less than the total VC investment in the valley during the previous 4 years (1996-1999). Two records were reached in the second quarter of 2000: the most VC investment per quarter and the highest valuation of the high-tech companies. The period 1996-2000 has been highly anomalous as, among others, there were almost no risks associated to (supposedly high-risk) VC investments. In fact, most dot-coms companies created during that period (many of which either became public after highly successful IPOs or were sold at high values) had not clear idea on how to generate revenues. Company valuations merely reflected expected potential to become substantial businesses. On the other hand, there was no known way to even roughly estimate this potential. The NASDAQ went from a peak of over 5.200 in April 2000 to values below 2.000 in March 2001. VC investments in the SV during 2001 have been projected to be about half of those the previous year. That value would be just 20% below the 1999 figure but almost twice that of 1998. The reduction of total investment would be accompanied by increase in investment per company.

2.4 Interests of the SV: The New Political Agenda

Until recently high-tech companies of the SV were not usually[13] included in the political agenda of the federal government reflecting a much stronger influence of the economic interests of the East coast and of the oil (South) and automobile (Midwest) industries. As the SV acquired an important relative weight in the U.S. economy, its political influence increased dramatically. During the Clinton Administration, both the president and vice-president visited the SV in large number of occasions. The SV is constantly receiving visits of many republican and democrat politicians, and also of many personalities from abroad. This interaction of the SV with the political class accelerated even more during the 2000 presidential elections.

In the last decade there has been a change of attitude of both, politicians and SV leaders. Politicians acquired a high respect for the SV as the engine for technological innovation and economic growth. SV leaders also have become increasingly active in politics influencing at various governmental levels (federal, state and local) and pushing for an agenda to benefit the SV industry. Most of the industry still focuses on narrow (and short-term) issues affecting the SV valley and the high-tech industry. They include rising the cap on H1-B visas for skilled immigrants, liberalizing encryption and computer export controls, making permanent the R&D tax credit for corporations, tax exemptions for internet transactions (e-commerce) and granting China Permanent Normalized Trade Relations.

Efforts to focus on other (longer term) critical issues are even more recent (e.g., TechNet discussed below). These issues include reforming R&D tax credit so it applies to more companies and stimulates industry-university relationship, increasing federal funding for basic research, and addressing (K-12) education and training crisis. Other highly critical issues that impact both short and long term include anti-trust regulations (e.g., Microsoft case) and intellectual property protection policy (e.g., Napster case).

The new role of the SV influencing the political agenda is reflected in a number of organizations such as TechNet and PITAC (1999). TechNet is a bipartisan political alliance of more than a hundred leading high-tech companies. John Doerr, a well-known venture capitalist, is one of the founders of TechNet (see Box 3). PITAC [President's Information Technology Advisory Committee State] is an special committee[14] assembled

---

[13] On the other hand some individuals from the SV had previously influenced Federal Government policies and in some cases also occupied high-ranking public positions. For example, David Packard, one of the founders of HP, was secretary of Defense during the Nixon Administration in the period 1969-1971.

[14] The industrial members of the PITAC include: Sun Microsystems, 3Com Corporation, MCI Communication, PointCast Inc, Hughes Electronic Corp., Former Cray Research, Microsoft Research, Walt Disney Imagineering, AT&T Labs, Intel Corp, Qualcomm, CenterPoint Ventures and IBM

by Clinton, former USA President to evaluate the federal and private research activities in the area of Information Technology (IT) and had been mostly composed of SV leaders. Although the main efforts of these groups are on short-term issues mentioned above, they are concerned about long-term balanced economic growth exploiting technological innovations associated with the Internet revolution.

Box 3 Profile of John Doerr, KPCB Partner: Political Agenda of the Valley

John Doerr was born in Saint Louis, Missouri and is 50 years old. He studied Electrical Engineering at Rice University in Texas, and then received an MBA from Harvard. In 1974 he began working at Intel as an engineer, and in short time he became a top sales executives of Intel. In 1980 he moved to KPCB (Kleiner Perkins Caufield and Byers), one of the best-known venture capital firms. He is a highly successful partner at KPCB and has led investments in Compaq, Sun Microsystems, Amazon.com, and Netscape among others. He was affiliated to the Republican Party, but had close relationship with leading democrats including Clinton and Gore. John believes that education needs to be changed to adapt to demands of "new economy". He is one of the founders of TechNet (Technology Network) that includes some of the most important high-tech companies of the Valley. [Technet also includes well-known entrepreneurs such as Jim Barksdale (former CEO de Netscape) y Art Levinson (CEO de Genentech, one of the most important biotechnology companies).] John believes that the yesterday's R&D explains today's innovations and that government investment in basic science and long-term projects has been the driver for the current technological innovations.

These groups are proposing compromises between federal government and industry to duplicate the financing of federal support for basic research in science, engineering and technology in the next years. The groups also asked that the Government continue with a tax break for investments in research by corporations. According to the commission " the role of the federal government in the areas of R&D is critical and it cannot be replaced, in particular, in areas in which short-term technological applications are unlikely. Moreover, a high percentage of IT research that impacted most technological innovations of the last 30 years have come from academic institutions and national laboratories financed with public funds by the federal government.

PITAC believes that required changes in the educational system benefit from larger support of basic research by the government. In turn, industry demands for the next decades requires to duplicate the number of students in engineering and sciences, which in turn, requires to make the population sensible to this needs. According to PITAC the federal government must keep and expand its leadership role supporting long-term research in information technology (IT) since losing U.S. leadership in IT would have dramatic economic consequences for the country. In this regard, advances in IT would enable a strong infrastructure for businesses, scientific research and social integration, thus constituting a fundamental pillar for progress in the XXI century. PITAC proposed that to the already planned budget for the period 2000-2004, the government add 4500 million dollars to be used in long-term IT projects by universities and federal laboratories[15]

The priorities selected are i) development of software to manipulate large amount of data ii) improvement in human-computer interfaces iii) expansion and improvement of the information infrastructure iv) development of IT to reduce the gap between information rich and poor. To fulfill these objectives that would allow IT to become a powerful tool to democratize the society, it is proposed that the NSF (National Science Foundation) takes leadership in basic research on IT in collaboration with other research organizations such as CIC (Computing Information and Communication) and HECC (High-End Computing and Computation) and the development of interdisciplinary research groups.

