Population Review
Volume 63, Number 1, 2024
Type: Article pp. 98 - 107

Regional Innovation and Economic Transformation

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Abstract

An important aspect of globalization is the role of science and technology whereby nations and regions exhibit their capacity for scientific and technological innovations. Even though ideas, knowledge and expertise have no borders, some areas are better positioned to embark on scientific discovery and innovation than others. Even though production of scientific knowledge in one area ultimately spills over in another, differences are likely to continue. Scientists, engineers, and entrepreneurs are highly mobile professionals who move easily beyond local and regional economic opportunities. These experts appear to prefer to locate in areas with sound scientific research and innovation infrastructure on the one hand and intellectual and scientific brain power on the other.

Keywords: globalization; regional development

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Introduction

The production of knowledge in most societies is a deliberate and organized activity. Institutions are formed to create knowledge, fostering human creativity and ultimately, the common good. Nations and regions differ substantially in their capacity to create and maintain such institutions. Often this capacity is rooted in cultural traditions that encourage the freedom of ideas and inquiry. Substantial investments of resources are made to ensure that the best minds do not go untapped.

There must be overwhelming public support for such programs to continue and flourish. An environment in which scientific collaboration between individuals and institutions is necessary and ideally, encouraged. The difficulty that Atlanta had in establishing a viable bio-tech cluster indicates dynamic, local leadership within networks and by individuals is also important. (Walcott,1999, p. 70). Clearly, no society can claim a monopoly in the production of knowledge and technology. Therefore, strategic cooperation allows the most efficient use of human and material resources. But there is no doubt that those nations and regions that make a greater investment in research and development are more likely to lead others in knowledge production and technical know-how. They generate more patents, some of which result in the development of new processes, products, and services. It is important to note that some of the same processes operate at the local level as well.

Regions with major research universities, government involvement and private research laboratories attract experienced scientists and engineers to work and live in the area. Research funds from various sources become available to not only embark upon new discoveries and find solutions to some of the most intractable problems as well. Regions endowed with these characteristics provide new economic opportunities and cultural ethos to its residents.

Yet during the past sixty years in the United States, regions that once enjoyed economic prosperity, population growth and vibrant institutions experienced massive restructuring of their local economies. This alteration in the economic fabrics resulted in the loss of employment, population, and a sense of despair in many communities. Some of the declining regions responded to these challenges quickly with a sense of strategic foresight and planning. Each had to determine its regional comparative advantage and pursue it with total commitment. Arguably, the most important ingredient for success was in the capacity of a region for innovation, entrepreneurship, and partnership with both institutions and stakeholders. In the conclusion of his study of the of the University of Massachusetts' role in its regional development process, Robert Forrant explained:

> …According to (high-tech) district can well exploit dozens of experiments simultaneously thorough a series of horizontal relationships with others with the requisite complimentary capabilities. It is here, at the interstices of these relationships, that i envision universities insinuating themselves in the regional development process as champions of knowledge generation and vigorous knowledge diffusion. In this way the university will advance its mission beyond a random approach to development and play an informative integrative and innovative role in the cultivation of a sustainable regional economy (Forrant, 2001, p. 623).

The Crucial Role of Research Universities

One of the greatest assets for a region is its research universities; they educate and train people in different fields. Research universities are a significant resource of the three generic types of R&D: basic, applied, and experimental development. Basic research is experimental or theoretical activity intended to generate knowledge without necessary application. Applied research also attempts to create new knowledge, but only that which has evident usefulness in everyday life. Experimental development takes the data generated

by basic and applied research to create “new materials, products, processes, and systems, or substantially improving existing ones” (see OECD, 1994, p. 29). Whatever type of research is involved, R&D can have a significant impact on jobs and wages in areas where it is concentrated. In some newer fields such as biotech, the distinction between basic and applied research is less distinct because technological research approximates basic research (OECD, 1998, p. 168).

