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CORPORATE RESTRUCTURING AND THE CREATION OF THE INNOVATION MILIEU: THE CASE OF A SECOND-TIER HIGH TECHNOLOGY REGION

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ABSTRACT
This paper analyzes the evolution of a high technology innovation milieu and examines how changing corporate governance facilitated this evolution. The paper focuses on the high technology industry in the Portland-Vancouver metropolitan region. The region's largest employer, Tektronix, functioned as the first seedling for the Silicon Forest. The company was vertically integrated and centralized R&D activities in a separate laboratory. By the 1980s, Tektronix restructured and ceased its strategy of vertical integration and eliminated the laboratory. Silicon Forest's largest high technology employer today, Intel, is embedded in the innovation milieu that is characterized by a set of related firms, supportive business services, a high technology-friendly political environment, and quality of life that roots people and businesses. The paper analyzes the creation of a regional innovation milieu by illustrating the implications of corporate restructuring.

A few keywords: Regional Innovation Milieu, Corporate Restructuring, High Technology Industry, Economic Development, Universities

Introduction

This paper[1] analyzes the evolution of a high technology innovation milieu and examines how changing corporate governance facilitated this evolution. The paper focuses on the Portland-Vancouver metropolitan region. Over the last three decades, this Pacific Northwest region evolved into a second-tier high technology center, also known as Silicon Forest. In 2000, the region had more than 1,000 businesses that employed 68,891 workers. High technology in the Silicon Forest is highly specialized in industry segments such as semiconductors, test and measure instruments, display technology, printers, silicon wafers, and electronic design automation.

The region's largest employer, Tektronix, functioned as the first seedling for the Silicon Forest. The company was highly vertically integrated and centralized R&D activities in a separate laboratory. By the 1980s, Tektronix went through a process of corporate restructuring and ceased its strategy of vertical integration and eliminated the R&D laboratory. This restructuring process contributed to the emergence of the regional innovation milieu. Silicon Forest's largest high technology employer today, Intel, is embedded in the innovation milieu that is characterized by a set of related firms, supportive business services, a high technology-friendly political environment, and quality of life that roots people and businesses.

Silicon Forest's innovation milieu evolved from corporate restructuring processes. Today, the high technology industry is rooted in this milieu. Economic developers need to recognize that the milieu is an important component of the region's economic infrastructure and is responsible for rooting people and businesses in the region.

Post-Fordist industrial restructuring and regional economies

Theories of industrial restructuring are important for the analysis of the emergence of an innovation milieu because they provide important insights as to how changes in corporate organization paradigms transform regional economies. The post-Fordist theory of flexible specialization, which is closely associated with the work done by Michael Piore and Charles Sabel (1984), explains the shift from the Fordist model of mass production to a flexibly specialized, craft-oriented production model. The theory also provides useful insights as to how a region's economic environment can change as a result of the introduction of flexible specialization and post-Fordist production methods. Piore and Sable argue that at certain periods in time, a shift in the prevailing production paradigm takes place; this shift is called 'industrial divide.' Such a divide took place in the 1970s when the world economy stagnated and regulatory changes in international trade led to the emergence of globalization (Harvey, 1990).

As a result of global political and economic changes, increased foreign competition forced U.S. manufacturers (especially producers of high technology products, but also automobile makers and the film industry) to restructure their vertically integrated organizations. Before then, in the post-war decades of the 1950s and 1960s large and vertically integrated companies dominated the economic landscape. These companies focused heavily on a Fordist organizational model that emphasized mass production.

In the Fordist model, the conception and execution of products were two completely separate organizational functions. In many cases, the conception function was institutionalized in a central research laboratory in which Ph.D. level researchers worked on basic breakthrough

[1] An earlier version of the paper was presented at the 44th Annual Conference of the Association of Collegiate Schools of Planning, November 20 – 24, 2002 in Baltimore, Maryland, U.S.

discoveries. Prominent examples of centralized R&D laboratories in the electronics sector include Bell Labs, GE's General Engineering Laboratory, and Xerox PARC. In the pharmaceutical industry, DuPont, Abbott Laboratories and Eli Lilly centralized their research efforts in such laboratories. While R&D was centralized in these separate laboratories, other corporate functions were usually layered in a hierarchical and disintegrated manner within the corporation: "A second subordinate hierarchy of engineers translated the designs into instructions" (Sabel, 1994, p. 117).

In addition, vertical integration meant that the company incorporated many tasks in-house and did not necessitate a large network of suppliers. Consequently independent companies that integrated their corporate functions in-house did not rely on a regional support system of suppliers and subcontractors. Therefore, large corporations were more or less independent and did not rely on their regional economic environment.

In the Fordist model, the basic assumption was that innovations would be developed in the laboratory and then transferred in a linear fashion to the production units. This assumption represents the linear model of innovation and product development that is usually pursued by academic institutions. Cooke and Morgan state "for much of the postwar period, the linear model was the dominant model of innovation, a model so heavily influenced by the rise of the scientific community that it was sometimes called the 'science-push' model of innovation" (Cooke & Morgan, 1998, p. 12).

The problem with organizing technological innovation in the Fordist way was that the model was time and resource consuming. Technology transfer from the centralized R&D laboratory to production groups posed serious problems to internal management of the corporation because each of these processes was complex and organized in a separate manner (Friar & Horwitch, 1985). Also, the model of large-scale corporate R&D lacked a culture of risk-taking and entrepreneurship. At the time when globalization forced corporations to innovate rapidly, the Fordist model increasingly put the corporation into a disadvantage.

By the mid 1980s, scholars of technology management discovered that large-scale, centralized R&D was giving way to a model of small high technology firm entrepreneurship (Friar & Horwitch, 1985). The latter model is characterized by the reintegration of conception and execution and the combination of design and product engineering. In other words, firms increasingly incorporate innovation processes within other corporate functions such as manufacturing. Centralized R&D laboratories were eliminated and the factory turned into a laboratory in which new processes and technologies are now tested within the manufacturing environment (Florida & Kenney, 1993). Florida and Kenney termed this development 'innovation-mediated production.' (1993)

Florida and Kenney (1993) present compelling arguments for why U.S. high technology firms have had problems in competing with competitors from nations like Japan. Before facing competition from abroad, U.S. high technology firms did not organizationally integrate their R&D labs with the factory floor unlike their Japanese competitors. This organizational disintegration (and in some cases spatial separation) of corporate functions stifled the competitive advantages of U.S. based high technology firms. In contrast, Japanese-based high technology firms pioneered new modes of integration (i.e. total quality management, just-in-time, keiretsu, etc.) that enable them to generate a continuous flow of new products.

