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Bootstrapping High-Tech:
Evidence from Three Emerging High Technology Metropolitan Areas

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This report shows how three metropolitan areas—Portland (OR), Kansas City, and Boise—became centers of high technology industry without the presence of a major university. For each metropolitan area it describes the history of high-tech development, current status of high-tech industry clusters, and the roles that public policy and higher education played in spurring the growth of high-tech industry. In the three metropolitan areas high-tech industry is very specialized, anchor firms and new business startups helped it develop, high-tech industry predated supportive public policies, and local universities that were not major research institutions helped support high-tech growth after high-tech industry was already established. The evidence on high-tech development in the three metropolitan areas offers important information for policymakers and practitioners interested in technology-based economic development outside of large, well-established high tech centers.

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Introduction

Technology-based economic development has spread beyond Silicon Valley and Boston's Route 128 corridor. These two pioneering high-technology centers have long captured the attention of policymakers and analysts with many wondering what it would take to become "the next Silicon Valley."[2] So far, efforts to imitate Silicon Valley have had a dismal track record.[3] In recent years, however, other metropolitan areas have gained momentum and are emerging as high-technology locations. Understanding the dynamics of growth in emerging high-technology centers is important because emerging centers may offer more realistic scenarios for developing high-tech economies in metropolitan areas than Silicon Valley or Boston would. As our metropolitan economies become more knowledge-based, innovation-driven, and service-oriented, it is important to understand how high-technology industries developed beyond Silicon Valley and Boston.

This report shows how three metropolitan areas—Portland (Oregon), Kansas City, and Boise—emerged as second-tier high-tech centers even though they did not host a major research university, which is often thought necessary for high-tech development. These metropolitan areas host significant concentrations of high-technology industry activity.[4] Relative to their size and location, they are highly innovative and entrepreneurial. Technology companies in these emerging high-technology metropolitan areas have grown by building on existing corporate assets. State and local policymakers in these metropolitan areas are developing unique policies to link universities with industry, facilitate entrepreneurship, and support the development and commercialization of innovation.

Portland, Kansas City and Boise are different from such large, well-known high-technology centers as San Francisco-San Jose (Silicon Valley) and Boston. They are smaller and somewhat less specialized in high technology industries. They do not attract large amounts of venture capital. Their businesses spend less on research and development than do those in San Francisco-San Jose and Boston. They do not have world class research universities. However, Portland and Boise are about as inventive as Boston, as measured by rates of patenting activity (Table 1).

Table 1. Portland, Kansas City, and Boise Metropolitan Areas Compared With San Francisco-San Jose and Boston Metropolitan Areas on Selected Indicators of High Technology Activity

	Portland	Kansas City	Boise	San Francisco and San Jose (combined)	Boston
High-Tech Industry					
High-Tech Employment, 2005	58,646	49,918	18,969	375,413	218,392
Number of High-Tech Firms, 2005	5,614	4,850	1,335	23,003	14,357
High-tech Location Quotient, 2005*	1.35	1.14	1.76	3.27	1.96
Entrepreneurship					
Total Number of High-Tech Firm Births, 1998–2000	24	71	23	622	297
Venture Capital Deals per 1,000 People, 2000–2005	6.2	2.2	1.0	58.1	35.5
Innovation and Research					
Total Industry R&D Funding, 2000–2005 (millions of dollars)	$2,087	$662	$506	$44,862	$26,422
Total University R&D Funding, 2000–2005 (millions of dollars)	$123	$163	$42	$10,480	$7,930
Patents per 1,000 People, 1990–1999	260	40	241	2,126	223

*The high-tech location quotient, a measure of the extent to which a metropolitan area is specialized in high-tech industries, is the ratio of the percentage of a metropolitan area's employment that is in high-tech industries to the percentage of nationwide employment that is in those industries. A location quotient above 1.00 indicates some degree of high-tech specialization, and the higher the location quotient the greater the metropolitan area's high-tech specialization. I define high-tech industries as those that Daniel Hecker of the Bureau of Labor Statistics classified as "Level I" high-tech industries; these are the industries that have the highest percentages of their nationwide employment in such technology-oriented occupations as engineers, technicians, life and physical scientists, and engineering and natural science managers. In general these industries group broadly into biotechnology, information technology, high-tech manufacturing, and high-tech services and R&D. See Daniel Hecker, "High-Technology Employment: A NAICS-Based Update," *Monthly Labor Review* 128 (July 2005): 57-70.

Sources: Author's analysis of data from County Business Patterns, U.S. Census, Small Business Administration, National Science Foundation, and U.S. Patent and Trademark Office.

All three of the emerging high-tech centers profiled in this report are home to innovative entrepreneurs and sometimes branch operations of well-known firms. Intel, for example, opened its first branch manufacturing facility in Portland in 1976 and has since then expanded it into a state-of-the-art manufacturing process development facility for semiconductor production. Consequently most of Intel's innovations are "made in Oregon." During the 1990s, for example, the majority of Intel's patents were assigned to Oregon-based inventors.[5] Hewlett-Packard relocated its printer division to Boise in 1973. Its trademark product, the laser printer, was developed in Idaho, not in Silicon Valley. Kansas City is an example of a highly specialized second-tier life sciences center. The Kansas City metropolitan area has a significant cluster of contract research organizations and it is home to the leading firms in the animal health industry. Those firms, combined, capture 30 percent of the world's animal health market.[6]

Three Emerging High Technology Metropolitan Areas

The three metropolitan areas profiled in this report were able to grow significant concentrations of high-tech firms without factors often considered critical in the growth of a technology region, such as major research universities. In addition, each of the three metropolitan areas can be considered a peripherally located area that has been overshadowed by other more prominent metropolitan areas. Seattle has always trumped Portland and Boise in the Pacific Northwest as a location for important business activities. Kansas City always stood in the shadow of St. Louis even though both were important metropolitan centers in the Heartland. The following case studies show how Portland, Boise, and Kansas City compensated for their lack of traditional high-tech growth factors, overcame their locational disadvantages, and developed high-technology economies. The case studies are based on interviews with entrepreneurs, industry representatives, and policymakers.