However, the role of U.S. universities in R&D activity should not be exaggerated given it was only 3.8% of all such activity in 1998 (Payson, 1999, pp.8). In addition, University research has suffered due to declines in Federal funding, only part of which has been compensated for by the industries. But university research is 50% basic, thus a major source of innovation. Much technological development by industry stems from basic advances in university research. Universities are also instrumental in developing a knowledge workforce through their training of engineers and scientists and their cooperative links to industry and the creation of spin-offs. Academic - industry links include joint research projects, ventures and international and research networks that may include other universities. “In a knowledge-based economy, university - industry links are likely to strengthen further, through new and evolving organized arrangement.” (OECD, 1998, pp. 175, 177). Industry has benefited from such R&D links with greater productivity and higher returns on investment. One of the main motives for these increasing ties is the rising prominence of high-tech sectors, including biotech and microelectronics. Types of networks that have evolved (with implications for industrial - academic clustering and hence employment opportunities) include: "co-enterprises and trading companies that commercialize products developed by institutions of higher education, science parks, incubators that encourage the creation and development of small technology-based firms, and consortia that enable long-term research projects (OECD, 1998, p. 177).

Even though universities attract students from other parts of the U.S. and around the world, many of the students come from the region itself. In addition to retaining researchers who came from the region, universities also help the region by attracting and retaining others from outside the region. The presence of varied talents in the region further strengthens existing scientific and technological capacities. Private sector research laboratories find the region attractive for pursuing their research and innovation agendas. The same is true for government research laboratories. Additionally, firms find the region attractive because they can tap into the educated workforce and the local research infrastructure. New private sector enterprises are established through the scientists and engineers themselves as they seek commercialization of their research and innovation for the common good as well as for profit.

It is in these contexts in major U.S. research universities is to bring some of the institutionally generated scientific knowledge and technology for commercialization under some explicit institutional guidelines. In addition to making scientific knowledge and technology useful to society at large, it also creates new revenue sources for the universities. When such efforts lead to the formation of new firms in the region or strengthen and expand existing firms, jobs are created, and other economic opportunities ensue. These ventures then help strengthen the region's economic base, which helps communities maintain their tax base and provide adequate services to their residents.

The public perception of universities is also undergoing some change. People in general consider research universities and other research centers as key to a region's long-term economic future and social stability. In this ever-changing economic landscape, people now understand that the investment of public money in these institutions is more critical now than ever before. Quoting from a study, Goldberg observed that:

> ... The fast-growing high-tech sector was increasingly determining which metropolitan areas are succeeding or failing ... High-tech activity could explain 65 percent of the difference in economic growth", among various metropolitan regions during the 1990s. And it found research centers and institutions are indisputably the most important factor in incubating high-tech industries. The

institutions, the experts say, provide nearby companies streams of cutting-edge. Knowledge as well as streams of smart labor (Goldberg, 1999, p. 12[a]).

Pittsburgh's Research Universities and Economic Transition

Not long ago, Pittsburgh region was a major hub of research and innovation in the U.S. It is home to two major research universities (i.e. Carnegie Mellon University [CMU] and the University of Pittsburgh [Pitt]) and many other higher educational institutions that contribute to the city's substantial research infrastructure. Too, the research laboratories of several major U.S. corporations were present in the Pittsburgh region. But the downsizing of the manufacturing sector and the out-migration of some major corporations reduced the infrastructure as well as the number of scientific and technical personnel in the region. Much of this activity happened in the 1970s and 1980s. This type of economic change was unprecedented at the time, and many believed that it would pass. It has not. Many plant closings and job losses became permanent. The population declined and the tax base of communities eroded. Despite these economic and social upheavals, the region's universities continued to prosper in terms of volume of research and quality of students and faculty, many of them world-class in stature. In the 1980s, the role of research universities began to be recognized. This was based substantially on the recognition of the pivotal role universities played in the economic growth and job creation in regions such as Boston, San Diego, Research Triangle Institute in North Carolina and elsewhere.