In an effort to externalize production costs, firms also increasingly began to rely on strategic alliances and subcontracting relationships with other corporate partners. Companies began to vertically disintegrate corporate functions and tasks. The process of vertical disintegration resulted in "spatial outsourcing of production processes into many small businesses which are closely interconnected with the parent company" (Sternberg, 1996, p. 525). As a result of vertical disintegration, inter-industry production networks began to take place. Scholars of regional economies claimed that the emergence of localized industrial districts or regional innovation systems had its roots in the process of vertical disintegration and the formation of inter-firm networks (Harrison, 1992; Annalee Saxenian, 1994). They theorized that the increased reliance on outside suppliers and subcontractors created regional agglomerations.

Post-Fordist organization of high technology regions

How does the post-Fordist industrial model influence regional economic development? Sabel makes a strong case for the ways in which flexible specialization encourages the geographical clustering of production activities (Sabel, 1989). He argues that the reliance on subcontracting and strategic alliances with other companies forces the producer to engage in interdependent relationships with other regional economic actors. In turn, "product-based area specialization leads to the growth of specialist services and other inputs as well as institutional support for what amounts to a central industrial cluster for a locality, thus serving to provide individual firms with a range of external economies of agglomeration" (Amin, 1994, p. 24)

Saxenian's (1994) study of Silicon Valley and Boston provides a powerful argumentation for the ways in which a high technology region was able to adapt to changes in markets and technologies. Silicon Valley's network-based industrial structure represents an example of a post-Fordist, flexibly specialized region in which firms rely on an innovation milieu that emerged from industrial restructuring efforts. According to Saxenian, this regional industrial system consists of regional institutions such as universities, business associations, and local governments. These regional institutions shape and are shaped by a certain local culture. The second element of the regional industrial system is the industrial structure, which refers to the social division of labor and the degree of vertical integration. The third dimension is the way in which firms are internally organized. Saxenian contrasts the hierarchical, vertically integrated industrial culture of Boston's 128 to the networked, vertically disintegrated culture in Silicon Valley. She attributes Silicon Valley's success to the more cooperatively organized industrial system that enables collective learning processes among the regional actors to take place.

Importance of regional innovation milieu

Why is such an innovation milieu now so important? The innovation milieu became more important with the change in the industrial paradigms. In the Fordist production model, firms did not influence the regional economic structure because they were self-sufficient. With the change to a post-Fordist model of production, corporations increasingly rely on other economic actors. As companies increasingly specialize and integrate their innovation processes, they need to incorporate suppliers and subcontractors. A supportive innovation milieu supports these firms because it provides a collective pool of knowledge and a common context for economic transactions. Since the regional economy is increasingly based on networks and interactions, trust is necessary to make these interactions work. Trust in turn is build through the local context with an industrial district that is characterized by a common cultural and institutional background (Harrison, 1992).

The theory of the innovation milieu was developed in the mid 1980s by European regional economists in the GREMI group[2] (Aydalot & Keeble, 1988; Camagni, 1991). Subsequently, other scholars incorporated and expanded on the approach (Castells, 1989; Castells & Hall, 1994; Garnsey, 1998; Lyons, 2000). At its core, the innovation milieu approach assumes that economic space is created through "social interactions, interpersonal synergies and social collective actions" by a variety of regional actors (Camagni, 1991, p.1).

The innovation milieu consists of the region's firms, professional associations, local and regional political authorities, universities and laboratories, schools, and individuals (Crevoisier & Maillat, 1991). Each of these regional actors has a different motivation and strategy in place. Firms for example in the pos-Fordist model rely on suppliers and subcontractors, they integrate innovation with production processes, and they rely on the regional networks. Regions that develop an innovation milieu possess a particular technology culture that evolves along certain trajectories, with a specific set of production capital and market relations that constitute a particular industrial organization.

A region's innovation milieu is built up by complex and interrelated dynamics. Institutions and routines are the cornerstones of such a milieu and regional actors develop them. Venture capital, for example, constitutes one important aspect of the innovation milieu. As a source of venture financing and as a source of management and business advice these venture capitalists play a fundamental role in high technology regions (Florida & Samber, 1999). Like venture capital, other specialized producer services such as patent lawyers, public relations firms, or employment agencies play important roles and contribute to the innovation milieu. They function as specialized subcontractors and suppliers. The cultural and political environments also play important roles in the formation of a region's innovation milieu.

While the GREMI group is successful in identifying the role and the components of the local environment for economic development, the group fails to be specific the processes by which a milieu is created. Castells specifies these critical ingredients and suggests that the following conditions are necessary for an innovative milieu to emerge: a) innovative technical knowledge, b) a large pool of scientific and technical labor, and c) availability of investors ready to risk capital. Castells suggests different sources of innovative technological information. Among those are higher education institutions, government-sponsored or corporate R&D. Both R&D centers and capital investors are closely connected to the locale in which they are located. Castells argues that this spatial embeddedness is necessary for the creation of a local innova tion milieu. In his theoretical elaboration, Castells, however, does not elaborate on the mechanisms by which knowledge and labor spills over to the regional context.

Storper (1997) criticized the innovation milieu theory for being circular. He states that the approach explains that "innovation occurs because of a milieu, and a milieu is what exists in regions where there is innovation." (p. 17) To avoid the problem of circularity, studies of regions that successfully developed innovation milieux should focus on the factors that gave rise to these particular socio-economic environments. The present study of the emergence of the Silicon Forest innovation milieu attempts to identify the pivotal events that led to the milieu's emergence. By focusing on the factors that lead to the creation of an innovation milieu – in particular the influence of corporate restructuring – we avoid this circularity. Such a focus will provide important insights as to how and why an innovation milieu emerges and shapes regional development patterns.

[2] GREMI stands for Groupe de Recherche Européen sur les Milieux Innovateurs. The group's aim was to develop a common theoretical framework to study innovative behavior.

Research question and hypothesis

This paper focuses on how changes in the industrial organization of a region give rise to a particular innovation milieu. The study of the emergence of an innovation milieu is valuable because the literature lacks systematic accounts of the evolution of regional industrial systems. It is hypothesized that the innovation milieu evolved because the region's largest and vertically integrated employer restructured and thereby created the seeds for high technology growth. Today, the region's high technology industry reflects a specialized industry cluster in which firms depend on the innovation milieu.