Portland

Overview. With just over 2 million residents, Portland is Oregon's largest metropolitan area. The Portland area is known not only for its innovative urban and regional planning system but also for being home to the so-called Silicon Forest.[7] In 2005, 5,614 high-tech firms employed 58,646 people.[8] The metropolitan area specializes in semiconductor manufacturing, computers, instruments, and software development. These industries comprise the core of the Silicon Forest. The most prominent firms are Intel, Tektronix, and Hewlett-Packard. Portland has an industry cluster organized around its semiconductor industry, with various firms representing the steps in the value chain of a semiconductor.[9] Silicon Forest firms produce silicon wafers, supply semiconductor manufacturing equipment (SME), and develop electronic design automation software.[10] Related and supporting industries include engineering firms that specialize in clean room construction, chemical suppliers, and professional services firms. The Portland area has become an attractive place for high-tech activities. In 2000, for example, 13 well-known high-technology firms (including Intel, Hewlett-Packard and IBM) jointly set up the Open Source Development Lab (OSDL), a nonprofit research and development entity.[11] Linus Torvalds, the founder of Linux, relocated to Portland from Silicon Valley, further validating the region's strength in high-tech. OSDL subsequently merged with the Free Standards Group to form the Linux Foundation, which is now located in San Francisco.

Important Milestones. The development of Portland's industry goes back to the 1940s when Tektronix, a leading manufacturer of oscilloscopes, was founded. Tektronix started in Portland because two of its founders were from there and had returned to the region after their military service during World War II. Over the years Tektronix set standards with its products and became the world's leading manufacturer of test and measurement instruments. Its market leadership translated into organizational growth and recognition beyond the Pacific Northwest. Because the Portland area lacked a world-class research university, Tektronix attracted the majority of its engineers and scientists from other areas, such as California and the Midwest. The firm also developed a comprehensive in-house education program and offered a variety of classes ranging from very advanced engineering courses to recreational classes. This education program at times even exceeded the offerings of area schools and colleges. Tektronix was pivotal in the region's development of a skilled labor pool.

More important than the firm's contribution to talent, however, was its impact on high-tech entrepreneurship. Tektronix turned into an incubator for talented entrepreneurs. By 2003, for example, more than 60 companies could trace their genealogical roots directly to Portland's pioneering high-tech firm and at least an additional 35 firms can be considered "grandchildren" or "great-grandchildren" of Tektronix.[12]

There are two reasons why Tektronix became an entrepreneurial wellspring. First, Tektronix developed a unique innovation culture. The company's monopolistic market position, which allowed an extensive focus on research and development in a variety of areas often not related to the core product, fueled the firm's innovation culture. By the early 1970s Tektronix institutionalized innovation in an in-house R&D laboratory, the so-called Tek Labs. Tek Labs offered its numerous Ph.D.-level researchers an environment similar to that of a university. The firm developed many cutting-edge

innovations, whose value corporate management often did not recognize. Employees who started their own companies commercialized many of these innovations.

Second, starting in the 1980s, Tektronix went through significant organizational restructuring, which led many Tektronix employees to found startup companies. Increased competition from Japanese firms and U.S. companies such as Hewlett-Packard undermined Tektronix's market leadership. Tektronix could no longer afford a corporate structure that was based on vertical integration, immense product diversity, and an R&D laboratory that functioned like an academic institution. In this restructuring the company laid off employees, closed Tek Labs, refocused on its core product, and sold its non-core business units. Many of the laid-off technical and managerial workers formed their own technology companies, which benefited from contracts with the slimmed-down Tektronix.

> "Tektronix and Intel managed to compensate for the Portland area's lack of a world-class research university."

The 1980s marked the beginning of Tektronix's decline and the region's expansion into a high-tech center. Tektronix went from more than 24,000 employees in 1981 (with about 15,000 employees based in Portland) to about 4,500 employees worldwide and about 2,100 in Portland in 2007.[13]

As Tektronix declined, Intel began to expand in the Silicon Forest. The California-based semiconductor manufacturer moved to a Portland suburb in 1976. Intel's Portland facility was the company's first branch operation outside of Silicon Valley. Corporate leaders chose Portland because of its proximity to Silicon Valley (less than a two hour flight) and the availability and low costs of basic production factors such as semi-skilled labor and raw materials such as water and electricity. Intel's expansion outside Silicon Valley in the late 1970s happened at a time when there was an explosion of demand for integrated circuits. Intel's sales, for example, increased from $94 million in 1971 to $134 million in 1974.[14] Other Silicon Valley firms experienced similar growth. As a result, poaching of employees was a common occurrence. As the cost of living in Silicon Valley rose, Intel also worried about the difficulty of retaining employees there.[15] Initially Intel relocated only manufacturing of memory chips to Portland. Soon, however, it added engineering units. A group of 17 Intel engineers, led by a native of the Pacific Northwest, moved to Portland. The move of this team put the Portland area at the center of microprocessor innovation after Intel abandoned memory production in the 1980s. The initial engineering group worked on the iAPX432 microprocessor, which proved to be a commercial failure but set the groundwork for Intel's most successful chip, the Pentium processor. A team of engineers at Intel's Silicon Forest campus subsequently developed the Pentium chip in the early 1990s.

