Portland's Knowledge-Based Economy

Regional Connections
Working Paper 2

Joseph Cortright
Heike Mayer

February 2000

Regional Connections Project
Institute for Portland Metropolitan Studies
Portland State University

www.upa.pdx.edu/ims/regcon/regecon.html.

Working Paper

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REGIONAL CONNECTIONS

Portland's Knowledge-Based Economy

By Joseph Cortright & Heike Mayer
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The driving force in Portland's high technology industry expansion is the emergence of the region as a key center for new knowledge creation. Various indicators underscore the region's progress in knowledge creation. Patenting activity is growing more rapidly in the metro area than in the nation, spurred largely by the growth of high technology, which accounts for the bulk of the region's patent activity. The region's population is becoming among the best educated in the nation: one-third of adults now have a four-year degree or higher level of education, placing metro Portland among the ten best educated larger metropolitan areas. Unlike other high tech centers, Portland's strengths in high tech knowledge creation and strong educational attainment seem to have been achieved without the presence of a perceived world-class research university. The growth of the high tech industry itself, particularly large firms such as Tektronix and Intel, have played a crucial role in stimulating the development of the region's knowledge base.

Knowledge creation is the central feature of high technology industrial activity. Well-educated people working with cutting edge technology, develop new ideas for better products and production techniques. One of the chief measures of any high tech region is its record for creating new ideas and its capacity for continuing to do so. Here we offer some statistical measures of Metro Portland's knowledge creation activity, and examine the region's capacity, measured by educational attainment, for continued innovation.

Regional Connections is an ongoing effort to analyze and explain the structure and performance of the Portland Metropolitan Economy, sponsored by Portland State University's Institute for Metropolitan Studies. Funding for this project has been provided in part by lottery funds from the Regional Strategies program for Multnomah and Washington Counties, administered by the Portland Development Commission and the Oregon Economic and Community Development Department., and from the American Electronics Association and Portland State University.

Regional Connections work products include a technical report - "Progress of a Region: The Metropolitan Portland Economy in the 1990s"- briefings on the regional economy and a series of working papers summarizing the project's studies of the region's industry clusters, including high technology, metals, creative services and nursery products.

For more information about Regional Connections, contact Ethan Seltzer at 503-725-5170 or visit our website at www.upa.pdx.edu/ims/regcon/regecon.html.

Patent Activity

The number of patents issues in a metropolitan area is a good rough indicator of innovative activity. Patent data shows that Metro Portland' now ranks 24th among US metropolitan areas in the total level of patents, and patenting is growing two-thirds faster in the metro area than in the nation. Electronics and software firms accounted for about 60 percent of metro Portland's patents in 1998, led by Intel, Tektronix, Hewlett Packard and Sharp Laboratories. Over the past five years, metro Portland has emerged as the most prolific of Intel's research operations, accounting for an absolute majority of all patents issued to Intel researchers in the United States. These patent data underscore the importance of new knowledge creation as one important reason for the region's strength in high technology. The region's cluster established itself and grew without the presence of a great research university. Nor is Portland's high tech center simply a collection of production-only branch plants. Even firms headquartered outside the region conduct large parts of their research and development activities in Portland.

Educational Attainment

The educational level of the workforce, measured by years of education completed, is a widely used yardstick for assessing the capacity for knowledge creation. One-third of metropolitan Portland's adult population has a four-year college degree or more education, ranking the region among the ten best educated large metropolitan areas. Educational attainment in the region, always somewhat above the national average, has improved dramatically in the 1990s, coincident with the region's high tech boom and the in-migration of many well-educated new residents.

Educational Institutions

Studies of the nation's other high tech regions (Boston, Silicon Valley, Research Triangle Park) frequently mention the leading role played by world-class universities in providing the initial ideas, the trained workers and the nurturing climate for the growth of knowledge-based firms. Interviews with Portland-area high tech firms confirm the notion that this region has grown a substantial high tech complex in the absence of a strong research university. High tech firms report valuing world-class higher education for the marquee-value it would provide (ratifying the region's significance as a high tech center), as a source of continuing education for current workers, and a source of newly trained graduates, and also as a source of research. Metro Portland's lack of a strong university has been compensated for by large private firms—once Tektronix, now Intel—that have acted as surrogate universities. Over the past several decades these companies have given the region a recognizable, respected big name, with a strong research function that attracts talented people to the region. Whether the region can depend on the private sector to continue to perform this key function in the years ahead is uncertain.

A better educated population, rapidly growing research and development expenditures and a critical mass of high tech firms, combined with the region's high quality of life have formed a virtuous circle that have helped sustain the region's economy.