In 2000, and in part as a result of PITAC's findings, the government increased basic research support for developing programs to promote technical careers and for capacitating young people in new skills. [16] In spite that the IT sector invest annually about 30.000 million in R&D which is about twice the U.S. industry average (as fraction of sales), PITAC is worry that the 50 largest IT companies have reduced the relative R&D invested (as fraction of their total sales).

We are at the beginning of profound social and economic transformations fueled by the Internet revolution. It is expected that pressure for both de-regulations and new regulations will increase, as critical issues must be resolved in the coming years. Changing regulations will heavily impact the high-tech industry. Main issues include business models for profiting from the Internet, ownership of transformed knowledge (patents, copyright, …), anti-trust regulations and financing of long-term (basic and applied) research. In contrast to the short-term agenda that has substantial consensus, some long-term issues promise to be much more conflictive since firms will be affected in different ways (e.g., Microsoft and Napster cases). This will required a dynamical agenda, as neither solutions to critical issues nor even emerging problems are currently known.

[15] It is proposed that the increases in the budget progressively increase from about 450 millions in the year 2000 to about 1.400 millions in 2004. One must remember that the additional 4.500 millions represents less than half (a fifth) of the 1999 (2000) VC investment in the SV.

[16] The 2000 budget gave the NSF a total of about 3000 million dollars, which represented an increment of 5% respect to the 1999 budget. From this total, 400 million corresponded to information technology to be used as recommended by PITAC. This is the segment of the NSF budget that registered the largest increase (30%) respect to the previous year.

3. Innovation and the Learning Process in the Silicon Valley

3.1 The Importance of Codified and Tacit Knowledge

The circulation of (codified and tacit) knowledge constitutes a critical element for learning, developing innovative processes and ideas, and thus for creating comparative advantages. In the SV the informal interrelationship among agents constitutes an element that greatly enables this circulation of knowledge.

The generation of new ideas and the cooperation among agents can only be understood from the previous history. An impersonal memo has much less impact than information associated with personal contacts. Similarly, formal meetings and structured groups are many times unable to solve problems that are then solved in informal discussions (maybe at a gym or a bar with either co-workers or friends from the competition). Then, as companies recognize that informal sessions can be critical for incremental (and of course revolutionary) advances, they try to change their organizational cultures to create more opportunities to encourage activities that were previously considered a waste of time. Hence, informal networks of employees and experts constitute a very important company active. These networks are constituted by individuals that may share a specialization or certain know-how and trust each other. These structures are not part of the company organization chart. These groups help each other solving problems and exchanging useful information and experiences, constituting communities of practice. In a sense, they can be considered the basic incubators of knowledge, innovation and cooperation, and constitute a fundamental assets that companies require to be successful in a new economic scenario in which winning teams require more than the traditional capital, land and working hands. [17]

The dynamics of (formal and informal) circulation of knowledge contributes to generate incremental innovations in the SV. Most innovations are usually a sum of many incremental ones and advances in existing processes and methodologies, start-ups in the valley produce an important proportion of the total innovation in the region, and an even much larger proportion of radical innovation. Start-ups heavily contribute to the innovation process as it is much more difficult to generate innovation in large companies with more rigid structures and complex procedures. Thus, large firms are usually slow to take high-risk decisions. Many times start-ups are originated or financed by large companies that are now well aware of their limitation to generate innovation. A few years ago, large organizations were able to produce most of the innovation required to fuel their

[17] The relevance assigned to knowledge as a fuel for the SV engine and the understanding that there are problems that limit the efficiency of the (formal and informal) learning process led the University of Berkeley (Hass School of Business) to create a degree to generate professionals trained in facilitating the learning process. This program has the contribution of Prof. Nonaka, one of the best-known researchers in the knowledge economy.

development at their own labs (some companies such as IBM and AT&T had first class laboratories where fundamental technological and scientific development had taken place). The relative importance of proprietary laboratories is quickly diminishing and start-ups are becoming an important source of incremental and radical innovation.

There are four elements that accelerate the circulation of knowledge i) the existence of a culture that encourages companies to "talk" with their competition ii) a very high job mobility iii) projects as the de-facto units of work and iv) agents that transmit information and connect demand with offer in different markets.

Firms "talk" fluidly with their competition for several reasons including the fast dynamics of creation and evolution of technologies and the de-verticalization of the regional economy (and also of the large companies). A large diversity of agents must cooperate/coordinate to bring interoperating hardware and software modules to the market. This creates the necessity of discussion forums, of standards accepted by consumers and providers of modules, and of centers for learning new technologies and for exchanging ideas. These dynamics develops with a background provided by the SV's culture that promotes strong interaction among agents.

The mobility in the job market is another element that contributes to knowledge circulation. It is not common for a person to work all his/her life in a single company. Typically one works 3 to 5 years at a given company until changes occur and better opportunities appear elsewhere (maybe across the street). Many people consider that they work in the SV but not for a given company. The natural units of work are projects with workers sometimes more bounded to these projects than to particular companies. The project conclusion brings a natural time to evaluate which next project is more challenging or rewarding. The next project will not necessarily be at the same company, but may include some of the same contributors. In fact, engineers in the SV are more loyal to their favorite technology sharing their passion within an engineering network. Rather than remaining in a single company, they would pursue the most challenging and/or rewarding project that advances the technology of their interest. Projects as unit of work allows for a much faster adaptation to change, adding flexibility to the provision of human resources and also allowing companies to quickly change and adapt.