Compared to Tektronix, Intel has not had a vast impact on Silicon Forest entrepreneurship. Given the size of Intel's Oregon employment—a little more than 16,000 employees in 2007[16]—the firm has not spawned many startup companies. The most prominent Intel-related startups are Sequent Computer Systems (acquired by IBM in 1999), Lattice Semiconductors, and Lucy, a women's clothing company cofounded by former Nike and Intel employees.[17]

There are several reasons why Intel's contribution to regional entrepreneurship was so limited. In contrast to Tektronix, Intel did not go through extensive corporate restructuring, so it did not "release" many laid-off engineers and managers to found new companies. In addition, Intel's employee stock ownership programs and generous stock options may function like "golden handcuffs," retaining employees who might otherwise leave to start new firms. Intel also encourages what it calls "intrapreneurship," the practice of keeping entrepreneurial employees in-house and allowing them to start new firms inside the corporation. Finally, Intel operates its own in-house venture capital firm, Intel Capital, one of the world's largest venture capital groups. Key personnel for Intel Capital are located in Oregon but Intel Capital makes investments worldwide.

Cluster Development Today. As Tektronix's importance declined, its spinoffs helped diversify the Silicon Forest. In 2007 Tektronix's local ownership came to an end as Danaher Corporation of Washington, D.C., acquired the Portland firm. Today Danaher operates Tektronix as a subsidiary located in Portland's Silicon Forest.

Intel's contributions to the development of the Silicon Forest are more related to the development of a cluster of interrelated firms than to spinning out entrepreneurial startup companies. Intel attracted suppliers, subcontractors, and competitors. Its narrow focus on improving one product—the

semiconductor—may also limit the range of ideas to which employees may be exposed. Intel is widely known for its rigorous strategic focus, which may explain why it has not spawned as many startups as Tektronix.[18] Unlike Tektronix, Intel never set up a separate in-house research and development laboratory. Instead, Intel, like many other semiconductor companies, aims to link innovation and manufacturing closely to minimize the time between the development of new products and their market introduction. Intel operates so-called process development fabrication facilities, in which engineers develop new chips along with the necessary process for mass production. Intel performs most of this type of development work in its Portland facilities.[19] For example, Intel completed its D1D fab in Portland in 2003 and its Portland facility is the site for the development of 65- and 45-nanometer chips. The facility is expected to develop new chip generations until 2013. In 2009 Intel announced that it will invest approximately $1.5 billion in its Oregon facilities as part of its push to develop 32-nanometer chips.[20]

The Roles of Public Policy and Higher Education. Corporate assets rather than public policy or government-led economic development created the Silicon Forest. Tektronix and Intel led the growth of the Silicon Forest. Public policy was reactive to the growth of high technology industry. State and local government, for example, reacted to pressure from Intel to grant tax breaks on large capital investments.[21]

Tektronix and Intel managed to compensate for the Portland area's lack of a world-class research university.[22] Both companies invested heavily in in-house education. Both also lobbied heavily for improvements in the higher education infrastructure.[23] State policymakers, however, only recently realized the importance of investments in higher education. In 2001 the state of Oregon established the Oregon Council for Knowledge and Economic Development, which was later merged into the Oregon Innovation Council (Oregon InC), a private sector-led advisory committee. In response to a recommendation by Oregon InC the state laid the foundation for "signature research centers" in biotechnology, renewable energy, and nanotechnology. The signature research centers link various universities and research laboratories with industry assets in Oregon. For the first time in the region's higher education history, all major research universities are collaborating and they have been able to leverage private, federal and state investments.

Kansas City

Overview. A small set of metropolitan areas can be considered second-tier life science centers.[24] Each of these areas specializes in a particular subset of the industry and can build on significant industrial capacity. Kansas City is such an emerging life science center. The Kansas City metropolitan area specializes in pharmaceutical contract research connected to therapeutic testing, clinical trials, and other related pharmaceutical developments. It is also home to a cluster of more than 100 animal health and nutrition companies. These Kansas City-based animal health and nutrition firms represent 27 percent of the U.S. animal health product sales and account for 30 percent of global sales.[25] In addition, Kansas City hosts one of the best funded biological and molecular research organizations, the Stowers Institute for Medical Research.

Important Milestones. Kansas City's strength in contract research and pharmaceutical development goes back to the founding of Marion Laboratories in 1950. Ewing Marion Kauffman, who later created the Kauffman Foundation, started the firm in the basement of his Kansas City home. Marion Labs never developed an in-house basic research capacity. Instead, it developed a unique business model that was based on the development and marketing of pharmaceutical products for which other companies performed the basic research, often outside the United States. In following this "search and development" model, Marion Labs attracted and developed a labor force that became highly skilled in clinical testing and in regulatory matters of drug development, sales, and marketing. At its height Marion Labs employed about 2,000 people in Kansas City.[26] Over time, however, the firm went through a series of mergers and acquisitions with large drug development companies such as Dow Chemical and Sanofi-Aventis. These corporate changes ushered in broad restructurings that included layoffs, business divestitures, and the relocation of jobs. Today, what remains of Marion is a manufacturing branch operation of Sanofi-Aventis that employs about 800 people.[27]

However, Marion's legacy looms larger over the Kansas City area. Marion's mergers and acquisitions spurred entrepreneurial activity. Former Marion employees started about 17 companies.[28] Most of these firms specialize in the development and marketing of drugs and pharmaceutical products. In addition to entrepreneurship, Marion Laboratories built a critical mass of talent, especially in the areas of commercialization, drug development, regulation, and clinical trials. Startup firms and established companies are leveraging this base of talent and entrepreneurs see it as a critical regional advantage.