The Pittsburgh region's two major research universities, CMU and Pitt, are members of an elite group called the Association of American Universities (AAU). Membership in the AAU is less than 70 U.S. institutions. Both CMU and Pitt have been recognized as being great research centers in several areas ranging from philosophy to computer engineering. In the 1980s, the role of research universities began to be recognized for the pivotal role they played in the economic growth and job creation in regions such as Boston, San Diego, Research Triangle Institute in North Carolina and elsewhere, including Pittsburgh. In the case of the latter, corporate and government research centers took advantage of university research centers and their scientific personnel. Together, these research centers employed several thousand researchers in such diverse fields as engineering, medicine, information technology, biological sciences, and chemistry, among others.

As employment in manufacturing declined over the years in the region, the job growth generated by bringing millions of research dollars to the region has been significant. CMU and Pitt attract more than $500 million in research grants and contracts annually, with Pittsburgh being one of the top 10 regions in the U.S. in per capita research funding. The University of Pittsburgh currently ranks seventh in the nation for the National Institutes of Health research funding. Clearly, knowledge-intensive jobs created are different from the manufacturing jobs that were lost, but they do provide economic and social stability to the region.

More specifically, knowledge-intensive activities created jobs in other sectors in the region. These sectors supply various goods and services to the many research centers. It must also be recognized that the growth in biomedical and information technology did not occur in a vacuum. As mentioned earlier, Pittsburgh has had a strong research tradition as it was a major industrial region in the U.S. for more than a century. The new research initiatives benefited from the existing scientific and engineering personnel, partnerships among the region's major academic and research organizations, and a tradition of public, private and university partnerships. All these pooled their diverse resources and talents to achieve shared regional goals. Those goals included, for example, environmental cleanup, transportation planning, development of research sites, improvement of the central business district, and the creation of industrial parks.

The environment of collaborative partnership in the Pittsburgh region helped the region's two major

research universities explore new possibilities in which scientific innovations could pave the way for creating a promising economic environment. The transitions undergone by the region's steel industry are particularly emblematic of how aging sectors, with the help of collaboratively generated knowledge, can form the basis of new high technology products and process innovations.

University-Industry Collaborations: Select Cases

Old Steel and New Steel

At one time, the Pittsburgh steel sector was characterized by large, vertically integrated mills. Foreign competition forced domestic steel producers to raise their productivity, which included the establishment of "mini mills" that produced a fraction of the quantity of steel the traditional mills could produce. Mini mills were more efficient in the use of energy and supported recycling. Mini-mills, at least in their original incarnation, mainly used scrap steel as their primary input and thus could pick and choose their mill sites much more liberally than the maxi-mills. They also used iron pellets and directly reduced iron in electric arc furnaces (EAF) to make a handful of products, typically in a continuous casting process (Huallchain, 1993, pp. 1339-40, 1344). From 1975 to 1994, the industry lost 30% of its raw steel making capacity, a blow suffered disproportionately by integrated plants. The integrated units employing direct-reduced iron or blast furnace methods dropped from 50 to 23 in the period, while some of the survivors also reduced in size. Non-integrated plants using EAF technology declined only 7%, many of the remaining having expanded production capacity (Hogan, 1994, p. 87). Pittsburgh's steel sector consequently suffered mightily given its domination by large, integrated mills.

> Maxi-mills accounted for most of the layoffs, plant closures, and bankruptcies associated with the history of the steel industry. Traditionally, maxi-mills were concentrated in eastern Pennsylvania, Pittsburgh, northeastern Ohio, Detroit, Chicago/Gary, and Los Angeles.
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> The elimination of steel-making capacity was geographically widespread in the period 1972 to 1989. However, Pittsburgh, eastern Ohio, Buffalo, and Los Angeles areas lost the largest number of plants. Plant abandonment was strongly influenced by the type of product the maxi-mill. Plant closures by maxi-mills contributed to the substantial geographical shifts in production in the 1980s. The decline was the largest in Pittsburgh, where the share of the total us production of raw steel shrunk from 17% to 9% in the period 1980-89 (Huallchain, 1993, p. 1343).