Job rotation and a substantial demand for qualified workers have generated a very strong competition for human resources. This was reflected in salaries much higher that those for equivalent positions elsewhere and in healthy distribution of stock options. In general, options during the 90's became much more important than salaries. [18] All of these have contributed to increase the spending capacity of the local market generating a virtuous

[18] Company employees excluding founders and CEO may own about 15% of the firm. At the end of 90's, 15% of the market value of the most successful SV firms such as Yahoo and eBay gave an average of 16 and 35 million dollars per employee. The value of stock options has been greatly affected by the crisis that started in 2000. For example, Yahoo's stock in March 2001 were over 10 times lower that its peak about a year earlier.

cycle.[19] The crisis that started in 2000 will probably modify these characteristics in the short-term.

3.2 The University-Enterprise Relationship

The generation and circulation of knowledge in the SV has greatly benefited from the strong relationship between local firms and universities. On the contrary, relationships between most U.S. universities and industries have usually been difficult during the postwar period. The relationship of Stanford with the local industry started at the end of the 30's and was reinforced after the Second World War. This relationship has served as an example initially to other local universities, and more recently to universities elsewhere in the country and rest of the world. In this section we briefly describe the dynamics of the interaction university-industry in the Valley as well as in the rest of the country.

One of the reasons for the difficult relationship between university-industry has been the quite different scale of time in the processes of innovation between the two agents. This is rapidly changing. While "long-term research" for the industry is moving from about 10 to 2 years or less, in academia is also changing from about 30-50 years to 10 years or less. The relationship between industry and academia has evolved, and in the last fifty years one can clearly distinguish two periods: a) Cold -War era, and b) post Cold War. In the first period which extended from the end of the Second World War to the mid 80's universities and national labs funding was provided mainly by the federal government and was generally associated to Cold War U.S. policies. Thus, the connection between both agents was weak and there was mutual mistrust. In contrast, in the second period there is a much stronger need for collaboration. Universities and national laboratories have seen a (sometimes sharp) reduction in public financing since the end of the Cold War and are looking, in many cases encouraged by government, for financial support from the private sector. In turn, the private sector needs help from academia for innovation and for human resources capable to drive these innovation processes. Due to the previous history of mistrust and lack of mutual understanding, the relationship between the two agents has only been improving slowly.

The private sector views academic research as too theoretical, not relevant to industry's problems, and of little application in the "real world". This perspective produced a myopia towards understanding the technological relevance of important results generated in the academic community. On the other hand, the relationship academia/industry has been conditioned by the tradition of older and mid-aged generations of researchers who

[19] The tremendous growth of the Valley in the 80's and 90's also brought undesired consequences such as a very high cost of living, sharp increase in traffic and other unwanted factors that have decreased the quality of life in the area.

disregard problems in the industry as too particular, not challenging enough for serious scientist and technologists, and of very little generality.[20]

Changes in regulations since the 80's promoted the collaboration of universities and national labs with private companies. The largest federal agencies supporting research such as NSF (National Science Foundation), NIST (National Institute of Standard and Technology), DOD (Department of Defense) began requiring that universities, labs and institutes applying for grants show industrial interest in their work. The industrial view (although still in minority but strong among top industrial leaders) is that the current dynamics of innovation forces firms to complement their competencies and to transform new technological and scientific discoveries into products very fast and efficiently (see Box 4). Universities and national labs are one of the critical pillars in networks that help firms to operate efficiently in this system. This is due not only to the value of R&D at these centers but also to the formation of critical human resources required to feed the system. In this growing relationship between companies and universities, it is common that large firms (IBM, AT&T, Ford, …) have agents that "bridge" between the two worlds. Usually, these people have Ph.D. in Computer Science, Electrical Engineering, Physics, Mathematics or Chemistry and sometimes have a stronger interaction and identification with the academic world than with the companies to which they are affiliated.[21]

Box 4 Main Topics of Research

In the knowledge economy, the value of knowledge is uneven, hierarchical and dynamical. Thus, if we imagine knowledge quoted in an exchange market there would be an ample spectrum of different "stocks" with their relative values changing at very fast pace. Knowledge is hierarchical because any area of knowledge (e.g., non-linear optics) contains sub-areas of knowledge, which in turn have uneven and dynamical value. Of course, there is a basic infrastructure of technical knowledge common to many diverse areas of technology. This infrastructure includes a strong background in mathematics, information technology and physical sciences. In turn the capacity of abstraction and synthesis rapidly begins to be more and more valuable. Let us enumerate some of the areas whose "stocks" are currently highly valued. This means that the "owners" of this knowledge can "sell" it (either as employees or as founders of companies commercially exploiting the knowledge, or as professors/researchers in universities/laboratories accessing to large grants). High-value areas include communication networks (local-area networks, wide-area networks and metropolitan-area networks), technologies for fast access to networks, communication protocols, quality of service using the internet protocol, methodologies for designing and testing chips, design automation tools, internet business models, network security,

[20] The approach between these two communities with different views and philosophies required the translation to very different languages and to overcome mutual mistrusts.

[21] On the other hand, the current educational system has not made necessary adjustments to facilitate the translation and transformation of knowledge from generic into specific and vice versa.

methodology and tools for developing software, methodology and tools for testing complex software, new internet devices for communication/computation (integrating telephone, TV, games, web browsing and email), chip fabrication technologies required to guarantee "Moore Law" during the next few years, business models based on exchange and integration of IP (intellectual property), DWDM (dense wave division multiplexing) y other laser technologies to make more effective transmission through optical fiber.

The current phase of development of the IT industry is characterized by a dramatic reduction of the product lifetime. Firms are increasingly aware of their need to complement their competency with groups of R&D from universities and national labs, and in particular with groups of agents constituting start-ups and spin-offs that pursue high-risk development. In this direction firms establish agreements with universities and laboratories financed by government agencies such as NSF, NIST, DOD, etc. These relationships are also encouraged by requirements for universities and laboratories to establish stronger links with industry to access to grants. Moreover, since the break of the of linear innovation model, academic centers recognize the importance of learning processes outside traditional universities and large R&D labs. In fact, the development of informal innovative activities in the high-tech industry is now, in many areas, at the vanguard of the innovation process.