We're used to thinking of economies as centering on the production of stuff -- lumber, wheat, computer chips. But, increasingly our economy is being driven by the production of knowledge. Economic advantage comes not so much from being cheaper at producing the products that everyone knows how to make, but from figuring out new and better ways to make products that no one else does. Entrepreneurship, innovation, and new ideas are all key to this process.

One of the troubles with understanding this new knowledge economy is that all of our yardsticks were designed for measuring the old economy of goods. We simply do not have good measures of knowledge creation.[1] The measures we do have, however, tell a powerful story about the evolution of the Portland economy, the key role of the high tech sector, and the character of the operations of the state's largest manufacturing employer.

I. Patents and Innovative Activity in Metropolitan Portland

Patents are a useful indicator to measure the pace of knowledge creation in form of officially registered technological improvements. While not all patents are of equal scientific (or economic) value, and while many significant innovations are never patented (because they are more valuable as undisclosed trade secrets), patenting is a good rough measure of new knowledge.

Patenting plays a key role in enabling and encouraging firms to create new techniques and technologies. Since the beginning of the nation, the Constitution has provided that the federal government may grant patents, essentially a limited monopoly on an original idea, to persons and businesses. Patents (and the courts to enforce them) give inventors a way of capturing the economic gains from their particularly good ideas, and create the incentive to further innovation.

One of the best available indicators of intellectual activity in different places is the residence of patent holders. Scholars have used data on the geographic distribution of patents for several years to try and quantify knowledge creation and knowledge flows (Jaffe, Trachtenberg et al. 1993), (Fogarty 1999).

Data on who gets patents, the kind of invention for which they are issued and where the inventor lives, provides a very detailed picture of innovative activity throughout the nation. Recently, the U.S. Patent and Trademark Office, has begun publishing (on the Internet) detailed data on the numbers of patents issued by county, metropolitan area and by company for the past decade.

U.S. inventors got more than 80,000 patents in 1998, a figure that nearly doubled from the level of 47,500 recorded in 1990.(US Patent and Trademark Office 1998) The

[1] Ironically, the lack of data about knowledge creation may have blinded scholars to measuring the role that knowledge creation plays in driving economic growth. As Paul Romer has pointed out, the absence of data on new ideas and knowledge flows drives economists to model only those things they can get data on: chiefly capital investment and labor. (Romer, 1994)

increase in patent activity is due in part to court decisions that have had the effect of increasing the value of patent rights. Some studies suggest that this has increased the number of patents filed. The effect appears to be particularly strong in the semiconductor industry where patenting increased more than two and a half times faster than in all industries in the early 1990s (Hall and Hunt, 1999).

New ideas and innovations are particularly important in the electronics and semiconductor industry, where products and production processes are constantly changing. The changing nature of the industry becomes obvious if we look at the fact that sales of products less than two years old account for a majority of all sales by Oregon electronics firms (American Electronics Association, 1998).

Patent data show not only the volume of innovation but its geography as well. Not surprisingly, the metropolitan area with the greatest number of patents was San Jose, home of Silicon Valley, where more than 4,900 patents were granted in 1998.

Table 1: Top 25 Metro Areas Ranked by Patent Activity 1990 and 1998

Rank	Metro Area	1990	1998
1	San Jose, CA	1,295	4,931
2	Boston-Worcester-Lawrence-, MA-NH	2,051	3,687
3	Chicago, IL	2,086	2,959
4	Los Angeles-Long Beach, CA	1,586	2,335
5	Minneapolis-St. Paul, MN-WI	1,154	2,051
6	Detroit, MI	1,342	1,913
7	Philadelphia, PA-NJ	1,213	1,758
8	New York, NY	1,084	1,749
9	Rochester, NY	915	1,749
10	San Francisco, CA	557	1,705
11	San Diego, CA	761	1,673
12	Orange County, CA	891	1,484
13	Dallas, TX	750	1,471
14	Oakland, CA	629	1,461
15	Houston, TX	1,009	1,445
16	Austin-San Marcos, TX	354	1,440
17	Washington, DC-MD-VA-WV	755	1,292
18	Seattle-Bellevue-Everett, WA	573	1,275
19	Phoenix-Mesa, AZ	493	1,182
20	Atlanta, GA	461	1,034
21	Middlesex-Somerset-Hunterdon, NJ	702	1,027
22	New Haven-Bridgeport-Stamford, CT	770	1,024
23	Newark, NJ	837	1,014
24	Portland-Vancouver, OR-WA PMSA	384	948
25	Raleigh-Durham-Chapel Hill, NC	233	828