Western Pennsylvania claimed 10 maxi-mills in 1972 and that decreased to 3 by 1989. The level of steel produced declined in the 1980-89 period from 19 to 9 million tons. Employment also dropped precipitously and partly because of industry efforts to raise productivity. Pennsylvania, along with many other states, suffered poor productivity in its steel industry, having been overly wedded to old technology (Huallchain, 1993, pp. 1342-43, 1346, 1353). An increasing use of substitutes for steel also contributed to the decline of American raw steel production from 151 to 98 million tons during 1973-89 (Huallchain, 1993, p. 1340).

In contrast, mini mills tended to employ "flexible human know-how and organizational structures," allowing quick reaction to changing markets (Huallchain, 1993, p. 1345). The mini mills also engaged in horizontal integration - the geographical and product diversification gained through applying production knowledge related to a given product to others (Berry, 1993, p. 20).

Specialty mills are dedicated to specific markets and customer needs. They produce alloy, stainless and tool steels of high quality and reliability (Huallchain, 1993, p.1343). Specialty mills' single biggest seller is stainless steel, which resists corrosion and rust and is used for household goods and various auto parts. Another high-volume market is electrical steel used for power transformers, though less profitable than

stainless steel. Such products are attractive to make as their profits are several folds more than those associated with carbon steel sales (Fine, 1993, p. 16).

Despite the attractiveness of the profits to be made in specialty steel, most of its mills have been and continue to be in western Pennsylvania. Approximately 15 such facilities are concentrated in the region. Pittsburgh was also the home of what was then known as the Mannesmann Demag Corporation, a producer of equipment and the construction of buildings for the steel industry (Pollock, 1994, p. 72). Aside from the economies attached to upgrades of existing facilities as opposed to new construction, the geographical inertia unique to specialty mills within the sector stemmed from its requirement of a highly skilled work force. The labor force of western Pennsylvania retained those skills not found abundantly elsewhere. As Huallchain explained, “Distinctive corporate organization, culture, and the know-how needed to produce customized products also serve as a barrier to the entry of new firms located in other regions. Finally, the higher value of specialty steel can support greater transportation costs” (Huallchain 1993, p. 1344).

But even with its embedded, highly skilled workforce, Pittsburgh's specialty steel sector could not afford to be complacent. This sector underwent great change and challenge, given that about two-thirds of the steel products made at the time were only developed in the previous 8 years or so (Gaboury, 2001, p. 6).

Global manufacturing overcapacity in specialty steels continued to threaten domestic producers, including Pittsburgh's firms. Despite decreases in 2003 in total and finished steel imports of 29.6% and 23.7%, respectively, (assisted by U.S. steel tariffs), imports in several major specialty steel categories were up, including tool steel (15%), stainless pipe and tubing (14%), and electrical sheet and strip (14%), (AIST, 2004).

The Pittsburgh region's specialty steel makers survived due to their investment in new technology and the development of new steel products. Examples include AK Steel's pre-painted steel (coated with an anti-microbial compound suitable for hospitals); super austenitic stainless steel with high strength and toughness by Allegheny Ludlum; and an advanced super austenitic stainless steel that resists corrosion in high heat from Special Metals Corporation (Invention, Creation, etc., 2004). Maglev, a public-private partnership working to bring high-speed, magnetic levitation trains to the region, invented a precision steel fabricating technology that reduces the distortion of large steel parts (such as lengthy train rails) during their manufacture. In this instance, the knowledge developed for one specific project could be commercialized for numerous other steel projects (Davis, 2004, p. 21-23).