The research is based on the historiography of a region's high technology industry. Descriptive quantitative data is complemented with qualitative information from interviews with high technology representatives. Some preliminary insights from an economic development strategy analysis are added to the section on policy implications.

The research focuses on the two main high techno logy employers and their influence on the region's economy over time. It does not, however, focus on the analysis of networks between regional actors. Future research needs to ascertain the nature of interaction in the regional innovation milieu.

This study is particularly relevant to urban and regional planners because it highlights the socio-economic conditions, which support and enhance regional economic competitiveness. Public and private institutions (including planning departments and economic developers) are part of the socio-economic environment and their strategies and motivations can critically influence the future of the innovation milieu. Thus, public policymakers have to begin toe view themselves as part of the innovation milieu.

Portland's high technology specialization

Most of Portland's 1,000 high technology firms with 64,891 workers in 2000 are highly specialized in certain industry segments. Portland's high technology industry[3] is characterized by higher than average employment in hardware-related high technology segment such as SIC 357, 36, and 38 (see table 1). Total high technology location quotient for Portland's high technology industry is larger than in San Diego, Phoenix, and Seattle; region's that are considered high technology regions as well. Portland is smaller when compared to Silicon Valley, Boston, or Austin. This indicates that the region is a second-tier high technology center.

[3] The figure represents total high tech employment in the Portland-Vancouver Primary Metropolitan Statistical Area. High technology is defined to include SIC 357 (Office and computing machines), SIC 36 (Electronic and other Electrical Equipment), SIC 38 (Instruments and related products), and SIC 737 (Computer Services). This definition follows the definition used by the Oregon Employment Department.

Table 1 - High technology location quotients in select metropolitan areas, 2000

SIC	Portland	Silicon Valley	Boston	San Diego	Phoenix	Austin	Seattle
357	1.59	19.7	2.72	1.6	0.39	10.58	N/a
36	2.63	7.26	1.53	1.49	2.15	3.32	0.55
38	1.41	6.92	2.31	1.39	0.96	1.04	1.36
737	1.19	5.46	1.78	1.05	0.92	2.16	2.77
Total HT	**1.74**	**7.32**	**1.85**	**1.3**	**1.3**	**2.96**	**1.59**

Source: Bureau of Labor Statistics, ES202 Employment Data

High technology regions tend to specialize in certain sub-segments of the high technology industry (Cortright & Mayer, 2001). Thus, Portland's high technology industry is further characterized by higher than average employment in certain high technology industry segments such as test and measurement instruments, semiconductors and semiconductor manufacturing equipment, silicon wafers, electronic design automation, printers, and display technology. The location quotient for semiconductor manufacturing employment (SIC 3674), for example, was 10.31 in 2000, indicating that this industry segment is 10 times more concentrated in the Portland region than in any other region in the U.S.

The analysis of patent data for the Portland metropolitan region confirmed that Portland's high technology industry is highly specialized. Most high technology patents are registered in technology fields such as printing, electrical computers and digital processing, computer graphics, circuit design, among others (see Appendix 1).

A third dataset adds additional evidence for Portland's high technology industry specialization. Even though Portland's venture investment patterns followed the general trend of investing in Internet services and software during the latter half of the 1990s, venture capital investment was also channeled into the region's distinct specialization areas, such as semiconductors, display technology, and test and measurement.

Table 2 - Venture capital investment in the top 25 industry segments, 1995-2002

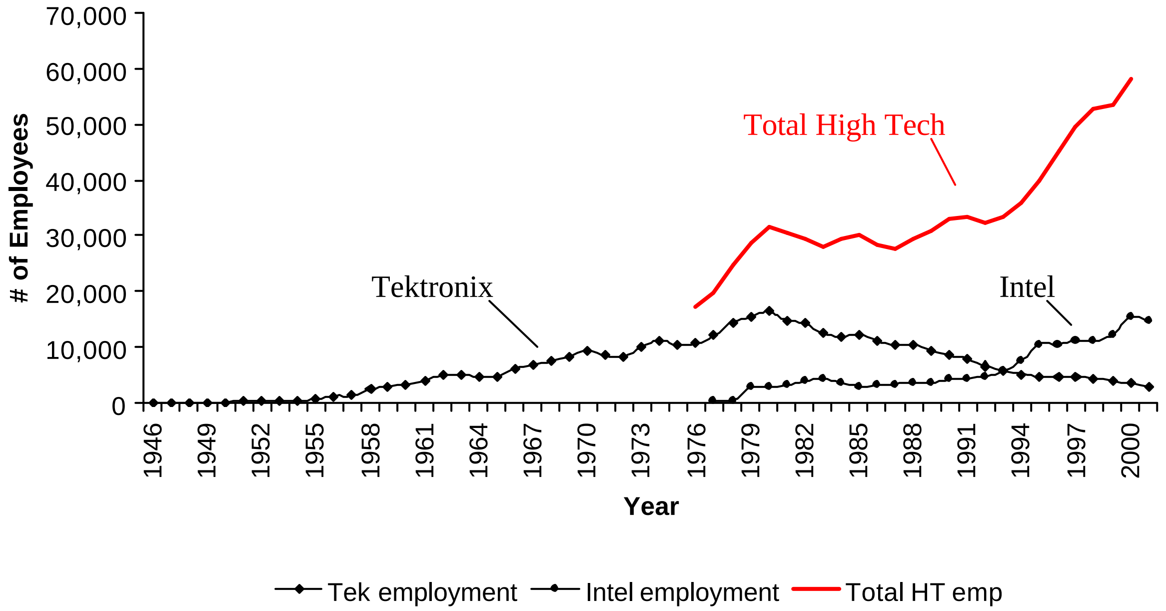
Technology Segment - Aggregate	1995	1996	1997	1998	1999	2000	2001	2002	# of deals, 1995-2002
Internet services	4	3	5	4	19	22	17	4	78
Specialized software	3	3	5	4	8	9	4	3	39
Health IT	2	3	2		5	3	6		21
Business services			4	1		8	2	2	17
Networking	2	2	2		3	4	1		14
Security software / internet		1	1	1	1	5	2	1	12
Telecommunication		1		2	2	4	2		11
Semiconductors		1	1	1	2	2	3		10
Sensor technology			2	3	1	2	1		9
Fault gas analyzers		2	4	1		1			8
Multimedia software	2	1	1	1	2	1			8
Biotechnology / Life sciences	1	2	2		1			1	7
Consumer products		1	2		1	2	1		7
Display technology	1		1	2		1			5
IT consulting / services		1	1		1	2			5
Medical instruments			4	1					5
Digital motor control technology		1	1		2				4
Electronic data services					1	1	1		3
Entertrainment software		1					1	1	3
Power supply equipment	1	1	1						3
Silicon wafer testing tools		1			2				3
Application service provider							1	1	2
Electric utility technology						1	1		2
Software	1	1							2
Speech recognition	1		1						2