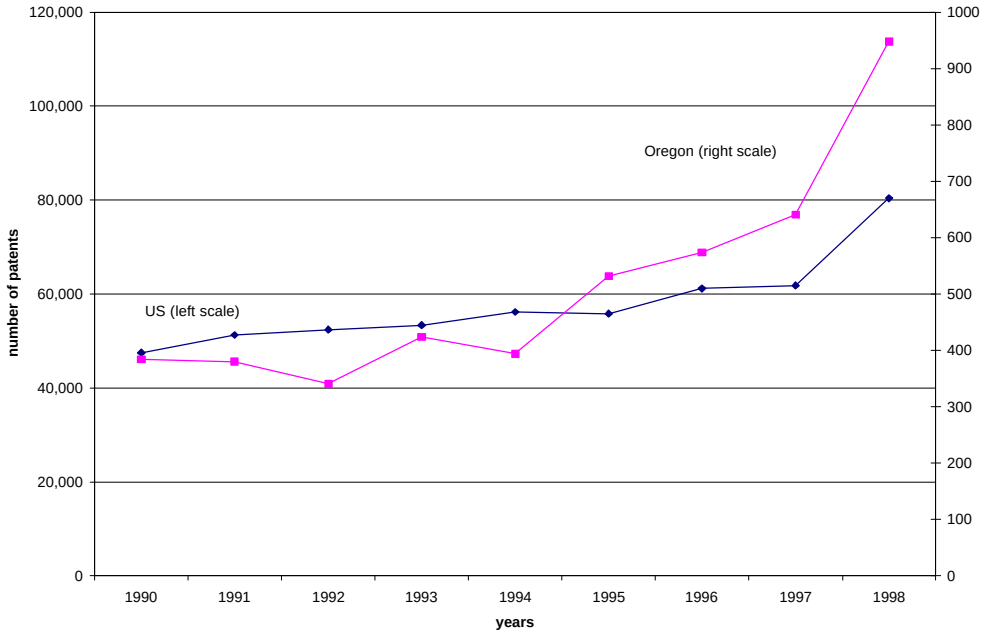
Source: U.S. Department of Commerce, Patent and Trademark Office, April 1999

We often think of research and development as being the product of universities and dedicated research laboratories. But the patent data show that innovative new ideas are

mostly the product of commercial endeavors. Even in Silicon Valley, Stanford University accounts for only six-tenths of one percent of all patents issued, with nearly all the others accounted for by local businesses, especially high tech firms.

Portland, the nation's twenty-sixth largest metro area, ranks 24th in patents activity. But patenting has been growing much more rapidly in the Portland area than elsewhere. Between 1990 and 1998, patent activity in the Portland metro area increased 10 percent per year compared to 6 percent in the rest of the nation.

Chart 1: Patent Growth in the U.S. and Portland 1990 to 1998



Source: U.S. Department of Commerce, Patent and Trademark Office, April 1999

As elsewhere, the majority of Portland's patents are awarded to private businesses. The companies that account for the bulk of the region's patents represent the region's decisive strengths in knowledge-creation. The leaders are all high tech firms - Intel, Hewlett Packard and Sharp Microelectronic Technology. Also represented are other areas where Oregon firms are technology leaders, Nike in shoes, Freightliner in trucks, and Oregon Health Sciences University in medical research.

While many lament the lack of a world-class research institution in the Portland area, this factor has not prevented local high tech businesses from aggressive technology development efforts. Electronics and software firms accounted for about 60 percent of all of the region's patents in 1998.

Table 2: Top Ten Patenting Firms in Portland MSA, 1998

Rank	Organization	1994	1995	1996	1997	1998	Total
1	Intel Corporation	47	105	192	194	341	879
2	Individually Owned	100	103	93	133	128	557
3	Tektronix Inc.	35	57	53	35	53	233
4	Hewlett-Packard Company	26	40	30	34	52	182
5	Sharp Microelectronic Technology	4	7	5	9	24	49
6	Nike, Inc.	8	10	1	7	11	37
7	Oregon Health Sciences University	4	7	8	7	7	33
8	In Focus Systems, Inc.	4	4	7	4	8	27
9	Freightliner Corporation	1	0	1	4	17	23
10	A-Dec, Inc	7	7	0	4	3	21

Source: U.S. Department of Commerce, Patent and Trademark Office, April 1999

Clearly, Portland is more than just a manufacturing center for the high technology industry. Portland, with about 43,000 employees in high technology had 574 patents in 1998, compared with Silicon Valley, which generated about 4,269 patents and had 190,000 high tech employees. Portland's "innovation intensity" measured by patents per thousand employees, was nearly 13.3 patents per 1000 employees in contrast to 22.4 patents per thousand employees in Silicon Valley (based on high tech employment).[2]

One likely reason for the increase in patent activity in the metropolitan area has been the accelerating levels of research and development spending. Table 3 shows data reported by the National Science Foundation suggests that statewide, industrial R&D spending in Oregon has been increasing more than two and one-half times faster than it has nationally. Total industrial research and development spending in Oregon now exceeds $1.1 billion annually, up from less than $300 million a decade ago.