Kansas City's second main pillar in life science is the animal health and nutrition industry. More than 100 companies are clustered in the central part of the metropolitan area, primarily in Johnson, Wyandotte, and Platte counties in Kansas and Jackson and Clay counties in Missouri.[29] The small community of St. Joseph, Missouri, which is outside the metropolitan area, also hosts a significant concentration of firms. The Kansas City area's animal health-related companies form an industry cluster; suppliers, equipment manufacturers, distributors and service providers co-locate around well known animal health product manufacturers such as Boehringer Ingelheim, Intervet, Novartis, Nestlé Purina, Hill's Pet Nutrition, and others.[30] Two important locational characteristics were critical in the development of this cluster. First, Kansas City's stockyard heritage established the region's legacy in the livestock industries. Keeping animals healthy and alive was critical to the success of the stockyards. Second, Kansas City's gateway location in the Midwest and its role as a transportation hub give its animal health firms excellent access to livestock producers. A 2006 consulting report states that "within 350 miles of Kansas City are more than 45 percent of the fed cattle in the US; more than 40% of the hogs produced in the US; and 20% of the beef cows and calves."[31]

In 2000, Kansas City's life science industry received an extraordinary boost. A philanthropic gift of $2 billion by Jim and Virginia Stowers, local entrepreneurs who founded American Century Investments, established the Stowers Institute for Medical Research. The Institute's endowment is the largest endowment in the world solely devoted to basic life science research.[32] The original plan for the Institute called for it to double its presence every decade. However, the political climate in Missouri changed that plan. Although Missouri voters approved a 2006 state constitutional amendment protecting embryonic stem cell research, political controversy around that issue continued, In 2007 the Institute put expansion plans on hold, citing the continued hostile environment and the resulting difficulties in recruiting stem cell scientists.

Cluster Development Today. Kansas City's life science economy started with Marion Laboratories. However, since the early years of Marion Laboratories, about 200 life science firms located in the region, employing between 17,500 and 20,000 people altogether.[33] More than 40 percent of these firms focus on biotechnology research and testing. The region's largest life science firms are Cerner, Quintiles, Bayer CropScience, REMEL, and Boehringer Ingelheim Vetmedica. The industry has grown substantially through relocations, mergers, and acquisitions.

The Stowers Institute employs about 380 scientists, researchers, and other staff members.[34] Its 600,000-square-foot facility is located on the Missouri side of the Kansas City metropolitan area in close proximity to the Kauffman Foundation and the University of Missouri, Kansas City. It provides its scientists and researchers with a well funded environment in which they can conduct basic research free of the pressures of grant writing and raising external funding. One of the main challenges the Kansas City life sciences cluster faces is that of networking the various academic and corporate life science assets to create commercialization synergies.

The Roles of Public Policy and Higher Education. The establishment of the Stowers Institute encouraged the region's policymakers to become proactive. In 1999 the Kansas City area's major business leadership and private sector economic development organizations created the Kansas City Area Life Science Institute (KCALSI) to support and facilitate networking and collaboration among ten research institutions and hospitals. KCALSI's goal is to increase the amount of research expenditures at area research facilities. Recognizing the strength of the animal health and nutrition cluster, KCALSI, the Greater Kansas City Chamber of Commerce, the Kansas City Area Development Council, veterinary schools, and several animal health companies in the metropolitan area became proactive in supporting this industry through the Kansas City Animal Health Corridor initiative. The initiative provides startup grants to Kansas City-area animal health researchers who are beginning new research projects and

who have a letter of support from a company.

On a statewide basis Kansas seems to be more encouraging of the life science industry than Missouri. In 2004, Kansas passed the Economic Growth Act, which established the Kansas Bioscience Initiative and the Kansas Bioscience Authority. The Initiative is funded through tax increment financing, which is expected to raise $580 million over a 10- to 15-year period.[35] The Kansas Bioscience Authority received about $30 million during its first two years and used the funding to invest in R&D vouchers, infrastructure, and the attraction of R&D institutions such as the Homeland Security Department's Bioscience Research Institute.[36] Other Kansas policy efforts address the support and development of entrepreneurs and commercialization of research, although recession-induced state budget cuts could jeopardize these efforts. In sum, the Kansas City metropolitan area stands out in connecting industry with universities and research institutions. However, it remains to be seen whether the research capacity that the Stowers Institute is building can also leverage commercial development and advance the region's life science industries.

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Boise

Overview. Idaho may be an unlikely state for high-technology development but its largest metropolitan area, Boise, has developed an entrepreneurial and innovative technology community. From 1970 to today the Boise metropolitan area has grown fivefold, from 115,000 to about 532,000 residents.[37] The metropolitan area is entrepreneurial, as evidenced by the list of well-known firms that started here: Albertsons, Morrison Knudsen, Ore-Ida, Boise Cascade, and the J.R. Simplot Company.

Although Idaho has been known more widely for growing potatoes, a large part of the state's economic power comes from exporting semiconductor chips and innovations for the laser printer. The Boise area's most prominent firms are Micron Technology, the only company that still manufactures memory chips in the United States, and Hewlett-Packard, the Silicon Valley-based technology firm.