Source: PriceWaterhouseCoopers MoneyTree Database

In sum, Portland's high technology industry is characterized by a particular set of specialized industry segments. The region's high technology industry grew by 5 percent annually since 1976. What is also interesting is that Portland was able to root a high technology cluster in the absence of a world-class electrical engineering and computer science university. This is contrary to claims made by case studies on California's Silicon Valley, Boston's Route 128, and North Carolina's Research Triangle Park. These studies focused on the importance of higher education institutions for the creation of high technology regions (Saxenian, 1985; Luger & Goldstein, 1990; AnnaLee Saxenian, 1994). In the Portland case, however, two dominant employers – Tektronix and Intel – have compensated for the absence of a research university and functioned as surrogate universities (Mayer, 2001). These dominant employers were also responsible for the ways in which Portland's innovation milieu formed.

Until the early 1980s, Tektronix dominated the region. The company was the largest employer and was characterized by a high degree of vertical integration. In the company's heyday, Tektronix employed 16,405 accounting for 85 percent of Portland's total high technology employment in 1980. By 2001, however, Tektronix had shrunk to 2,826 employees and represented only 0.05 percent of total high technology employment. In the meantime, Intel took root in the Silicon Forest and emerged as the area's largest high technology employer. In 2001, Intel employed 14,742 people accounting for 23 percent of Portland's total high technology employment (see figure 1).

Figure 1 - Tektronix' and Intel's share of Portland's total high technology employment, 1946-2001



Source: Company reports, Oregon Employment Department (ES202 data)

In the following, I will outline the ways in which two high technology firms, Tektronix and Intel have contributed to the creation of Portland's innovation milieu. In particular it will be shown how corporate restructuring processes led to the emergence of a regional innovation milieu.

Tektronix role in the Silicon Forest

When Tektronix was incorporated in 1946, the Portland region wasn't a high tech region yet and the firm found itself in the company of only a few other high tech employers. Tektronix quickly became known beyond the Pacific Northwest as the world's leading manufacturer of oscilloscopes. Demand for scopes surged in the postwar years and the company's market share rose to more than 60 percent. The combination of its monopolistic position with the isolation from other high technology centers at the time, contributed to a Fordist corporate strategy. Until the 1980s, Tektronix represented a highly vertically integrated firm that institutionalized research and development in a centralized laboratory that was separate from other corporate functions.

Since the oscilloscope was an instrument that needed to be as innovative as other electronics innovations, Tektronix put great effort into the quality of components and the production. Vertical integration began in 1949, when the company decided to manufacture its own transformers and inductors. Later in 1954, Tektronix decided to manufacture its own cathode ray tube, a device that displays the electronic currents. This strategy did not only affect the technical side of the business, but also corporate services such as PR and education. Tektronix' education program, for example, extended beyond training and incorporated general education offerings. A print shop printed all manuals and other documentation and the metal shop produced the metal covers for the oscilloscopes.

Tektronix' monopolistic position allowed an extensive focus on research and development efforts. The company had become profitable enough to fund a variety of experimental research projects and it was easy for management to liberally support innovative research ideas. By the early 1970s, R&D activities at Tektronix had become an important part of the company's operations and they were institutionalized within a separate corporate R&D laboratory, the so-called Tek Labs. The innovation culture within Tek Labs resembled that of a university very closely and Tek Labs' internal structure reflected the company's vertical integration. Research groups were separated by functions and specialization. They conducted leading edge research on display technologies, semiconductors, signal processing, computer and software among others.

Corporate restructuring seeds innovation milieu

During the 1980s, Tektronix increasingly experienced the pressures of competition and the financial burdens of its growing organization. Tektronix' immense organizational growth, vertical integration and product diversification were hard to maintain when competition became more intense and demanded quicker responses.

Market pressures also highlighted the problems with separating innovation from other corporate activities such as production and marketing. By setting up Tek Labs separately from other corporate functions, Tektronix allowed the development of an isolated ivory tower. Researchers within the Labs were increasingly out of touch with market demands and commercialization opportunities. Management in turn didn't understand the potential of research produced in the labs. Often projects were cancelled in the last minute. As a result, researchers and engineers became increasingly frustrated and many of them decided to leave the company to start their own business. Because of Tektronix' inability to turn innovation into products, Tek Labs increasingly turned into a generic development laboratory for the Silicon Forest.

The 1980s also marked the beginning of Tektronix' decline and the emergence of a Silicon Forest innovation milieu. Since the late 1940s, Tektronix had build up a critical mass of employees. When the company used layoffs to restructure its operations, it shed more than half of its employees. By the mid 1990s, Tektronix ceased Tek Labs and began to divest several of its business units. Vertical disintegration deepened the regional division of labor since most of the divested business units began to function independently within the Silicon Forest high tech industry cluster.

In sum, Tektronix' restructuring efforts seeded Silicon Forest's innovation milieu and thereby created the environment for other high technology firms such as Intel. In 1976, Intel began to locate a semiconductor manufacturing plant in the region. By the mid 1990s, Intel had evolved as the region's largest employer. During its growth, the semiconductor manufacturer took advantage of the innovation milieu that Tektronix created.

Comparing Tektronix to Intel

Intel and Tektronix are two contrasting examples of high technology firms. They evolved during different historical periods that were characterized by contrasting industrial paradigms as illustrated in table 2. Intel followed a model of research and development in which innovation became closely integrated with other corporate activities, namely production. Intel management consciously avoided the ivory tower approach by making R&D an integral part of manufacturing. Tektronix followed the model of the R&D lab that was separated from production and other corporate functions. By organizing innovation in a linear fashion, which emphasized science and basic research as the originator of new knowledge, Tektronix allowed the development of a separate ivory tower for research and development in which the culture of innovation resembled very closely that of a university.