Table 3: Industrial Research & Development Spending, 1987 and 1997 (Millions of Current Dollars)

Area	1987	1997	Growth Rate
Oregon	281	1,102	14%
U.S.	92,155	157,539	5%

Source:

Other sources suggest that the National Science Foundation data may understate the amount of research and development spending. The American Electronics Association, estimates, based on a survey of 77 high tech companies, estimates that total research and development spending in high tech alone was $1.95 billion in 1998, up from abut $1.6 billion in 1995 (American Electronics Association, 1999).

It's particularly interesting to examine the record of Intel, the region's patent leader. Intel's level of patenting has increased by nearly a factor of ten in the decade of the 1990s from only 48 in 1994 to 339 in 1998. Even more striking, the total number of patents issued to Intel's Oregon operations during the 1990s exceeds the number of patents

[2] Estimates of high tech employment in Silicon Valley and Metropolitan Portland are taken from Census Bureau employment estimates contained in County Business Patterns, 1996.

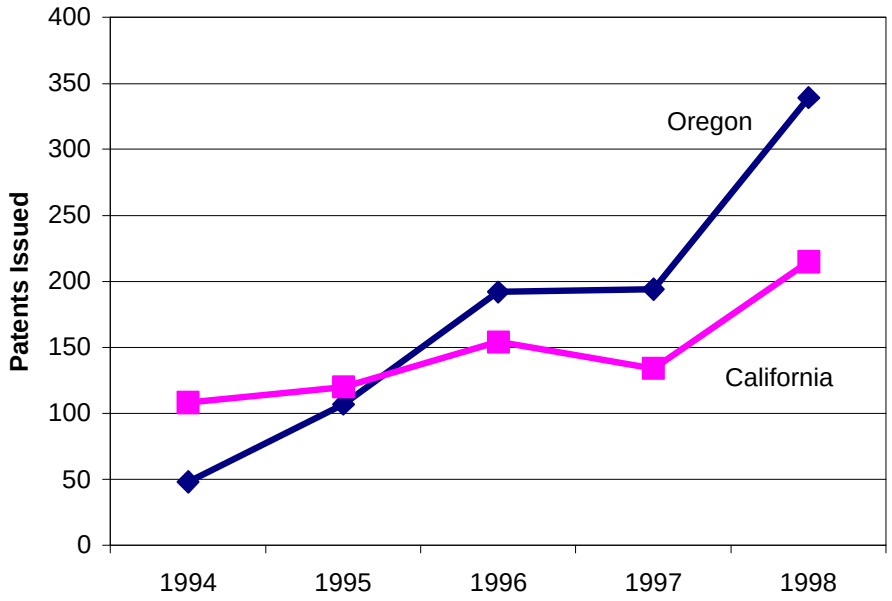
issued to Intel's California operations. In 1998, Intel's Oregon operations accounted for a majority of all Intel patents issued in the United States 339 of 642 patents.

Table 4: Intel Patents by State, 1994-98

State	1994	1995	1996	1997	1998	Total
Oregon	48	107	192	194	339	880
California	108	120	154	134	215	731
Arizona	12	18	41	36	84	191
Texas	1	3	3	0	0	7
Washington	0	0	1	2	4	7

Source: U.S. Department of Commerce, Patent and Trademark Office, April 1999

Chart 2: Intel Patents by State, 1994-98



Source: U.S. Department of Commerce, Patent and Trademark Office, April 1999

None of this should come as a surprise to anyone who follows Intel closely. The code names of the last several generations of Intel Pentium Processors—chosen by the Hillsboro based design team—read like the Atlas of Oregon: Deschutes, Tillamook, and Klamath.

Though far from being a complete picture of the role of innovation and knowledge creation, the patent data give us some clear indications of how our economy is changing. The rapid growth of patenting suggests Portland is competing successfully as a knowledge-creating region. The dominance of high tech firms in the region's patent mix underscores the importance of this industry in driving the metropolitan economy. The fact that Intel, the world's premiere producer of microprocessors, gets more patents from its Oregon R&D than everywhere else combined, suggests that Portland is an important center of knowledge creation in its own right, and not simply a manufacturing satellite.

The patent data should also lead us to question the critical role of university research in propelling the growth of nearby high tech enterprises. While it is widely believed that university research drives high tech expansion (see for example Goldberg 1999). Universities account for a relatively low level of patenting activity, not only in Portland, but also in area's with vaunted research universities. The level and growth of patent activity in Portland suggests that a strong cluster of high tech businesses can flourish well apart from a related world-class research institution. The link between academic research spending and high tech growth may not withstand careful scrutiny (Markusen, Hall et al. 1986).