As would be expected, high-technology employment is considerably lower in metropolitan Boise than in the much larger Portland and Kansas City metropolitan areas. The Boise area's 18,969 high-tech workers work for 1,335 firms, of which 77 percent employ less than 9 people and a mere 3.4 percent employ more than 100.[38] These companies specialize in semiconductors, computer and electronic products, software publishing, and engineering services.

Important Milestones. Both Hewlett-Packard and Micron Technology started their operations in Boise in the 1970s. At the time, Boise was a small city located in the midst of a largely rural state on the periphery of the Pacific Northwest. Back then, the region did not have a higher education infrastructure that would have supported a budding high-tech economy. Boise State University, for example, gained university status in 1974 and granted its first doctoral degree in 1992. Supported by Micron and Hewlett-Packard (HP) but hampered by intrastate university rivalries, Boise State began to offer undergraduate degrees in engineering and created its College of Engineering only in 1996. Thus, the region's emergence as a technology community was anything but university-based.

Like Intel in Portland, Hewlett-Packard selected the Boise location because it was within a two-hour radius of Silicon Valley.[39] In the final selection Boise competed with Salt Lake City and Spokane, Washington. It won because the HP manager in charge of the selection followed the advice of his family, who liked the idea of living in Boise. This chance event triggered Boise's high-tech growth. HP began to manufacture line printers and magnetic tape drives in Boise. Following a well-established company tradition it set up its branch-plant operation to function quite independently of corporate headquarters, much like a small business.[40] (The Boise operation was not a separate company or subsidiary, however.) Like Tektronix in Portland, HP attracted most of its engineers and scientists from other states. The region's high quality of life facilitated the attraction and retention of skilled labor. Today, HP employs about 3,340 people in Boise.[41]

Over time HP's Boise unit developed a range of innovative products. In 1977 HP issued its first line printer, which was designed solely by Boise-based engineers. In the early 1980s, in cooperation with

Canon, HP introduced the laser printer. The Canon partnership ushered in a paradigm shift in the way HP created innovations. By partnering with another technology firm, HP broke with its longstanding belief that every innovation that was "not invented here" was not a good innovation. The partnership allowed the Boise facility to focus mainly on innovations in the realm of printer performance, embedded software, connectivity, and marketing. Driven by the quest to make the printer cheaper, smaller, faster, and quieter, HP's Boise facility primarily focused on R&D and marketing to final consumers, while the company relocated most of its printer production to low-cost locations abroad.

Micron Technology was founded in 1978 by four Idaho natives. It is a semiconductor manufacturing company that specializes in the production of computer memory chips including DRAM, SDRAM, flash memory, and CMOS image sensing chips. Today the firm employs about 6,000 people at its Boise operations.[42] This is down from 10,600 in 2007, illustrating corporate challenges resulting from major financial losses during the recession that began in late 2007.[43] Most other U.S. firms exited the memory market segment in the 1980s because of price volatility and intense competition from Asia.[44] As a result of the dismal record of the industry in the United States and strong competition from Japan, no venture capitalist would finance a company interested in manufacturing memory chips at the time. However, Micron's founders were able to start their operations with money from Idaho-based investors who made their riches in agriculture. Boise proved to be a good location for a new memory manufacturing firm because land and labor were cheaper and less startup capital was required than in Silicon Valley, which at the time was the center of the semiconductor industry. Micron was able to make a name for itself because it created more reliable and smaller chips than its competitors. In the early 1990s Micron began to diversify into other industry segments, most notably the personal computer market. It established Micron Electronics (also known as Micron PC) to manufacture personal computers.

"There is, however, an active grassroots culture of entrepreneurial networking and support among entrepreneurs and managers in Boise.

Boise's entrepreneurial community benefited most from the presence of Hewlett-Packard and to a lesser degree from Micron Technology. By 2007, 26 firms had been founded by former HP employees and only seven firms had originated from Micron Technology. Micron Technology was more active in setting up subsidiaries. (One of its 11 subsidiaries was Micron Electronics, which spawned 15 spinoffs. However, Micron Electronics' business culture was more like HP's than like Micron Technology's, so its entrepreneurial impact should not be attributed to Micron Technology.).

HP and Micron Technology differed in the extent to which they generated entrepreneurial startups because they had different business models, innovation cultures, and products. HP's main product—its laser printer—is distinguished from its competitors' products by a higher degree of customization and innovative design features, not by a lower price. In contrast, Micron's memory chips differ from those of competitors because of their lower price. Unlike Micron's product, which is geared toward businesses and other intermediate users, HP's laser printer is targeted toward final consumers, who are more sensitive to customization and design features. HP's decentralized business culture and its famous "HP Way" created a culture of learning that enabled nascent entrepreneurs to gain critical skills not only in creating innovative technologies but also in management.[45] In contrast, Micron Technology is focused on process improvement to reduce the price of its product, vertical integration to take advantage of scale economies, and a highly targeted as well as secretive culture of innovation. These features have limited Micron's influence as an incubator for entrepreneurs.

Cluster Development Today. Even though metropolitan Boise has a highly innovative and entrepreneurial high-tech community, it has a weak high-tech industry cluster because its technology-oriented businesses consist mainly of HP, Micron Technology, and their spinoffs. Neither Micron Technology nor HP has attracted many suppliers or competitors. The metropolitan area also has relatively few service providers that specialize in serving high-tech firms (e.g., intellectual property lawyers, human resource agencies, and specialized accountants). There is, however, an active grassroots culture of entrepreneurial networking and support among entrepreneurs and managers. The Boise area has also developed a small but vibrant angel investor community.