R&D laboratories like Tek Labs played a prominent role in high technology companies until the 1980s. The establishment of these labs was a common practice for companies for which innovation was at the core of their corporate activities. The underlying organizing principle was the linear model of innovation, or science-push model (Freeman & Soete, 1999). In this model "technological innovation was essentially conceived as the application of 'upstream' scientific knowledge to the 'downstream' activities of product design, production, and marketing." (Cooke & Morgan, 1998, p.12) Industrial R&D laboratories like Tek Labs were used to produce this 'upstream' scientific knowledge. These corporate R&D labs were set up separately from the rest of the company and it was expected that innovation produced in the lab was handed to downstream activities like production in an assembly line fashion. However, as the economic environment changed, this principle put high technology companies at a disadvantage. The increasingly competitive environment demanded the integration of R&D activities with the rest of the corporation, namely production and manufacturing.

High tech companies like Tektronix were forced into a much faster pace of product commercialization. In order to keep up with a quicker pace, companies had to integrate their corporate functions. Additionally, other sources of knowledge and innovation (i.e. customers, suppliers, manufacturing shopfloor, etc.) became increasingly important.

For the first 40 year of its existence, Tektronix was able to afford being organized like a university because its success gave the company enough slack resources that were invested back into extensive research and development efforts and vertical organization. This in turn gave researchers the freedom to pursue work in a variety of scientific fields.

Intel represents a different model of R&D with different implications for the innovation milieu. From the beginning, Intel management looked at research and development as an integral part of semiconductor production. Intel deliberately decided not to organize R&D as a "separate ivory tower." Management was clear that in order to be successful in a highly competitive environment, Intel needed to adopt a R&D model that would allow the interaction with a variety of knowledge and innovation sources outside of R&D labs, like production engineers and technicians, suppliers and subcontractors.

Table 2 - A comparison of Tektronix and Intel

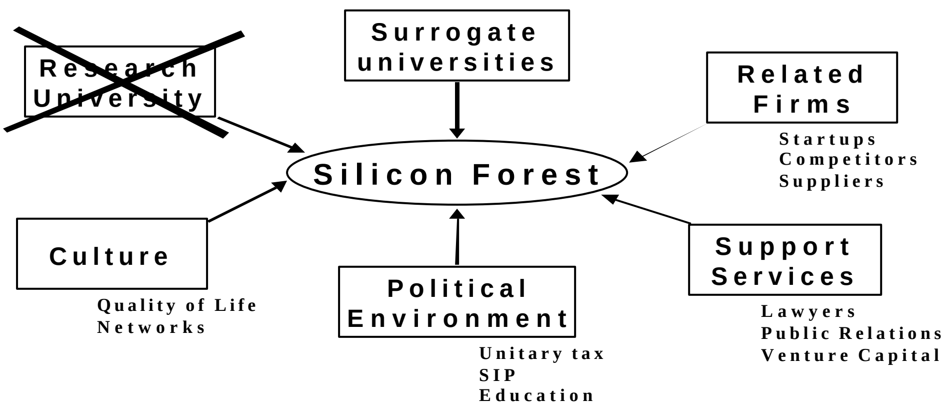
	Tektronix approach	**Regional Implications**	**Intel's approach**	**Regional implications**
R&D	Centralized R&D lab Late response to changing innovation paradigm propelled corporate failures	Tektronix functioned as incubator of basic research with potential for commercialization. Tek Labs evolved into region's "generic development lab."	Responded to changing innovation paradigm: Decentralized R&D, no separate lab.	Innovation is kept in-house. But limited spillovers to the region
Entrepre-neurship	Centralized R&D lab created wealth of innovation with many opportunities for commercial exploitation. Opportunities were not exploited by Tektronix management.	Opportunities for commercialization and employee frustration promoted regional entrepreneurship. Surge in regional startup activity.	Innovation is very focused on corporate intentions. Corporate policies motivate people to stay with company (i.e. stock options as golden handcuffs)	Few opportunities for commercialization didn't create wealth of startup activities. Corporate policies limited effects on regional entrepreneurship
Labor	Developed extensive in-house corporate education program. Wide-ranging education portfolio.	Evolved into a generic education and training provider. Labor pool benefited from it.	Imported many new hires from outside the region to leverage their knowledge. Very focused approach towards corporate education.	Affected region as labor magnet, mainly by importing hires. Limited effects from corporate education., leveraged local higher education infrastructure.

Silicon Forest innovation milieu

Tektronix' restructuring efforts spurred the creation of a regional innovation milieu. The company divested its business units and shed employees in an effort to become more competitive in a global market place. The company also ceased its central R&D laboratory. Frustrated and laid off employees started their own companies and contributed to the deepening of the region's division of labor and industry specialization. Tektronix' innovation areas contributed directly to the region's high tech specialization. High technology firms that subsequently took root in the Silicon Forest like Intel have not followed the Fordist organization model. They rather rely on the region's innovation milieu. The Silicon Forest innovation infrastructure consists of four components:

- Firms in related industries
- Support services
- Political environment
- Cultural environment