II. Metro Portland's Knowledge Workers

One of the key measures of a knowledge-based economy is the educational level of the population. The region's high tech boom of the 1990s coincides with a dramatic increase in the average educational attainment of metro Portland residents. As a whole, the region has gone from being somewhat better educated than the average American population, to among the top ten large metro areas in the United States for years of education completed.

While definitive estimation of the educational attainment of the population depends on the large sample sizes provided by the Decennial Census, three different survey-based measures paint the clear picture of rapidly rising educational attainment in the Portland metropolitan area.

The last Decennial Census, completed in 1990, reported that 25.8 percent of the six-county Portland-Vancouver metropolitan area population had a four-year degree or higher level of education, compared with an average of about 21.3 percent for the nation's population as a whole.

The Oregon Population Survey, conducted biennially by the State of Oregon asks respondents to identify their educational attainment. The survey reports that for 1996, for the Oregon portion of the Portland metropolitan area, fully 34.2 percent of the region's adult population (aged 25 and older) had a four-year degree or higher level of education. These data include Clackamas, Multnomah and Washington counties in Oregon but exclude Clark County Washington. This increase is far greater than for the U.S. as a whole. For 1996, the Census Bureau estimates that 23.6 percent of the US population has a four-year degree or higher level of education.

The American Community Survey (ACS) is being developed by the Census Bureau as a long-term replacement for the "long-form" socioeconomic data gathered as part of the Decennial Census. Since 1996, Multnomah County (the most populous county in the region) has been a pilot site for implementation of the ACS. Educational attainment data for 1996 and 1998 is available from the ACS. In 1990, about 23.7 percent of the Multnomah County Population had a four-year degree or higher level of education. In 1996, according to the ACS, this had risen to 28.0 percent and by 1998 to 29.3 percent. As the central county in the region, Multnomah County has the largest stock of affordable housing, and the region's largest concentration of persons living in poverty, so it isn't

surprising that educational attainment for this group is somewhat lower than the metro average (Census Bureau 2000).

Paul Gottlieb and Mike Fogarty of the Center for Regional Economic Issues at Case Western Reserve University have used the Census Bureau's Current Population Survey data for 1998 (gathered in Spring, 1998), to estimate the educational attainment of the 75 most populous metropolitan areas in the United States(Gottlieb and Fogarty 1999). They report that Portland ranks among the ten best educated of the large metro areas.

Table 5: Ten Highest Ranked Metropolitan Areas by Educational Attainment, 1998

Austin, TX
Boston-Worcester-Lawrence, Lowell, Brockton, MA-NH
Denver-Boulder-Greeley, CO
Minneapolis-St. Paul, MN-WI
Nashville, TN
Portland-Salem, OR
Raleigh-Durham, NC
San Francisco-Oakland-San Jose, CA
Seattle-Tacoma-Bremerton, WA
Washington-Baltimore, DC-MD-VA-WV

Source: (Gottlieb and Fogarty 1999), Ranked in alphabetical order.

The average fraction of the adult population with a bachelor's degree or higher level of education for this group was 34.9 percent. Gottlieb reports that their estimate for the Portland-Salem consolidated metropolitan statistical area (which includes the 5 Oregon Counties of the Portland MSA, plus Clark County Washington, plus Marion and Polk Counties) is 32.8 percent.(Gottlieb 1999)

The growth of the high technology industry is closely tied to rising educational attainment. The American Electronics Association estimates that 54 percent of Oregon high tech employees have a four-year degree or greater level of education.(American Electronics Association Oregon Council and KPMG Peat Marwick, 1998) High technology employment in the metropolitan area increased by approximately 20,000 persons from 1992 to 1997. This implies that the high tech industry alone created a local demand for more than 10,000 additional workers with four-year degrees or higher levels of education over this five year period.

Part of the reason for the higher educational attainment of the metro area population is the relatively high educational status of in-migrants. The Oregon Employment Department estimates that about 50 percent of interstate migrants to Oregon who settle in the Portland metropolitan area have a four-year degree or higher level of education.(Oregon Employment Department 1999) The metropolitan area apparently attracts more highly educated in-migrants than do other regions of the state. The Oregon Progress Board estimates that about 42 percent of interstate migrants to Oregon have a four-year degree or higher level of education, compared to about 28 percent of resident Oregonians.(Vaidya 1998)

III. Institutions and Process for Knowledge Creation

We can use patents to measure the overall rate of knowledge creation and use educational attainment as a rough surrogate for the number of knowledge workers, but these measures tell us little about the mechanisms for knowledge production in the high tech arena. While the traditional view is that world-class research universities create the conditions for a high technology cluster, Portland's experience seems to be contrary to this model.