The Roles of Public Policy and Higher Education. Boise's higher education infrastructure has come a long way, primarily as a result of corporate investments. With financial support from Micron Technology and HP, Boise State University established a College of Engineering and has improved its business school. Boise State serves the region's high-tech community primarily by supplying talent. Boise's high-tech entrepreneurs also value university services such as technical assistance, business development support, and prototype development. BSU's TECenter, for example, provides technical assistance and prototype development while the Small Business Development Center helps with business development. Less important, and partly due to Boise State's low ranking on research and development measures, are licensing and patenting activities. These findings, however, confirm other research about the critical role of universities in supporting regions with traditional outputs such as human capital and more informal channels of knowledge exchange between universities and industry.[46]

Idaho provides little public policy support for the high technology community. In 1999 Governor Dirk Kempthorne established the Idaho Science and Technology Advisory Council. Since then, however, the council has not been able to convince the predominantly non-metropolitan legislators of the importance of technology-based economic development to the state's economy. Even though the current Governor, C.L. "Butch" Otter, appointed a former Silicon Valley semiconductor executive as the head of the state's Department of Commerce, many of his funding recommendations did not address the needs of the high-technology industry. (The Commerce director has since resigned.) Micron Technology, not the state government, was the primary funder of improvements to Boise State University's technology-oriented programs. In late 2007 Boise entrepreneurs and high-technology representatives began a discussion about setting up a technology advocacy group, the Idaho Innovation Alliance, with which they hope to give a greater voice to small and medium-sized high-tech firms.

Observations

The cases of Portland, Kansas City, and Boise illustrate four important features of high-tech development that are likely to be relevant to other metropolitan areas.

The Three Metropolitan Areas Have Very Specialized High-Tech Industries

The metropolitan areas profiled in this report are specialized in particular kinds of high-tech production. While large, pioneering high-tech regions such as Silicon Valley have much more diverse high-tech economies, Portland, Kansas City, and Boise have unique industrial footprints.[47] Portland specializes in high-tech manufacturing and has competencies in semiconductors, test and measurement instruments, display technology, and software. Boise is known for semiconductor manufacturing (particularly memory chip production) and computer peripherals (printers). Kansas City specializes in life sciences, particularly animal health and drug development.

Portland and Boise started as low cost manufacturing sites for firms whose headquarters and R&D activities were located elsewhere (such as Silicon Valley). However, over time, firms moved some of their R&D and other innovative activities to the places where related production facilities were already located.[48] In this way, Portland and Boise became locations for both R&D and production. In addition, suppliers, subcontractors and customers, who are often co-located, have become important sources of innovation. As a result, metropolitan areas that started out as branch plant locations are now part of an integrated innovation system.

Kansas City followed a different model. The Kansas City area was able to support an innovative life science economy because of its historical assets and strengths (Marion Laboratories and historical skills in keeping animals healthy). In this metropolitan area the life science economy grew out of institutions and capabilities that already existed in the metropolitan area.

Anchor Firms and Startups Helped High-Tech Industry Develop

The three second tier high-tech centers emerged as a result of the growth of anchor firms—firms that employ a significant number of talented employees, are engaged in innovation, have strong market

connections inside and outside the metropolitan area, often dominate or play a strong role in their product markets, and have spinoff companies. Tektronix and Intel in Portland, HP and Micron Technology in Boise, and Marion Laboratories in Kansas City are (or were) anchor firms. Some anchor firms (such as Tektronix, Micron and Marion Laboratories) were started locally, while others (Intel and HP) relocated from elsewhere as their industries matured.

Certain anchor firms can take on the role of "surrogate universities," attracting and developing talent, investing in research and development, and spinning off entrepreneurial startup firms.[49] Firms that are located in metropolitan areas that lack world-class research universities can function as surrogate universities if they are engaged in product innovation, develop talent, and create spinoff companies.

"Although anchor firms played an important role in planting the initial seeds of high-tech industry, it is entrepreneurship that led to sustained growth.

Anchor firms have other characteristics that make them especially likely to influence metropolitan high-tech growth. These firms are leaders in their specific markets. As a result, they are able to invest in research and development. They play an important role in the local economy, supporting much of a metropolitan area's employment and income and, directly or indirectly, creating business opportunities for locally based small and medium-sized firms. Consequently, their growth and decline can have large, impacts on the economies of their host metropolitan areas.

Although anchor firms played an important role in planting the initial seeds of high-tech industry in Portland, Kansas City, and Boise, it is entrepreneurship that has led to the sustained growth of high-tech industry in these metropolitan areas. The three high-tech centers grew because new high-tech firms spun off from existing ones, often as a result of corporate changes such as mergers and acquisitions, layoffs, and corporate downsizing. In most cases, entrepreneurs stayed in the metropolitan areas when they started their firms.

High-Tech Industry Developed First and Public Policy Followed

Anchor firms and spinoff companies formed the basis of high-tech economies in the three metropolitan areas. In Portland and Kansas City, clusters of related and supporting firms evolved over time. Although the anchor firms in these metropolitan areas initially located and grew in isolation from other firms, they gradually developed relationships with customers, suppliers, subcontractors, and research partners. Intel, for example, attracted many suppliers, subcontractors, and competitors. The animal health care industry in Kansas City displays similar relationships among firms.