Figure 2 - Silicon Forest's innovation infrastructure

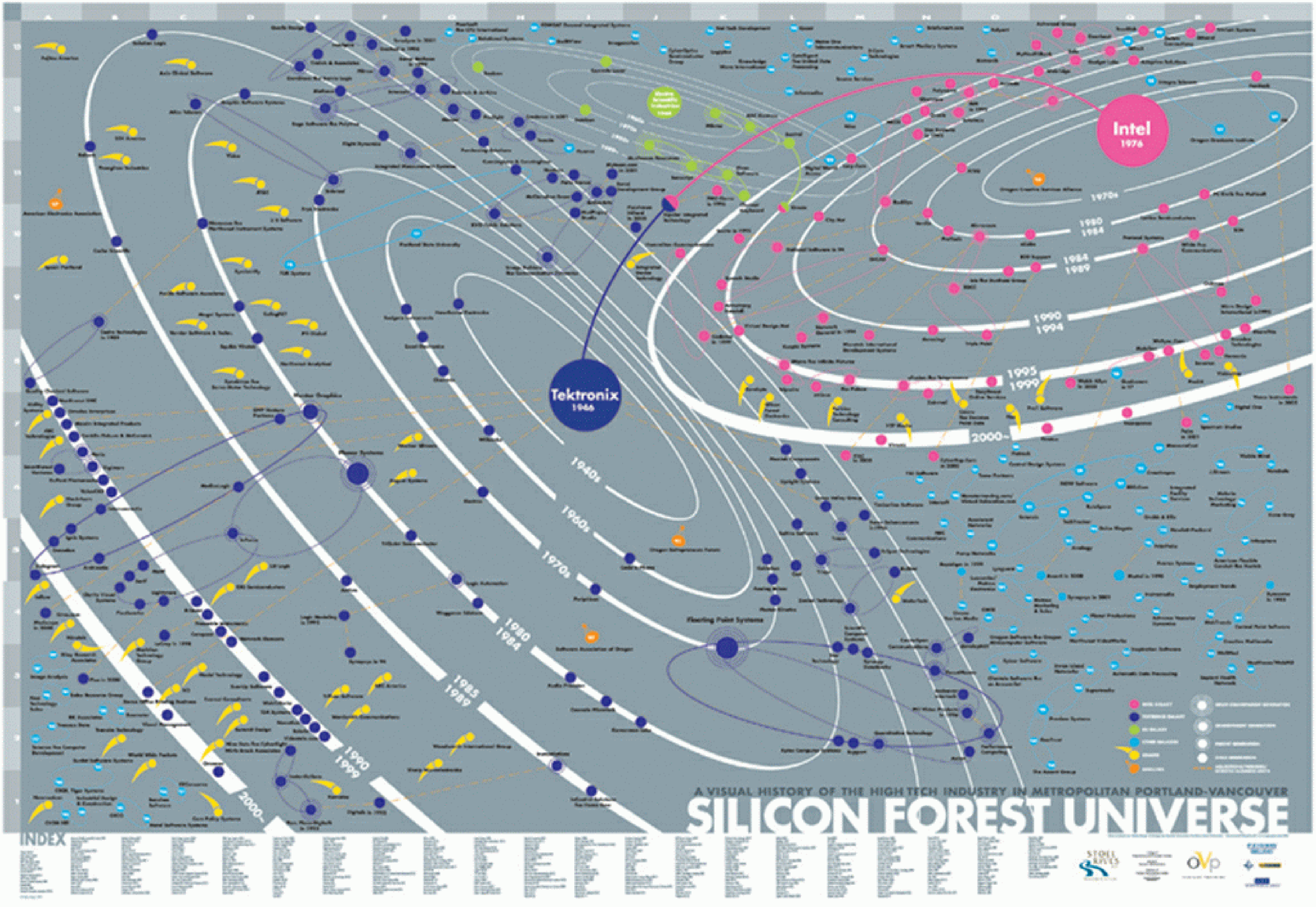


Firms in related industries

Through Tektronix' influence on entrepreneurship, a set of firms in related high tech segments took root in the Silicon Forest. Tektronix startups contributed to the diversification of the regional high tech industry (see Figure 3). In many cases, they have become viable and successful competitors to other firms in the region. Intel's presence in the Silicon Forest contributed to the attraction of a diverse set of suppliers critical to the company's local operations. Semiconductor manufacturing equipment makers are part of today's Forest. Intel can also draw on specialized suppliers such as companies that provide chemicals to semiconductor manufacturing.

Intel's presence in the Silicon Forest attracted the attention of competitor firms. Foreign-based semiconductor companies (i.e. Fujitsu America, WaferTech, etc.) began to locate in the region thereby taking advantage of the established supplier infrastructure and the specialized pool of labor.

Figure 3 - Silicon Forest entrepreneurship



Support services

High technology firms rely on specialized support services such as patent lawyers, public relations companies, management consulting firms, employment agencies, and venture capitalists. Over the past two decades, Portland was able to build up a critical mass of such specialized services that companies can draw from. Among these are venture capital firms that play an important role in the creation of new businesses. Venture capitalists not only provide seed investments, they also provide networking and mentoring services to the entrepreneurs. They oftentimes put together the management team that is needed for the company to succeed.

Portland's Silicon Forest has seen ups and downs in the amount of venture capital that flowed to the region. During the mid 1980s the region benefited from an inflow of venture capital and consequently the region saw more startup activity peaked. During the first half of the 1990s there was little venture capital activity. But by the end of the 1990s, this trend reversed and the dot.com boom brought venture capital investments back to the region.

Political environment

Instead of being proactive, the political environment in the Silicon Forest is characterized as being reactive to high technology growth. Motivated by the decline of the timber industry in Oregon and the first signs of high tech success, policymakers changed the state's tax structure to help recruit capital-intensive and foreign-based high technology companies. Thus, in the mid 1980s, state legislatures repealed the so-called unitary tax, which was aimed at taxing multinational corporations on their worldwide revenues. As a result Japanese-owned high technology corporations moved branch plants to the Silicon Forest (such as NEC, Epson Portland, and Fujitsu). In the early 1990s, state legislatures instituted the Strategic Investment Program (SIP), which allowed Oregon counties to grant tax breaks to corporate capital investments. The passage of the SIP program in the early 1990s was especially pivotal to Intel's evolution in the Silicon Forest because it came at a time when Intel made significant capital investments to expand its manufacturing facilities. The first SIP tax break was granted to Intel in 1994 (which covered $3.2 billion of investments for the conversion of D1A into Fab15). In 1999, Intel applied for the third SIP tax break. This time, the tax break covers $12.5 billion in investments for the next 15 years.

The absence of a better higher education infrastructure wasn't unnoticed by business leaders and policy makers. Over the years, efforts to improve education offerings were undertaken. In the early 1960s, the Oregon Graduate Institute (OGI) was established with substantial financial help from Tektronix. The Institute was modeled after Stanford University. However, OGI never received enough funding necessary to grow into a Stanford- or MIT-like institution. The recent merger of OGI with Oregon Health Sciences University into Oregon Health and Sciences University might influence OGI's impacts on education offerings and the creation of new industry clusters such as biotechnology.

As a corporate citizen, Tektronix has always been a proponent of a better higher education infrastructure. As a company that provided extensive education offerings to its employees, it realized the importance of education to high tech success. Through philanthropic contribution to education institutions in the area (i.e. Reed College – the alma mater of Tektronix founder Howard Vollum, OGI, and others) Tektronix tried to boost the standing of these institutions. Intel in contrast did not assume the role of a corporate citizen for a long time. Only in the early 1990s, when the company assigned a senior executive as Oregon manager to its site in the Silicon Forest, has the company been more involved in public decision making. While this involvement in the beginning was mainly geared towards tax break programs, Intel's discourse increasingly revolved around higher education by the end of the 1990s.