For many, higher education and in particular the research university are synonymous with knowledge creation, particularly for high technology industries. The creation myths of high technology generally envision a linear path of ideas, starting with research breakthroughs in university laboratories and advancing their practical application in (nearby) companies, many of them started by former university researchers. Universities do basic science, this results in companies doing applied technology.

The stories told about the development of high technology in particular regions usually follow this plot line. High technology industries prosper in the Boston area because of the world-class research done at MIT or Harvard, and Silicon Valley is fuelled by the research done at Stanford or Berkeley. This view of the critical role of universities is regularly echoed in the popular media. A recent New York Times article confidently declared "If there is one never-absent factor at work on these silicon corners, experts say, it is the proximity of a research university . . ." (Goldberg 1999 at A1).

This belief runs deep in the high tech community as well. The lack of an MIT or a Stanford is the most frequently cited weakness of the Portland metropolitan area as a high tech center, according to our interviews. One interviewee stated that "universities influence the intellectual climate; lacking a Stanford or University of Texas at Austin impairs recruiting and retention" (Personal Interview).

Portland's experience is, on its face, evidence that one does not need a world-class research university to flourish as a high tech center. The region has grown rapidly, in spite of the uniformly low esteem of the current system of higher education, and at a time when the number of engineering degrees granted in Oregon declined 25 percent. (American Electronics Association Oregon Council and KPMG Peat Marwick, 1999)

We asked each of our survey respondents to reconcile this paradox. Most agreed that the current level of higher education resources had not hindered the region's growth, but that a stronger higher education presence would definitely improve the region's prospects. When pressed to identify the attributes of higher education that were of greatest utility to their companies, interviewees described five ways a strong university could benefit them:

Universities provide:

- a source of skilled labor, particularly engineers
- opportunities for continuing education for technical and managerial employees
- an indicator of the depth of the region's technological prowess
- an amenity for an educated population
- a source of research

We have listed these factors in approximate order of importance as stressed by interview subjects. The university's role as training ground for engineers was the most frequently cited benefit. Oregon's rapidly growing high tech industry hires far more engineers than are trained locally, hence forcing firms to hire from outside the state. This has not historically been a problem (both because of the relatively small size and slow growth of the industry prior to 1992, and because the industry nationally was in a downturn in the mid 1990s (Cortright 1996)). In recent years, it has become more challenging to hire technically trained workers; 44 percent of Oregon high tech firms said the availability of an engineering workforce is worse in Oregon than in other states in which they operate (37 percent indicated the availability of continuing education was worse than elsewhere). These two factors ranked highest out of eight criteria (including labor costs, supplies, costs of facilities, and tax burden) about which firms were queried (American Electronics Association Oregon Council and KPMG Peat Marwick 1999).

Proximity is not, however, the most important attribute of engineering graduates. Even if local institutions graduated more engineers, most, if not all firms would continue to recruit outside the state because the firms want to get access to the highest quality graduates with specialized skills of interest to their firms. The region's largest leading high tech producers, company's like Intel, recruit the best and brightest from throughout the world for their operations, and do not restrict their search to local candidates even in locations where engineering graduates are abundant (as in the Bay Area).

Continuing Education

Opportunities for continuing education are important for both technical and managerial employees of high technology firms. Rapid changes in technology, markets and business strategies put a premium on continuously upgrading one's skills. One of our interviewees emphasized this function when asked for the role of higher education. He stated that "constant education is necessary because of constant change in technology" (Personal Interview). Most high tech firms have explicit policies of subsidizing continuing employee education-86 percent of firms offer tuition reimbursement programs that cover an average of 96 percent of the cost of educational programs.(American Electronics Association Oregon Council and KPMG Peat Marwick 1999)

We heard frequent personal testimonials from interviewees about their personal experiences in obtaining continuing education, often mixing an academic career with their work, obtaining an MBA at company expense and updating engineering skills. These arrangements are an accepted part of the employer/employee relationship in high tech firms, benefiting both the worker (higher skills, more earning opportunities) and the company (more knowledgeable, productive and innovative workers).

Interviewees expressed dissatisfaction with the quality of continuing education opportunities in the Portland metropolitan area. While pleased with expanded offerings from Portland State University and Oregon Graduate Institute, firms want to see even more choices in this area. Larger firms like Intel bring in world-class experts to teach and lead seminars; many firms pursue distance-learning opportunities.

Marquee Value: Universities as an Indicator of Technical Prowess

High quality higher education (almost always references as the equivalent of a Stanford or an MIT, occasionally as a University of Texas) is taken as an emblem of a well-rounded world-class high technology center. For firms and individuals who know little about the depth and breadth of the technological or intellectual community in a particular area, the presence of a well-known institution conveys a sense of security. A talented young engineer weighing job offers from firms in unfamiliar places is making a major life decision with limited information and considerable uncertainty. All other things being equal, a place with a nationally famous university would seem to assure more opportunities-for education, for other jobs, for social and professional interactions with peers.