University-industry collaborations also helped the Pittsburgh region’s steel makers survive through knowledge sharing and invention. Carnegie Mellon University facilitates the development of many new steels and production processes with firms from within and outside the region. These development projects included new ways to make sheet steel; new and emerging sources of iron and their applicability to the North American steel industry; recycling of waste oxides in steel making furnaces; optimization of past combustion in steel making; and advancing the state of clean steels. Pitt also engaged in such research partnerships with the industry, exemplified by its project to reduce the variability of HSLA steels (AISI, 2004). In a separate consortium with industry, two Pitt scientists developed a lead-free steel suitable for numerous uses in cars, informally referred to as "green steel." Green steel is easier to machine than leaded steel and, by definition, has no lead shavings to release into the environment (Spice, 1999, pp. 6-7 [A]). Pitt's Office of Technology Management in turn helped to commercialize and license the new steel in North America and Europe. Sales of green steel steadily rose in 2003 with 33 firms seeking to purchase it (Office of the Chancellor, 2003, p. 2).

Life Sciences Greenhouse

The Bio-venture Life Sciences Greenhouse is a public-private partnership program founded by the state government in cooperation with Pitt, CMU, and the University of Pittsburgh Medical Center (UPMC). In addition to these institutions, private industry, local governments, and civic groups worked together on a 10-year plan to make the Pittsburgh region a world leader in life sciences. The combined strengths of the two universities were reflected in their prominence in light microscope imaging, biotechnology, medical robotics, artificial and biohybrid organ development, and bone tissue engineering, among other efforts in related fields. Several firms that manufacture medical devices and diagnostic tools relocated to the Pittsburgh region to take advantage of the scientific and engineering programs and personnel. Firms such as *Launchcyte* located in the region to provide commercialization, marketing, and management expertise. The jobs in this knowledge-intensive sector are in small- and medium-sized firms. Indeed, the source of innovation for firms was related to the size of the firms. Large companies relied more on in-house R&D, while university-generated research was more important to small firms.

> Apparently, large firms are more adept at exploiting knowledge created in their own laboratories, while their smaller counterparts have a comparative advantage at exploiting spillovers from university laboratories (Audretsch 1998, p. 23)

Digital Greenhouse

The Pittsburgh Digital Greenhouse was established in 1999 to employ system on chip, fostering the networking and expansion of multimedia programs. "Advances in semiconductor manufacturing technology make it possible to create a single chip that contains one or more processors, memory, communication interfaces, analog interfaces, and embedded software" (Pittsburgh Digital Greenhouse, 2004). Private sector participation began the enhancement of various applications in the networking and multimedia fields. The major participants in the program includes universities, economic development organizations, local government, and private industry. The program relied heavily on the region's tremendous strengths in information technology, computers and software, and the presence of highly trained scientific manpower. The capacity of the region to innovate and take risks in areas that held future promise had gained momentum.

Tissue Engineering Institute

The Pittsburgh Tissue Engineering Institute (PTEI) represented a partnership between the region's major universities and the two major hospitals and medical research centers. Local foundations provided seed money to finance projects in this area. Projects were led by scientists working in tissue engineering, bio-surgery, and artificial and biohybrid organ devices. PTEI aims to grow human tissues for liver, bone, muscle, cartilage, and heart muscles, among others. Biotechnology firms produce tissue-engineering products that are expected to have significant pharmaceutical applications. *Tissueinformatics* was one such firm. Several other biotechnology firms were also funded jointly by universities and private sector organizations. According to one report, there were 26 firms in the Pittsburgh region employing 624 people with a combined operating budget of $774 million (Pittsburgh Tissue Engineering Initiative, 2000, pp. 20-24).

CMU and Pitt established technology management offices that helped faculty bring their research products to the marketplace. Both institutions coordinate their activities in such a way that collaborations between researchers possessing complementary expertise are fostered. The greatest possibilities were and continue to be in the field of biomedical sciences. The two universities hired a professional to help coordinate programs most relevant to the region's economy. A nonprofit organization was established to provide the organizational framework for coordination and to avoid the usual bureaucratic hurdles.