In the SV there is a very solid tradition of collaboration between academia and industry which has generated a strong link between these communities. It could be said that the relationship university-industry in the SV is in a more advanced phase of evolution as compared with that in the rest of the country. In fact, as borders between firms in the Valley are fuzzy and one could think of the Valley as a single firm with high mobility and several coordinating agents, the separation between academy and industry is also fuzzy. The generation of innovation and of new businesses does not recognize borders. These activities are based on transactions where knowledge has much higher value than capital as discussed in Box 4. Thus, many times professors and/or students of engineering, computer sciences, biotechnology, applied physics and other technical areas from Stanford, UC Berkeley and other local centers become entrepreneurs and start their own companies or join existing start-ups, usually exploiting technologies developed by them. On the other hand, entrepreneurs and venture capitalists become "academics" teaching classes in local universities.[22]

3.3 Dynamics of the Innovation Process and of the Creation of Firms

[22] In fact, the largest worldwide concentration of venture capital firms is along Sand Hill Road, very close to Stanford campus in Palo Alto. Some of the most recognized VCs teach at the School of Business. The departments of Engineering, Science and Business, the VC community and local firms have strong interactions and many times Stanford University is a meeting center.
.

In this section we explore the process for generating new businesses. Process starts with an initial idea by a qualified team that later leads to the creation of a start-up. The firm evolves in several possible ways concluding with a premature death, acquisition by a larger firm or becoming public after an initial public offering (IPO). Only a small percentage of start-ups becomes public with a successful IPO, or is acquired by a larger company for a hefty amount of money. Many start-ups never attract appropriate funds, others end up with technologies that may already be outdated before release of their products or even without acceptable products. In the highly competitive environment of the 1995-2000 period, investors usually recovered their investments as these ill-fated companies typically still ended up acquired just for the technical team and/or some pieces of the technology.[23] It is likely that after strong market adjustments that started in 2000 high-risk investment will again be high risk.[24]

The process usually starts with a small group of highly qualified people (founders) with a good idea and (sometimes) knowledge of how to transform the idea into a company. Say, it could start with 2 young Stanford professors and a couple of their best graduating students, or a group of 2-4 engineers and a marketing specialist coming from different companies of the Valley. All or some of them may know each other from previous jobs, churches or social activities. The founding group may not only have a good idea but also a novel technology that can be patented, and a good experience on how to implement their technology to bring a product to market, for example in the fiber optics field.

If the group has not yet raised money from venture capital it may try to start in an incubator. There are many incubators located in the Silicon Valley. They usually provide an infrastructure for starting companies, which may include furnished office space, fast internet connection, receptionist, office equipment (copy and fax machines), usually at a price below market. Some of the incubators are financed by the federal, state or local government (or agencies such as NASA depending on the federal government) others are private, instead. In these incubators, companies may pay low rent for space and other infrastructure, but may give the host incubator some company equity. The group must produce a business plan describing how to establish the company (including founders' bios, technology, market, competition analysis, hiring plan and other details about the company). It must be shown that the technology and business model of the start-up gives it a competitive advantage in usually highly contested markets. In addition to (or as part of) the business plan there is also a financial plan that discusses the money flow during usually the first 5 years of the company.

The group is planning to raise 60 millions in three rounds in exchange for company equity. In the first round, the company would like to get about 10 million, 20 more in the second round at the end of the first year, and an additional 30 million in the third round at the end of the second year. The next step is to attract the best investors. Venture capital

[23] Also some acquisitions are driven not by the buyer planning to use the technology of the acquired company but because the buying company would like to avoid that competitors access the start-up technology.

[24] Failed companies could become worthless, at least in certain areas, as it would be easier to assemble technical teams. In the medium to long term we still expect that there will be high demand for qualified manpower.

and angel provide not just money but many other important benefits. Thus, it is not only the quantity of money but also the quality of the investors. Top-tier VCs may provide, in addition to the name recognition, help in recruiting a first class management team, good contacts with customers and partners, and may help in the initial steps for the start-up to transition to a solid company. Then, founders must identity the best VCs specialized in their area of expertise. In exchange for the VC investment, the founders give investors company equity. There is always a healthy pool of stocks reserved for the coming employees. Possibly, at the end of the third round the founders may own 20% of the company, employees (including the CEO and the rest of the management team) may have another 20% and 60% of the company is owned by the investors.

After the first round of investment, the company grows from the initial 4-6 founders to about 50 people at the end of the first year, and about 90 at the end of the second year. At the end of the third year, after company's products have been in the market for over a year and conquest a significant percentage of the market, the company may go public in a successful IPO. Alternatively the company may have been sold at the end of the second year. In general, the buying company retains the IP (intellectual property) that includes the patent portfolio, and all technical employees (and some of the marketing/sales team) that are now encouraged to stay in the acquiring company for at least a year by offering them stock options. Typically, the most innovative and entrepreneurial people of the acquired team would leave the buying company after a year or two and then either start a new company or become angels or VC investing in other companies. In any case, these creative destruction dynamics increases the competency of technical and financial services and the development of more and highly efficient companies, recycling and circulating knowledge and fueling the economic development of the SV. [25] In general these new VCs are highly competent professionals with a rich diversity of backgrounds (engineers, marketing, sales, finance…) and a extensive experience working in high-technology, usually in the SV.