Amenities

A strong university is a positive community amenity. The people and activities at a university may have many attributes attractive to high tech workers, not so much for business reasons, as for personal and social ones. Universities often have a greater degree of cultural diversity than the general population, especially important for industries where many employees are recent immigrants to the US. Opportunities to interact with the intellectual community of a great university, even outside one's own primary discipline may be important to many in high tech. Not least important among these considerations is the desire to have access to nearby educational opportunities for one's own children.

Research

Higher education is viewed as a source of research ideas, but none of the firms we interviewed looked exclusively, or even primarily, to Oregon researchers to help their firms. Interviewees told us that they sought out the best researchers in the world in their specific technical fields, as did their competitors in other regions. Only about 1 in six Oregon high tech companies report having a research and development agreement with an Oregon higher education institution (although the number rises to one in two for firms with gross sales over $100 million) (American Electronics Association Oregon Council and KPMG Peat Marwick 1999).

Why has Metro Portland Prospered in the Absence of World Class Higher Education?

While it is clear that metro Portland stands as an exception to the accepted rule that world class higher education institutions are a pre-requisite to creating a thriving high technology center, we should be cautious in assuming higher education is unimportant. First, it appears that the strength of higher education in high tech centers is perhaps as much effect of high tech agglomeration as it is cause. The presence of a strong cluster of growing high tech firms can stimulate the development of stronger higher education programs, funding research, providing adjunct faculty, hiring students, maintaining strong professional and personal networks. Second, in the case of Portland, it is apparent that many of the functions undertaken by (or attributed to) universities in other settings

have been assumed by the Portland area's dominant high tech firm (Tektronix in the 60s, 70s and 80s, and Intel since then). These dominant firms have attracted and trained hundreds of talented engineers and managers who have matriculated to other local businesses. They have funded enormous amounts of research, much of it far broader and more basic than incremental refinements to existing products or technologies. They have supported considerable amounts of continuing education, both in-house and at other institutions. And they have also provided the region with the marquee names to attract new firms and workers.

Portland has been fortunate to have large firms with such an enlightened view of their self-interest, and with the resources to undertake these efforts. Intel today, and Tektronix in its heyday were the dominant providers of their technology, with commanding market shares and abundant profits from a rapidly growing market.

What happens next in this regard is less clear. The decline of Tektronix over the past decade and a half clearly illustrates that private sector firms are unlikely to perform this role indefinitely. If Intel falters, the region may well be deprived of the institution that plays a crucial role in providing many of the attributes that high quality research universities play in other regions. From the standpoint of the regional economy, relying on the private sector to fill these roles may be risky in the long run.

Critical mass and the evolution of a knowledge cluster

High technology firms such as Tektronix and Intel have, in part, filled the void of higher education and research in the Portland area. How they came to play this role over time is an important factor in the development of the knowledge creation capacity of the region. The critical mass of firms and knowledge workers, coupled with the strong attractiveness of the region's quality of life, have been key to the region's success.

A brief review of the history of the region's high tech cluster illustrates the cumulative nature of growth. By all accounts, the flourishing of Tektronix in the 1950s, 60s and 70s was the cornerstone in the establishment of the Silicon Forest. Tektronix had a strong reputation as a creative, exciting company, open to new ideas. It was also extremely profitable and its leaders chose to plow much of those profits back into research and development. Interviewees, former employees of Tektronix, stated that the company "had the best experts in the field. It might has well have been a university-it was a great finishing school for engineers" (Personal Interview). Another interviewee stated that "Tektronix was incredibly rich in technology, it had incredible minds, Tektronix attracted a lot of people to Portland and the high quality of life, and a high quality, technology centered company" (Personal Interview).

As the fortunes of Tektronix waned in the 1980s, this leadership role was assumed by Intel, the world's largest manufacturing of microprocessors. Intel's initial decision to locate in Portland was made at the recommendation of Keith Thomson, who selected the company's Aloha site in 1974. Intel had made the decision to expand outside the Bay area, in part to minimize the risk that its production capacity would be knocked offline by

an earthquake (the companies major fabs in Santa Clara and Livermore California were both in an earthquake sensitive area).

A critical factor in selecting Portland was the availability of labor. In California, Intel experienced that especially young engineers did not stay long in the company. They left because they had plenty of other opportunities for work in the Silicon Valley. The growth of Tektronix, which employed 13,000 people in 1974, established Portland as a viable high tech labor market.[3] Intel's Oregon operations bolstered the region's attractiveness, drawing still more talented people into the region. One interviewee even stated that "Intel in Oregon overshadowed even California in terms of good people with technological talent" (Personal Interview).