In Boise, an industry cluster with a large number of related and supporting firms has yet to form. Hewlett-Packard's corporate changes yielded limited outsourcing opportunities for local firms. Micron Technology did not trigger the growth of a semiconductor cluster because as a company the firm has been fairly self-sufficient. This indicates that cluster formation depends on whether firms have extensive, local inter-firm business relationships.

High-tech industry in Portland, Kansas City, and Boise evolved without the aid of explicit public policy. Little or none of the high-tech presence in these metropolitan areas resulted from aggressive firm recruitment. Proactive public policy, however, has become more important in recent years. As high-tech firms grew in these regions, their needs for highly skilled workers and sophisticated research grew. Consequently, they became more concerned with postsecondary education and university-based research and advocated public policies to support higher education. Grassroots efforts helped set up angel investor networks and other entrepreneurship support programs. Civic leadership by entrepreneurs and high-tech firms followed, sometimes leading to changes in public policy. However, public policies differ substantially among the three metropolitan areas, in part because of differences in political culture. Each metropolitan area's roots in high-tech go back decades. Policymakers should be aware that technology-based metropolitan economic development needs to be a long-term strategy.

High-Tech Development Began Without Major Universities but Local Universities Later Helped Support the Growth of High-Tech Companies

Each of the three metropolitan areas became a high-tech center even though it lacked a major world-class research university. This indicates that universities are not necessary for high-tech development.[50] However, over time universities became important partners to firms in the local high-tech economy. Once high-tech firms became established in the three metropolitan areas, universities played a critical supporting role in developing talent, providing opportunities for university-industry interactions and applied research, and supporting entrepreneurship through small business development centers, incubators, or prototyping facilities. Although technology licensing, patenting, and spinoffs are often a prominent focus of public policy toward universities in relation to high-tech industry, these activities seem to be less important than more informal interactions such as faculty consulting, student internships, and small business advice.[51] In each of the three metropolitan areas corporate leaders and entrepreneurs have been important supporters and advocates of the postsecondary education system. ■

Endnotes

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2. Roger Miller and Marcel Cote, "Growing the Next Silicon Valley," *Harvard Business Review,* July-August 1985, pp. 114-123.

3. See Stuart W. Leslie, "Regional Disadvantage: Replicating Silicon Valley in New York's Capital Region," Technology and Culture 42 (2) (April 2001): 236-264; Stuart W. Leslie and Robert H. Kargon, "Selling Silicon Valley: Frederick Terman's Model for Regional Advantage," *Business History Review* 70 (4) (Winter 1996): 435–472.

4. All three regions examined here have a high-tech location quotient that indicates regional specialization in high-tech (Portland: 1.35, Boise: 1.76, Kansas City: 1.14). The high-tech location quotient is a measure of the extent to which a metropolitan area is specialized in high-tech industries. For further explanation see the note accompanying Table 1 in the text.

5. Heike Mayer, "Taking Root in the Silicon Forest: The Role of High Technology Firms As Surrogate Universities in Portland, Oregon," *Journal of the American Planning Association* 71 (3) (Summer 2005): 318–333.

6. Brakke Consulting, Inc., "Review of Kansas City Area Animal Health Assets," available at www.kcanimalhealth.com/pdf/Brakke_report.pdf (2006).

7. See Carl Abbott, *Portland: Planning, Politics, and Growth in a Twentieth Century City* (Lincoln: University of Nebraska Press, 1983); Gordon B. Dodds and Craig E. Wollner, *The Silicon Forest: High-Tech in the Portland Area* (Portland, OR: Oregon Historical Society, 1990).

8. Author's analysis of data from County Business Patterns, 2005.

9. An industry cluster is "a group of firms, and related economic actors and institutions, located near one another and that draw productive advantage from their mutual proximity and connections." Joseph Cortright, *Making Sense of Clusters: Regional Competitiveness and Economic Development* (Washington: Brookings Institution, 2006), p. 1.

10. See Joseph Cortright and Heike Mayer, "Overview of the Silicon Forest," Regional Connections Working Paper 1 (Institute for Portland Metropolitan Studies, Portland State University, 1999)

11. For more information see www.osdlab.org/en/Main_Page.

12. Heike Mayer, "Planting High Technology Seeds: Tektronix's Role in the Creation of Portland's Silicon Forest," *Oregon Historical Quarterly* 106 (4) (Winter 2005): 568–593. Also see the author's work on visualizing entrepreneurial genealogies, at http://uap.ncr.vt.edu/research/knowledge_regions.html or at http://heikemayer.com.

13. For historical data on Tektronix employment, see Marshall M. Lee, *Winning With People: The First 40 Years of Tektronix* (Portland, OR: Tektronix, Inc., 1986). For the 2007 figures see Portland Business Journal, *The Book of Lists 2008* (Portland, OR: Portland Business Journal, 2008).

14. Christophe Lecuyer, *Making Silicon Valley: Innovation and the Growth of High-Tech, 1930–1970* (Cambridge: MIT Press, 2005).

15. Heike Mayer, "Taking Root in the Silicon Forest: The Role of High Technology Firms as Surrogate Universities in Portland, Oregon." Ph.D. dissertation, Portland State University, 2003.

16. Portland Business Journal, *Book of Lists.*

17. Lucy was founded by a former Intel employee along with a former Nike employee. Nike is also headquartered in the Portland region. The presence of Nike along with Adidas and Columbia Sportswear, whose U.S. headquarters are also in the Portland area, has led to the development of a vibrant sports apparel cluster.

18. Albert Yu, *Creating the Digital Future* (New York: Free Press, 1998).

19. Portland is home to Intel's Research Pathfinding Lab (RP1) which is dedicated to advanced research on silicon technologies and equipment. The lab is immediately adjacent to Intel's fourth process development fab, D1D.