4. Conclusions

The dynamics of business creation in the SV shows that the local environment can become a critical source of knowledge generation, circulation and processing. In turn, this knowledge is the fuel of local companies helping them to acquire competitive advantages benefiting companies of all sizes, but more in particular, the generation of new ventures. Currently, most technological innovations are brought by start-ups. The big players now understand this dynamics and are becoming increasingly active in financing new ventures. Usually those who develop ideas are not the same as those who invest in these

[25] The most dynamical agents of the local system are the "stars", "good players", venture capitalists, recruiters and coaches. The stars are the best engineers, highly creative and with acute business vision. In addition, "stars" may include outstanding marketing and sales agents with powerful connections in a SV network. The venture capitalists provide not only money but also direction and connections. Recruiters could be headhunters or even the same VCs that bring very valuable people to the team. Finally, the coaches are advisors, people with long years of technical, business or financial experience, and many times with prior experience in putting together new companies. Some of them could be part of the boards of directors or advisors.

ideas. In general, the implementation and execution of new ideas and projects is possible thanks to the financial and organizational contributions of venture capitalists, corporations and angels. These agents usually have technical or business expertise in high-tech ventures.

Investments proceed in function of the power of the ideas, team and execution and do not required collateral. The fast pace at which companies are created, evolve, become public or part of a larger company can only be explained from the previous history of the region whose main elements include i) partnership among private firms and collaboration of companies, universities, national labs, and government, ii) partition of work into projects usually involving a variety of expertise from many different departments (and/or companies) and that usually do not last more than 3 years, iii) existence of a culture that highly values the circulation of (codified and tacit) knowledge and does not disapprove persons/organizations that did not succeeded in an activity, but rewards the learning experience of unsuccessful projects and iv) agents that transmit information and connect demand with offer in different markets, An important difference with other local systems, industrial districts or clusters is that the SV develops high-tech activities at the technological edge enabling innovations and creating competitive advantages that will be critical in the next few decades.

References

Becattini G. y Rullani E., (1993); ¨Sistema locale e mercato globale" en Economia e Politica Industriale, Nro 80.

Boscherini F. y Yoguel G (2000), Aprendizaje y competencias como factores competitivos en el nuevo escenario: algunas reflexiones desde la perspectiva de la empresa; en Boscherini y Poma (Eds), Territorio, conocimiento y competitividad de las empresas: el rol de las institucones en el espacio global, Minño y Davila, Madrid

Camagni, R. (1991) "Local «milieu», uncertainty and innovation networks: towards a new dynamic theory of economic space". En Camagni, R. (ed.) Innovation networks: spatial perspectives. Belhaven Press, London and New York.

Ducatel (1998), Learning and skills in the knowledge economy, Danish Research Unit for Industrial Dynamics, Working paper 98-2

Ernst D. y Lundvall A. (1997). Information technology in the learning economy, challenges
for developing countries, Danish Research Unit for industrial dynamics (DRUID), Working Paper Nro 97'12

Lall S. (1995), ¨The creation of comparative advantage: the rol of industrial policy¨, en Irfan ul Haque (ed) Trade, Technology and International Competitiveness, Economic Development Institute, World Bank.

Lundvall B.A. "The learning economy: challenges to economic theory and policy", paper at the EAEPE Conference Copenhagen, 1992.

Morgan, K. (1995) "The Learning Region: Institutions, Innovation and Regional Renewal", University of Wales Cardiff.

PITAC, President Information Technology Advising Committee, Washington 1999.

Poma L (1998), "La nuova competizione territoriale", en Politica e Organizzazione, Quaderni Aroc, n. 1/98, mayo, Bolonia.

Poma L (2000), La pro0ducción de conocimiento. Nuevas dinámicas competitivas para el territorio; en Boscherini y Poma (Eds), Territorio, conocimiento y competitividad de las empresas: el rol de las institucones en el espacio global, Minño y Davila, Madrid.

Rullani E. (1997), Piu locale e piu globale: verso una economia postfordista, en Bramanti y Maggioni (Ed) La dinamica dei sistemi produttivi territoriali teorie, tecniche, politiche.

Saxenian A. (1994), Regional advantage, culture and competition in Silicon Valley and Route 128. Harvard University Press, USA.

Yoguel G. (2000) Algunas reflexiones acerca de la importancia de los procesos de aprendizaje en el desarrollo de las ventajas competitivas de los agentes, Revista de la CEPAL Nro 71, Santiago de Chile.

---

i

Danish **R**esearch **U**nit for **I**ndustrial **D**ynamics

The Research Programme

The DRUID-research programme is organised in 3 different research themes:

- The firm as a learning organisation
- Competence building and inter-firm dynamics
- The learning economy and the competitiveness of systems of innovation

In each of the three areas there is one strategic theoretical and one central empirical and policy oriented orientation.

Theme A: The firm as a learning organisation

The theoretical perspective confronts and combines the resource-based view (Penrose, 1959) with recent approaches where the focus is on learning and the dynamic capabilities of the firm (Dosi, Teece and Winter, 1992). The aim of this theoretical work is to develop an analytical understanding of the firm as a learning organisation.

The empirical and policy issues relate to the nexus technology, productivity, organisational change and human resources. More insight in the dynamic interplay between these factors at the level of the firm is crucial to understand international differences in performance at the macro level in terms of economic growth and employment.

Theme B: Competence building and inter-firm dynamics

The theoretical perspective relates to the dynamics of the inter-firm division of labour and the formation of network relationships between firms. An attempt will be made to develop evolutionary models with Schumpeterian innovations as the motor driving a Marshallian evolution of the division of labour.

The empirical and policy issues relate the formation of knowledge-intensive regional and sectoral networks of firms to competitiveness and structural change. Data on the structure of production will be combined with indicators of knowledge and learning. IO-matrixes which include flows of knowledge and new technologies will be developed and supplemented by data from case-studies and questionnaires.

Theme C: The learning economy and the competitiveness of systems of innovation.

The third theme aims at a stronger conceptual and theoretical base for new concepts such as 'systems of innovation' and 'the learning economy' and to link these concepts to the ecological dimension. The focus is on the interaction between institutional and technical change in a specified geographical space. An attempt will be made to synthesise theories of economic development emphasising the role of science based-sectors with those emphasising learning-by-producing and the growing knowledge-intensity of all economic activities.