The growth of other local firms (Electro Scientific Industries) and the establishment of a number of spin-offs (such as Floating Point Systems, Mentor Graphics, Planar Systems) not only expanded the size of the high tech cluster, they increased its breadth and diversity, and helped create a local market for suppliers and for the specialized services of venture capitalists, lawyers, accountants and others who could facilitate the growth of successive rounds of new startups. The region's growing high tech base also helped attract foreign investment, particularly from Japan, in the 1980s.

Not all firms locating in the region have contributed so strongly to bolstering the region's knowledge base. One interviewee noted that few foreign-owned firms in the region had produced significant spin-offs or attracted workers who subsequently set up their own firms. Foreign-owned firms tend mainly to be manufacturing operations with little emphasis on the research, development and marketing functions that generate the knowledge and skills for creating new businesses (Personal Interview).

The combination of attracting talented people and high quality of life contributed to a process of cumulative causation in which talented engineers stayed in the region, even after leaving employment with the firm that brought them to Oregon. They either started their own company or began in another firm. One interviewee stated "you find Tek alumni in almost every company" (Personal Interview).

As talented people chose to stay in the region, their knowledge and skills spread to other firms in the region. Often these companies focused on products or technologies related to the skills of these workers, and a process of technological specialization set in. For example, local expertise in test and measurement equipment and integrated circuit

[3] Tektronix played an even more direct role in Intel's decision to come to Oregon. Intel considered Oregon reportedly because a Tektronix Board member contacted Intel CEO Gordon Moore, and said "we're tired of being the only high technology firm in town" (Personal Interview). Thomson spent just a few days in Portland and looked at the only two available 30 acre sites in the region, one in Wilsonville and the other in Aloha. He recommended the Aloha site. A key factor in selecting Portland was Tektronix presence, at the time, Tek employed about 13,000. "If Tek can operate here, we can operate here."(Personal Interview) Another source told us that Intel's representatives made a trip up here to Oregon to talk to Vollum, to find out how Tek felt about Intel coming to Portland. "Gee, c'mon in, competition for labor doesn't hurt' was the response." (Personal Interview) Tektronix welcomed Intel, believing that a larger high tech sector would help it attract workers.

manufacturing facilitated the growth of new firms making semiconductor manufacturing equipment and software design tools and hence contributed to the development of EDA industry. This process illustrates clearly the important role of spin-offs in shaping the technological specialization of the region (i.e. Mentor Graphics as spin-off from Tektronix). But not only did expertise and the knowledge base shape the regional technological trajectory. Management styles and skills also shaped to the evolution of the high tech industry. Oftentimes management styles were copied from other companies. Electro Scientific Industries modeled its business culture after Hewlett Packard.

The Role of Quality of Life

The importance of quality of life in the Portland region was mentioned by almost all of our interviewees. Oregon and Portland are attractive places to live for high technology employees. One can go out and enjoy the mountains and the coast on the same day or spend a Saturday night at a concert in the Arlene Schnitzer Hall or at a basketball game in the Rose Garden. Such amenities make it easier for high technology firms to attract and retain people. Place is an important factor not only because it can function as a lure for people, but also to retain them because they tend to become welded in place. In contrast to Silicon Valley, the community of high technology engineers is less oriented towards business, but more towards their communities such as neighborhoods or social groups (Personal Interview).

In contrast to Silicon Valley, the Portland region does not have such a wide array of alternative employment opportunities for high tech employees. This is especially crucial for senior level management. But on the other hand, such limited possibilities for employees might be more sustainable for the companies with regards to their long-term development because people tend to stay longer and more committed to the company and in the case of Portland, to the region. In Portland, place is anchoring because employees are reluctant to leave. Reflecting on his personal experience, one interviewee said "once people are here in the region, they tended to stay" (Personal Interview).

Conclusion: A Knowledge-based Economy

Increasing educational attainment, growing research and development spending, and more patents underscore metropolitan Portland's emergence as a knowledge-based economy. The data clearly show that for the high technology industry, metropolitan Portland is not a branch plant production center, but a source of an enormous amount of innovation. These data are, at best, superficial indicators of the underlying dynamic fueling growth. Workers and firms in the region propel regional economic expansion by continually creating and refining economically valuable new knowledge.

The region benefits from a virtuous circle of knowledge creation and industry clustering, abetted in significant part by the local quality of life. Key high tech anchors, like Intel and Tektronix, signify the region's status as a bonafide technology center, and play many of the roles of attracting and nurturing technological talent attributed to universities in other high tech regions. The quality of life in the region attracts many bright people, and convinces them to stay once they are here.

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