Cultural environment

The final component of the Silicon Forest innovation infrastructure is the cultural environment. Portland is often heralded as a unique metropolitan area for its quality of life. This quality of life roots skilled individuals and businesses and functions as important magnet for labor. Silicon Forest entrepreneurs are reluctant to leave the region because they like to live here and conduct their business at their place of residence. Quality of life has been an essential component of Portland's economic development.

In addition to quality of life Portland's high tech firms benefit from collaboration created through informal networking. In contrast to the East Coast, West coast companies are often thought to be less hierarchical and more informal. This in turn promotes networking within the firm and between companies. This is believed to be an important component of the knowledge-based economy because if people are networking with each other then knowledge is transmitted. Such knowledge transfer is critical for tomorrow's success of high tech firms. Silicon Forest firms embrace the more informal West Coast style of conducting business.

Implications for regional development theory

In Portland, the innovation milieu emerged from corporate restructuring processes. In particular, Tektronix' switch to a post-Fordist model facilitated the creation of the regional innovation milieu. The innovation milieu provides the fertile ground for high technology seeds to take root and grow and contributes to long-term success in high technology. Today's high technology firms, such as Intel, depend on this milieu, rely on regional suppliers and subcontractors, as well as specialized local support services. Proximity minimizes transaction costs and contributes to knowledge exchange and collective learning processes.

This is an important theoretical implication because it refutes the idea of a borderless world in which information and communication technologies make the conduct of corporate transactions seamless. As the rise of global telecommunications networks paved the way for economic globalization, scholars expected the "death of distance" (Cairncross, 1997). Consequently, it was assumed that the importance of cities and regions for economic activities would decline. But as this study showed, the opposite happened: as globalization took place, cities and regions have become more relevant as platforms for certain economic, and cultural interactions because they provide the innovation milieu and the context necessary to achieve corporate competitiveness.

Other theories of regional economic development also focus on aspects of the local environment and their influence on economic performance. Michael Porter's theory of industry clusters, for example, outlines the ways in which the local environment enhances a firm's competitiveness (Porter, 1990; 1998; 2000). Porter's theory, however, does not provide an explanation of how such an environment evolves. This is also a shortcoming of GREMI's innovation milieu approach. This study, however, tries to avoid these shortcomings by taking a historical perspective on the emergence of a regional innovation milieu. Moreover, by studying firm strategies and their implications for regional development, in the tradition of Markusen's approach of 'studying regions by studying firms' (Markusen, 1999), this study is able to provide a detailed analysis of the emergence of the Silicon Forest innovation milieu. Future studies of innovation milieus should investigate corporate strategies and structures and in particular how these corporate practices change over time.

The emergence of Portland's innovation milieu, as shown by the research in this study, reveals that the initial driver was increased international competition that spurred the change from the Fordist to the post-Fordist paradigm. In the Portland region, an 'industrial divide' (Piore & Sabel, 1984) took place in the early 1980s. Under the Fordist organization paradigm, Tektronix did not rely on a local innovation milieu because its vertical integration made it self-sufficient and independent of local suppliers. Until the 1980s, Portland's economy was relatively small and did not have a significant concentration of high technology activity. In this market Tektronix maintained a monopolistic position, enabling it to invest significantly in research and development and the establishment of Tek Labs. Knowledge creation and innovation processes were not as time sensitive as they would become when globalization took place. When market conditions changed in the 1970s and 1980s, Tektronix management became aware of the company's weak competitive position and responded by divesting business units, eliminating Tek Labs, and laying off employees. Consequently, Tektronix' restructuring spurred the creation of Portland's innovation milieu.

Intel in contrast relied heavily on Portland's innovation milieu from day one. The company is in essence place-bound and represents a corporation that adopted the post-Fordist paradigm of flexible specialization. Innovation and knowledge creation processes are closely connected and integrated with other corporate activities such as production. Intel depends on suppliers and subcontractors. Furthermore, employees value a high regional quality of life and the company takes advantage of a supportive political environment. This innovation milieu is a necessary element in Intel's success.

The detailed analysis of Portland's innovation milieu also revealed that traditional neo-classical location factors such as land and production inputs like water and electricity were not pivotal for the industry's growth. Qualitative aspects of the region's economy such as the industrial mix (suppliers, competitors, business support services, etc.), quality of life, and a supportive political environment have been more important for the growth of the Silicon Forest. Studies of local high technology industries and economic development policies need to focus on these qualitative aspects. In recent years, economic development research has taken these aspects into account. Florida (2000; 2002), for example, examined the location characteristics that help attract and retain highly skilled and talented workers in a region. He calls this group of people the 'creative class' and argues that this segment of the population chooses to live in locations with high quality of life. The Portland region's high quality of life is indeed responsible for rooting people and businesses. This confirms the importance of these intangible location factors.

Policy Implications

This study and a preliminary analysis of an inventory of economic development strategies form the basis for the following policy implication discussion. As the research showed, Portland's innovation milieu was created through the corporate restructuring of Tektronix. Today's high technology firms, such as Intel, rely on the local environment, in particular on the innovation milieu. This implies that economic development policies need to adopt an innovation milieu focus.

The strategy analysis, however, revealed that economic developers do generally not adopt a holistic innovation milieu focus. Economic development efforts in the Portland metropolitan area do not relate with the innovation milieu components. Most efforts focus on recruitment and retention, industrial land supply, workforce development, and business climate issues. The core components of the innovation milieu – i.e. industry cluster dynamics and networks, business support services, quality of life, supportive political environment – are missing.

Economic development policies need to take into account that the components of the innovation milieu play an important role in the competitiveness of today's high technology firms. The industry is place-bound and depends on the industrial, political, and cultural environment. Regarding the industrial environment economic development policies need to focus on the distinct set of industry clusters in this region (including related firms such as suppliers, competitors, subcontractors, etc.). Recruitment strategies, for example, would need to be targeted at companies that fit the set of firms already present in the region. The region also needs to preserve its high quality of life because it plays an important role in attracting and retaining employees and businesses.