The preceding discussion shows that the Pittsburgh region had most of the elements that helped it remain a center of scientific research and innovation following the regional decline in steel manufacturing. This region, like others, continues to face new opportunities to exceed its own expectations and also faces challenges that are beyond its control. For the region to continue its success and achieve its future promise, it must work to create conditions in which scientists, innovators, and high-technology firms are able to both find their own niches and collaborate for the continued pursuit of excellence and success. Industry clusters provide an environment that is naturally conducive to such collaborations.

Clusters

Michael Porter argues that to enhance competitive advantage, a region must create specialized economic activities in clusters. "Clusters are geographically close groups of interconnected companies and associated institutions in a particular field linked by common knowledge and skills" (Porter, 2001). Firms in a cluster share knowledge, resources, and sometimes even risks. Important alliances are formed between firms to enhance their competitiveness. It is critical that the political, economic, and regulatory environments be conducive to the formation of such strategic partnerships between firms, which often are competitors themselves. The regions that are endowed with innovative capacity are more likely to provide the opportunities for the formation of clusters.

Some of the important measures of regional innovation include the number of patents granted per worker, the formation of new firms, and the patterns of growth in relation to competing regions and the U.S. The availability of venture capital and a spirit of entrepreneurship are also critical in this context.

Pittsburgh's Clusters

In comparing San Diego, Pittsburgh, Atlanta, Wichita, and the Research Triangle Institute in Raleigh-Durham in North Carolina, Porter found that innovative regions were more prosperous than those that lagged. But spending on research and development must be accompanied by opportunities for commercialization. Porter found that the Research Triangle Institute in North Carolina attracted significant research and development funds, but that it was relatively weak in converting the research results into marketable products and services. In the case of Pittsburgh, he observed that:

> Some of Pittsburgh's most valuable assets are its research universities and institutes, with world-renown centers of research in transplantation, bioscience, computer science, and engineering acting as anchor firms in the region. Pittsburgh is a powerhouse for university research and development as it receives more than twice the national average on a per worker basis, but it requires better commercialization mechanisms. The universities are a tremendous source of innovation, and opportunities exist to capitalize on relationships, such as the University of Pittsburgh's affiliation with the Healthcare/Hospital Industry (Porter 2001, 16)

As discussed earlier, scientific research and innovations result in patents and their volume reflects the potential for product development, and ultimately their commercialization. In fact, the level of patent activity reflects the regional availability of various sources of innovation, including academic and non-academic research centers and educational attainment of the populace (Audretsch, 1998, p. 23). In this context, the Pittsburgh region seems to be doing well. The aggregate patents per 1,000 scientists and engineers from 1997 to 2001 was greater for Pittsburgh than Boston, New York, Washington, D.C., and Baltimore, but was behind San Diego, Philadelphia, and the Research Triangle in North Carolina. In both Philadelphia and Pittsburgh, life sciences, computer and software systems have produced most of the patents (Thornburgh, 2002 pp. 21-23).

Summary

The Pittsburgh region underwent a radical economic transformation in the late 20th century. The region responded to industrial decline by identifying its strengths in research and innovation and moved quickly to capitalize on them. It developed partnerships enabling the pooling of talents, resources, and ultimately, the initiation of programs for innovation and technology transfer. Industry sectors or initiatives that have a significant presence in Pittsburgh today, but which enjoyed only a marginal presence twenty years ago include tissue engineering, the Life Sciences Greenhouse, and the Digital Greenhouse. Most importantly, the Pittsburgh region found a path to build on the strengths of existing aging industries and used that knowledge to preserve market share and expand into new related market niches, as exemplified by the steel sector. Many accomplishments resulted from the sharing of high-tech knowledge between the region's research universities and the councils of industry. For the region to survive economically, it must continue to intensify its approaches to knowledge sharing and the commercialization of that knowledge, for if it fails, other regions will surely not.

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