The main empirical and policy issues are related to changes in the local dimensions of innovation and learning. What remains of the relative autonomy of national systems of innovation? Is there a tendency towards convergence or divergence in the specialisation in trade, production, innovation and in the knowledge base itself when we compare regions and nations?

The Ph.D.-programme

There are at present more than 10 Ph.D.-students working in close connection to the DRUID research programme. DRUID organises regularly specific Ph.D-activities such as workshops, seminars and courses, often in a co-operation with other Danish or international institutes. Also important is the role of DRUID as an environment which stimulates the Ph.D.-students to become creative and effective. This involves several elements:

- access to the international network in the form of visiting fellows and visits at the sister institutions
- participation in research projects
- access to supervision of theses
- access to databases

Each year DRUID welcomes a limited number of foreign Ph.D.-students who wants to work on subjects and project close to the core of the DRUID-research programme.

External projects

DRUID-members are involved in projects with external support. One major project which covers several of the elements of the research programme is DISKO; a comparative analysis of the Danish Innovation System; and there are several projects involving international co-operation within EU's 4th Framework Programme. DRUID is open to host other projects as far as they fall within its research profile. Special attention is given to the communication of research results from such projects to a wide set of social actors and policy makers.

DRUID Working Papers

96-1 **Lundvall, Bengt-Åke:** The Social Dimension of the Learning Economy. (ISBN 87-7873-000-7)

96-2 **Foss, Nicolai J.:** Firms, Incomplete Contracts and Organizational Learning. (ISBN 87-7873-001-5)

96-3 **Dalum, Bent and Villumsen, Gert**: Are OECD Export Specialisation Patterns Sticky?' Relations to the Convergence-Divergence Debate. (ISBN 87-7873-002-3)

96-4 **Foss, Nicolai J:** Austrian and Post-Marshallian Economics: The Bridging Work of George Richardson. (ISBN 87-7873-003-1)

96-5 **Andersen, Esben S., Jensen, Anne K., Madsen, Lars and Jørgensen, Martin:** The Nelson and Winter Models Revisited: Prototypes for Computer-Based Reconstruction of Schumpeterian Competition. (ISBN 87-7873-005-8)

96-6 **Maskell, Peter:** Learning in the village economy of Denmark. The role of institutions and policy in sustaining competitiveness. (ISBN 87-7873-006-6)

96-7 **Foss, Nicolai J. & Christensen, Jens Frøslev:** A Process Approach to Corporate Coherence. (ISBN 87-7873-007-4)

96-8 **Foss, Nicolai J.:** Capabilities and the Theory of the Firm. (ISBN 87-7873-008-2)

96-9 **Foss, Kirsten:** A transaction cost perspective on the influence of standards on product development: Examples from the fruit and vegetable market. (ISBN 87-7873-009-0)

96-10 **Richardson, George B.:** Competition, Innovation and Increasing Returns. (ISBN 87-7873-010-4)

96-11 **Maskell, Peter:** Localised low-tech learning in the furniture industry. (ISBN 87-7873-011-2)

96-12 **Laursen, Keld:** The Impact of Technological Opportunity on the Dynamics of Trade Performance. (ISBN 87-7873-012-0)

96-13 **Andersen, Esben S.:** The Evolution of an Industrial Sector with a Varying Degree of Roundaboutness of Production. (ISBN 87-7873-013-9)

96-14 **Dalum, Bent, Laursen, Keld & Villumsen, Gert**: The Long Term Development of OECD Export Specialisation Patterns: De-specialisation and “Stickiness”. (ISBN 87-7873-014-7)

96-15 **Foss, Nicolai J.:** Thorstein B. Veblen: Precursor of the Competence-Based Approach to the Firm. (ISBN 87-7873-015-5)

96-16 **Gjerding, Allan Næs:** Organisational innovation in the Danish private business sector. (ISBN 87-7873-016-3)

96-17 **Lund, Reinhard & Gjerding, Allan Næs:** The flexible company Innovation, work organisation and human ressource management. (ISBN 87-7873-017-1)

97-1 **Foss, Nicolai J.:** The Resource-Based Perspective: An Assessment and Diagnosis of Problems. (ISBN 87-7873-019-8)

97-2 **Langlois, Richard N. & Foss, Nicolai J.:** Capabilities and Governance: the Rebirth of Production in the Theory of Economic Organization. (ISBN 87-7873-020-1)

97-3 **Ernst, Dieter:** Partners for the China Circle? The Asian Production Networks of Japanese Electronics Firms. (ISBN 87-7873-022-8)

97-4 **Richardson, George B.:** Economic Analysis, Public Policy and the Software Industry. (ISBN 87-7873-023-6)

97-5 **Borrus, Michael & Zysman, John:** You Don’t Have to Be A Giant: How The Changing Terms of Competition in Global Markets are Creating New Possibilities For Danish Companies. (ISBN 87-7873-024-4)

97-6 **Teubal, Morris.:** Restructuring and Embeddeness of Business Enterprises-Towards an Innovation System Perspective on Diffusion Policy. (ISBN 87-7873-025-2)

97-7 **Ernst, Dieter & Guerrieri, Paolo:** International Production Networks and Changing Trade Patterns in East Asia: The case of the Electronics Industry. (ISBN 87-7873-026-0)

97-8 **Lazaric, Nathalie & Marengo, Luigi:** Towards a Characterisation of Assets and Knowledge Created in Technological Agreements: Some evidence from the automobile-robotics sector. (ISBN 87-7873-027-9)

97-9 **Ernst, Dieter.:** High-Tech Competition Puzzles. How Globalization Affects Firm Behavior and Market Structure in the Electronics Industry. (ISBN 87-7873-028-7)

97-10 **Foss, Nicolai J.:** Equilibrium vs Evolution in the Resource-Based Perspective: The Conflicting Legacies of Demsetz and Penrose. (ISBN 87-7873-029-5)