The analysis of economic development strategies revealed that while the majority of these strategies adopt a cluster-based approach to economic development, they fail to be more specific about the dynamics of the innovation milieu. Policies are devised to improve capital formation, research and development at the local universities, and workforce development. These strategy areas, however, do not specifically address the region's high technology specialization.

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Appendix 1 - Location quotient for high technology patent classes, 1975-1999 (ranked by 75-99 LQ)

Patent Class	Title	LQ 75-79	LQ 80-84	LQ 85-89	LQ 90-94	LQ 95-99	LQ 75-99
347	Incremental Printing of Symbolic Information	2.19	1.39	4.86	6.17	8.77	7.36
712	Electrical Computers and Digital Processing Systems: Processing Architectures and Instruction Processing (e.g., Processors)	1.53	2.02	1.85	3.06	6.51	6.35
713	Electrical Computers and Digital Processing Systems: Support	-	-	2.33	1.05	5.84	6.08
709	Electrical Computers and Digital Processing Systems: Multiple Computer or Process Coordinating	-	4.69	0.81	1.57	4.50	5.16
345	Computer Graphics Processing, Operator Interface Processing, and Selective Visual Display Systems	1.64	2.94	10.38	4.79	3.47	5.10
711	Electrical Computers and Digital Processing Systems: Memory	-	2.65	2.65	4.20	4.76	4.99
710	Electrical Computers and Digital Data Processing Systems: Input/Output	-	3.01	2.94	3.49	4.64	4.87
327	Miscellaneous Active Electrical Nonlinear Devices, Circuits, and Systems	2.91	2.37	8.00	5.75	3.18	4.49
330	Amplifiers	4.55	5.29	7.85	3.70	2.16	4.28
349	Liquid Crystal Cells, Elements and Systems	-	-	6.20	5.00	3.46	4.21
348	Television	2.66	2.01	3.28	3.39	3.85	3.53
395	Information Processing System Organization	-	3.63	2.38	2.60	2.68	3.37
323	Electricity: Power Supply or Regulation Systems	-	3.62	4.70	1.18	3.82	3.31
353	Optics: Image Projectors	-	1.46	-	4.28	7.35	3.27
714	Error Detection/Correction and Fault Detection/Recovery	0.58	2.78	4.22	1.97	2.55	2.98
341	Coded Data Generation or Conversion	0.52	2.11	4.67	3.23	2.06	2.79
326	Electronic Digital Logic Circuitry	-	-	3.39	3.22	2.25	2.76
708	Electrical Computers: Arithmetic Processing and Calculating	2.26	2.50	3.02	3.57	2.37	2.76
178	Telegraphy	-	-	3.73	1.35	5.68	2.74
241	Solid Material Comminution or Disintegration	3.32	2.80	3.72	4.06	1.19	2.70
313	Electric Lamp and Discharge Devices	3.52	3.32	2.80	3.04	2.03	2.62
324	Electricity: Measuring and Testing	1.90	2.18	3.49	3.20	1.90	2.62
702	Data Processing: Measuring, Calibrating, or Testing	1.11	0.62	5.43	2.70	1.31	2.57
377	Electrical Pulse Counters, Pulse Dividers, or Shift Registers: Circuits and Systems	1.19	1.51	3.02	6.38	2.65	2.44
706	Data Processing: Artificial Intelligence	-	-	4.26	1.26	2.02	2.33
333	Wave Transmission Lines and Networks	2.13	2.54	4.11	2.57	0.33	2.10
380	Cryptography	-	-	-	1.03	3.58	2.09

Patent Class	Title	LQ 75-79	LQ 80-84	LQ 85-89	LQ 90-94	LQ 95-99	LQ 75-99
140	Wireworking	3.95	-	2.70	4.71	-	2.02
382	Image Analysis	-	6.34	1.12	1.05	1.92	2.01
331	Oscillators	0.54	1.90	3.50	0.63	2.46	2.01
358	Facsimile and Static Presentation Processing	-	0.72	3.16	1.52	1.89	2.00
381	Electrical Audio Signal Processing Systems and Devices	2.79	1.51	2.28	2.94	1.28	1.97
365	Static Information Storage and Retrieval	-	2.55	3.13	3.72	0.99	1.90
117	Single -Crystal, Oriented-Crystal, and Epitaxy Growth Processes; Non-Coating Apparatus Therefor	-	-	0.57	-	4.93	1.87
438	Semiconductor Device Manufacturing: Process	0.47	2.03	1.67	1.52	1.55	1.69
335	Electricity: Magnetically Operated Switches, Magnets, and Electromagnets	0.98	3.96	1.63	1.30	1.31	1.57
707	Data Processing: Database and File Management, Data Structures, or Document Processing	-	-	1.29	0.26	1.32	1.50
320	Electricity: Battery or Capacitor Charging or Discharging	4.27	1.15	-	1.08	1.40	1.41
370	Multiplex Communications	-	0.91	0.74	1.49	1.33	1.40
355	Photocopying	-	-	2.64	2.08	2.39	1.35
307	Electrical Transmission or Interconnection Systems	1.40	1.08	1.76	1.46	1.17	1.35
174	Electricity: Conductors and Insulators	1.30	1.53	1.43	0.76	1.50	1.32
361	Electricity: Electrical Systems and Devices	0.79	0.77	1.72	1.18	1.31	1.31
116	Signals and Indicators	1.13	1.10	1.27	3.03	0.45	1.29
375	Pulse or Digital Communications	-	0.49	1.28	1.30	1.17	1.28
340	Communications: Electrical	0.88	1.20	1.31	1.28	1.09	1.19
474	Endless Belt Power Transmission Systems or Components	2.99	-	1.49	0.78	0.71	1.11
322	Electricity: Single Generator Systems	5.01	3.37	-	-	-	1.11
352	Optics: Motion Pictures	4.41	-	-	-	-	1.09
283	Printed Matter	6.02	-	-	1.22	0.91	1.09
455	Telecommunications	0.33	1.42	0.45	1.92	0.83	1.08
318	Electricity: Motive Power Systems	0.26	0.47	1.24	1.44	1.34	1.06
200	Electricity: Circuit Makers and Breakers	2.39	1.79	0.63	0.79	0.61	1.05
257	Active Solid -State Devices (e.g., Transistors, Solid-State Diodes)	-	1.77	1.13	0.81	0.97	1.04
704	Data Processing: Speech Signal Processing, Linguistics, Language Translation, and Audio Compression/Decompression	4.05	-	-	0.37	1.05	1.00