20. Mike Rogoway, "Intel Pledges $7 Billion to Upgrade U.S. Factories," *The Oregonian*, February 11, 2009, available at

www.oregonlive.com/business/index.ssf/2009/02/intel_pledges_7_billion_to_upg.html.

21. Intel's initial location decision in the 1970s did not involve any tax incentives or other types of local government concessions.

22. Mayer, "Planting High Technology Seeds."

23. Heike Mayer, "Competition for High-Tech Jobs in Second-Tier Regions: The Case of Portland, Oregon." In Douglas J. Watson & John C. Morris, eds., *Building the Local Economy: Cases in Economic Development* (Athens, GA: Carl Vinson Institute of Government, The University of Georgia, 2008).

24. Heike Mayer, "Completing the Puzzle: Creating a High-Tech and Life Science Economy in Kansas City" (Washington: Brookings Institution, 2006).

25. Brakke Consulting, Inc., "Review of Kansas City Area Animal Health Assets." Available at www.kcanimalhealth.com/sec_business/section/brakke.htm (2006).

26. Joseph Keenan, "Marion Labs Attributes Soaring Success to Its Staff," *The Kansas City Star*, August 13, 1985, p. D1.

27. Thomas Miller and Associates, "Greater Kansas City Life Sciences Industry Survey." Report prepared for the Kansas City Life Sciences Institute and Kansas City Area Development Council (2003).

28. Mayer, "Completing the Puzzle."

29. Brakke Consulting, "Review."

30. Ibid.

31. Ibid., p. 1.

32. Greater Kansas City Community Foundation, "Time to Get It Right: A Strategy for Higher Education in Kansas City" (2005).

33. Kansas City Area Life Sciences Institute, Inc., "Kansas City Regional Life Sciences Industry Census - 2006" (2006).

34. Stowers Institute for Medical Research, "Fact Sheet," available at www.stowers-institute.org/MediaCenter/docs/FactSheet.pdf.

35. Kansas Bioscience Organization, "Kansas Bioscience Initiative," available at www.kansasbio.org/news/events/07presskit/kansasbioscienceiniativesheet.pdf. Under tax-increment financing a governmental unit issues bonds to finance a project and repays the bonds out of the additional tax revenue that the project generates.

36. Heike Mayer, "A Review of State R&D Investment Funds: Ten Case Studies" (2007) available at http://uap.ncr.vt.edu/docs/HeikePublications/Heike%20Mayer%20Virginia%20Tech%20Publications/A_Monographs/Mayer%20(2007)%20Pew%20NGA_Final%20Report_March%201%202007.pdf.

37. Chris Blanchard, "This Urban Idaho," *Idaho Issues Online,* available at www.boisestate.edu/history/issuesonline/spring2006_issues/5f_numbers_06spr.html (2005).

38. Author's analysis of data from County Business Patterns, 2005.

39. Heike Mayer, "Bootstrapping High-Tech: Entrepreneurship and Innovation in Second-Tier Regions," Paper presented at North American Meetings of the Regional Science Association International, November 2007.

40. David Packard, *The HP Way* (New York: HarperCollins, 1995).

41. Idaho Business Review, *Idaho Book of Lists 2007* (Boise: Idaho Business Review, 2007).

42. Peter Goodman, "Free Fall's Over, but Where Are We Landing?" *The New York Times*, May 10, 2009, p. BU1.

43. Goodman, "Free Fall's Over." For the 2007 employment figure, see Idaho Business Review, *Idaho Book of Lists 2007* (Boise: Idaho Business Review, 2007).

44. Robert C. Leachman and Chien H. Leachman, "Globalization of Semiconductors: Do Real Men Have Fabs, or Virtual Fabs?" In Martin Kenney and Richard Florida, eds., *Locating Global Advantage: Industry Dynamics in the International Economy* (Stanford, CA: Stanford University Press, 2004).

45. Packard, "The HP Way."

46. Harvey Goldstein and Joshua Drucker, "The Economic Development Impacts of Universities on Regions: Do Size and Distance Matter?" *Economic Development Quarterly* 20 (1) (February 2006): 22-43; Richard Lester, "Universities, Innovation, and the Competitiveness of Local Economies: Summary Report from the Local Innovation Systems Project—Phase I," MIT Industrial Performance Center Working paper IPC-05-010, (MIT 2005).

47. As the Portland and Boise cases show, the specialized high-tech industries in those metropolitan areas emerged, in part, because firms relocated routine production to lower-cost locations. For a theoretical treatment of this process, see Gilles Duranton and Diego Puga, "Nursery Cities: Urban Diversity, Process Innovation, and the Life Cycle of Products," *American Economic Review* 91 (5) (December 2001): 1454–1477.

48. David P. Angel, *Restructuring for Innovation: The Remaking of the U.S. Semiconductor Industry* (New York: Guilford, 1994).

49. Mayer, "Taking Root."

50. In recent years, a lively academic debate developed about the role of universities in the evolution of industry clusters. See, e.g., Pontus Braunerhjelm and Maryann Feldman, eds.. *Cluster Genesis: Technology-Based Industrial Development* (Oxford: Oxford University Press, 2006); Timothy Bresnahan and Alfonso Gambardella, eds., *Building High-Tech Clusters: Silicon Valley and Beyond* (Cambridge: Cambridge University Press, 2004).

51. See Lester, "Universities," for a related argument based on evidence from other parts of the United States and Europe.

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