97-11 **Foss, Nicolai J.:** Incomplete Contracts and Economic Organisation: Brian Loasby and the Theory of the firm. (ISBN 87-7873-030-9)

97-12 **Ernst, Dieter & Lundvall, Bengt-Åke:** Information Technology in The Learning Economy – Challenges for Developing Countries. (ISBN 87-7873-031-7)

97-13 **Kristensen, Frank Skov (p):** A study of four organisations in different competitive environments. (ISBN 87-7873-032-5)

97-14 **Drejer, Ina, (p) Kristensen, Frank Skov (p) & Laursen, Keld (p):** Studies of Clusters as a Basis for Industrial and Technology Policy in the Danish Economy. (ISBN 87-7873-033-3)

97-15 **Laursen, Keld (p) & Drejer, Ina (p):** Do Inter-sectoral Linkages Matter for International Export Specialisation? (ISBN 87-7873-034-1)

97-16 **Lundvall, Bengt-Åke & Kristensen, Frank Skov (p):** Organisational change, innovation and human resource Development as a response to increased competition. (ISBN 87-7873-036-8)

98-1 **Præst, Mette (p):** An Empirical Model of Firm Behaviour: A dynamic Approach to Competence Accumulation and Strategic Behaviour. (ISBN 87-7873-037-6)

98-2 **Ducatel, Ken:** Learning and skills in the Knowledge Economy. (ISBN 87-7873-038-4)

98-3 **Ernst, Dieter:** What Permits Small Firms to Compete in High-Tech Industries? Inter-Organizational Knowledge Creation in the Taiwanese Computer Industry. (ISBN 87-7873-039-2)

98-4 **Christensen, Jens Frøslev:** The Dynamics of the Diversified Corporation and the Role of Central Management of Technology. (ISBN 87-7873-040-6)

98-5 **Valente, Marco (p):** Laboratory for Simulation Development. (ISBN 87-7873-041-4)

98-6 **Valente, Marco (p):** Technological Competition: a Qualitative Product Life

Cycle. (ISBN 87-7873-042-2)

98-7 **Lam, Alice:** The Social Embeddedness of Knowledege: Problems of Knowledge Sharing and Organisational Learning in International High-Technology Ventures. (ISBN 87-7873-043-0)

98-8 **Jørgensen, Kenneth M. (p):** Information Technology and Change in Danish Organizations. (ISBN 87-7873-044-9)

98-9 **Andersen, Esben Sloth:** Escaping Satiation in an Evolutionary Model of Structural economic Dynamics. (ISBN 87-7873-045-7)

98-10 **Foss, Kirsten:** Technological Interdependencies, Specialization and Coordination: A Property Rights Perspective on The Nature of the Firm. (ISBN 87-7873-046-5)

98-11 **Andersen, Poul H:** Organizing International Technological Collaboration in Subcontractor Relationships. An Investigation of the Knowledge-Stickyness Problem. (ISBN 87-7873-047-3)

98-12 **Nymark, Søren (p):** Billeder af strategi i forandringsrige organisatoriske omgivelser: 3 cases fra DISKO studierne. (ISBN 87-7873-048-1)

98-13 **Andersen, Esben Sloth:** The Evolution of the Organisation of Industry. (ISBN 87-7873-050-3)

98-14 **Foss, Kirsten & Foss, Nicolai J.:** The Market Process and The Firm: Toward a Dynamic Property Rights Perspective. (ISBN 87-7873-051-1)

98-15 **Lorenz, Edward:** Societal Effects and the Transfer of Business Practices to Britain and France. (ISBN 87-7873-053-8)

98-16 **Ernst, Dieter:** Catching-Up, Crisis and Industrial Upgrading. Evolutionary Aspects of Technological Learning in Korea's Electronics Industry. (ISBN 87-7873-054-6)

98-17 **Kaisla, Jukka (p):** The Market Process and the Emergence of the Firm: Some Indications of Entrepreneurship Under Genuine Uncertainty. (ISBN 87-7873-055-4)

98-18 **Laursen, Keld (p):** Do Export and Technological Specialisation Patterns Co-evolve in Terms of Convergence or Divergence?: Evidence from 19 OECD Countries, 1971-1991. (ISBN 87-7873-056-2)

98-19 **Foss, Nicolai J.:** Firms and the Coordination of Knowledge: Some Austrian Insights. (ISBN 87-7873-057-0)

98-20 **Mahnke, Volker (p) & Aadne, John Harald:** Process of Strategic Renewal, Competencies, and the Management of Speed. (ISBN 87-7873-058-9)

98-21 **Lorenzen, Mark (p):** Information, cost learning, and trust. Lessons form co-operation and higher-order capabilities amongst geographically proximate firms. (ISBN 87-7873-059-7)

98-22 **Lam, Alice:** Tacit Knowledge, Organisational Learning and Innovation: A Societal Perspective. (ISBN 87-7873-060-0)

98-23 **Lund, Reinhard:** Organizational and innovative flexibility mechanisms and their impact upon organizational effectiveness. (ISBN 87-7873-061-9)

98-24 **Christensen, Jesper Lindgaard & Drejer, Ina (p):** Finance and Innovation System or Chaos. (ISBN 87-7873-062-7)

98-25 **Laursen, Keld (p):** How Structural Change Differs, and Why it Matters (for Economic Growth) (ISBN 87-7873-063-5)

98-26 **Holmén, Magnus & Jacobsson, Staffan:** A method for identifying actors in a knowledge based cluser. (ISBN 87-7873-064-3)

98-27 **Richardson, G. B.:** Production, Planning and Prices. (ISBN 87-7873-065-1)

98-28 **Foss, Nicolai J.:** Austrian Economics and Game Theory: a Preliminary Methodological Stocktaking. (ISBN 87-7873-067-8)

98-29 **Foss, Nicolai J. & Mahnke, Volker (p):** Strategy Research and the Market Process Perspective. (ISBN 87-7873-068-6)

98-30 **Laursen, Keld (p):** Revealed Comparative Advantage and the Alternatives as Measures of International Specialisation. (ISBN 87-7873-069-4)

99-1 **Lorenz, E.:** Organisationaal Innovation, Governance Structure and Innovative Capacity In British and French Industry. (ISBN 87-7873-070-8)

99-2 **Ernst, Dieter:** Responses to the Crisis: Constraints to a Rapid Trade Adjustment in East Asia's Electronics Industry. (ISBN 87-7873-071-6)

99-3 **Foss, N. J. :** Understanding Leadership: A Coordination Theory. (ISBN 87-7873-072-4)

99-4 **Foss, K & Foss, N. J:** Understanding Ownership: Residual Rights of Control and Appropriable Control Rights. (ISBN 87-7873-073-2)

99-5 **Foss, K & Foss, N. J:** Organizing Economic Experiments: The role of Firms. (ISBN 87-7873-075-9)

99-6 **Jørgensen Kenneth. M. (p) :** The Meaning og Local Knowledges. (ISBN 87-7873-076-7)

99-7 **Foss, N. J.:** Capabilities, Confusion, and the Costs of Coordination: On Some Problems in Recent Research On Inter-Firm Relations. (ISBN87-7873-

077-5)

99-8 **Lund, Reinhard:** Tillidsrepræsentantsystemet og de fleksiblevirksomhedsformer. Juli 1999. (ISBN887-7873-078-3)

99-9 **Nymark, Søren:** Organisatorisk læring gennem den værdibaserede organisations fortællinger. (ISBN 87-7873-079-1)

99-10 **Laursen, K. & Meliciani, V.:** The importance of technology based inter-sectoral linkages for market share dynamics. (ISBN 87-7873-080-5)

99-11 **Laursen, K.**, **Mahnke, V., Vejrup-Hansen, P.:** Firm growth from a knowlegde structure perspective. (ISBN 87-7873-081-3)

99-12 **Lundvall, Bengt-Åke, Christensen, Jesper. L.:** Extending and Deepening the Analysis of Innovation Systems - with Emperical Illustrations from the DISCO-project. (ISBN 87-7873-082-1)

00-1 **Llerena, Patrick & Oltra, Vanessa:** Diversity of innovative strategy as a source technological performance. (ISBN 87-7873-085-6)

00-2 **Llerena, Patrick & Mireille Matt:** Technology policy and cooperation: A paradigmatic approach. (ISBN 87-7873-086-4)

00-3 **Cusmano, Lucia:** Technology Policy and Co-operative R&D: the role of relational research capacity. (ISBN 87-7873-087-2)

00-4 **Mikkola, Juliana Hsuan:** Modularization assessment of product architecture. (ISBN87-7873-088-0)

00-5 **Yvrande, Anne:** The new British railways structure: A transaction cost economics analysis. (ISBN87-7873-089-9)

00-6 **Dijk, Machiel van &Nomaler Önder:** Technological diffusion patterns and their effects on industrial dynamics. (ISBN 87-7873-090-2)

00-7 **Storper, Michael & Chen, Yun-chung with De Paolis, Fernando:** The Effects of Globalization on Location of Industries in the OECD and European Union (ISBN87-7873-091-0)

00-8 **Sanders, Mark & Weel, Bas ter :** Skill-Biased Technical Change: Theoretical Concepts, Empirical Problems and a Survey of the Evidence (ISBN87-7873-092-9)

00-9 **Tomlinson, Mark:** Innovation surveys: A researcher's perspective (ISBN87-7873-093-7)

00-10 **Nymark, Søren:** Value-based management in learning organizations through 'hard' and 'soft' managerial approaches: The case of Hewlett-Packard

(ISBN87-7873-094-5)

00-11 **Yoguel, Gabriel; Novick , Marta & Marin, Anabel:** Production Networks: Linkages, Innovation Processes and Social Management Technologies (ISBN87-7873-095-3)

00-12 **Yoguel, Gabriel & Boscherini, Fabio:** The environment in the development of firms' innovative capacities: Argentine industrial SMEs from different local systems (ISBN87-7873-096-1)

00-13 **Arocena, Rodrigo & Sutz, Judith:** Interactive Learning Spaces and Development Policies in Latin America (ISBN87-7873-098-8)

01-01 **Mathews, John A.:** Competitive Interfirm Dynamics within an Industrial Market System (ISBN87-7873-099-6)

01-02 **Giarratana, Marco & Torrisi, Salvatore:** Competence accumulation and collaborative ventures: Evidence from the largest European electronics firms and implications for the EU technological policies (ISBN 87-7873-100-3)

01-03 **Nemirovsky, Adolfo & Yoguel, Gabriel**: Dynamics of high-technology firms in the Silicon Valley (ISBN 87-7873-101-1)

01-04 **Castellacci, Fulvio**: A 'technology-gap approach to cumulative growth': toward an integrated model. Empirical evidence for Spain, 1960-1997 (ISBN 87-7873-103-8)

01-05 **Nuvolari. Alessandro**: Collective invention during the British industrial revolution: The case of the Cornish pumping engine (ISBN 87-7873-104-6)

01-06 **Costa, Ionara**: Ownership and technological capabilities in Brazil (ISBN 87-7873-105-4)

01-07 **Foss, Nicolai J**.: Economic organization in the knowledge economy: some austrian insights (ISBN 87-7873-106-2)

01-08 **Cantwell, John & Kosmopoulou, Elena**: Determinants of internationalisation on corporate technology (ISBN 87-7873-107-0)

All correspondence concerning the DRUID Working Papers should be send to:

Jonna Jacobsen
Fibigerstræde 4
DK-9220 Aalborg OE
Tel. 45 96 35 82 65
Fax. 45 98 15 60 13

E-mail: druid-wp@business.auc.dk