2 Industrial and Technology Clusters: An Everyday Topic of Popular Conversation

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It is not often that major research themes in geography and regional science are central to national and international discussions of government leaders, the business press, and economic development practitioners working to improve national, regional, state, and local government economies. "Industry clusters," but particularly its popular cousin "technology clusters" has moved from academia to enjoy widespread press, popular and practitioner attention in both developed and developing economies (see Taylor's contribution in this book). This is no surprise. It is now recognized that innovation-driven sectors of the economy are yielding great returns and that many of the firms in these sectors are "clustered" in particular regions. Not only do industries in knowledge-driven sectors report higher value added than other manufacturing sectors, but wages rates and growth rates are higher as well (National Science Foundation, 2006, Chapter 6, 9). The NSF reports that over the period 1980–2003 world output by high-technology manufacturing industries grew at an inflation-adjusted average annual rate of 6.4 percent compared to 2.4 percent for other manufacturing industries. It is explained by the NSF and others that high technology industries are intensive users of research and development (R&D) that leads to innovation resulting in gains in market share, the creation of new markets, and the efficient use of resources. Regions with successful clusters are working to retain their advantage and others are seeking to create clusters as a path to economic growth and development.

A cluster-based approach is now a mainstream strategy to promote regional economic development throughout all advanced economies and even by many developing countries (Martin and Sunley, 2003, 12). Although the theory and practice underlying the concept is not new to geographers and regional economists, it is not surprising that the concept is used rather loosely in the press, by those involved in economic development efforts (politicians, various board members, planners, economic development professionals), and perhaps by some in the halls of academia. Even serious scholars argue that the concept is vague and perhaps loosely applied. As shown in this book, the concept is wrapped around related concepts that may also have definitional problems or different interpretations such as "embeddedness," "social capital," "new economy," "corporate complexes," "entrepreneurship," "spillovers," "absorptive capacity," "knowledge or learning regions," and "technology-based development" to name just a few. However, most academics and practitioners do understand a cluster to be a concentration of interconnected companies, including suppliers and service providers, who are

supported by various governmental and non-governmental institutions (particularly universities) that both compete with and cooperate with one another within a defined region. What may not be known to the casual observer is the corpus of theory and practice behind the technology cluster concept. A good review of this theory and practice is provided by a number of manuscripts and books, such as that provided by Cooke (2002), so it is not the purpose of this brief introduction to repeat this discussion. But for those new to the topic a few pages are provided on the topic to set the stage for the more focused chapters in this book.

Michael Porter is generally credited for popularizing the industrial cluster concept. Writing about conditions that explained the competitive economic position of nations, he argued through examples that much of the economic power of most advanced countries was concentrated in a few districts that often had elements within four dimensions (Porter's diamond) that affected regional competitiveness—factor conditions; demand conditions; firm strategy and rivalry; and supporting industries (Porter, 1990). "Technology clusters," an extension of the industrial cluster concept, have in addition to the four dimensions of the Porter diamond the following elements: entrepreneurship, a source of innovation, sources of financial capital and social capital. Social capital describes the trusting relationships among individuals within organizations in a region that promotes the exchange of information and joint action for mutual benefit (Fountain, 1998; Saxenian, 1994).

However well received Porter's his 1990 book was to geographers and regional economists, most understood that the concept of an industrial cluster has been a topic of interest and development for much of the 20th century and perhaps could be traced to Ricardo's early 19th century concept of comparative advantage (if a country has an absolute advantage over another in two different products, it should still focus on the product in which it has the strongest advantage). If this is a stretch, Marshall's concept of the "industrial district" that capitalized on the value of skilled labor and traditions in addition to resource endowment as fostering a concentration of industrial activity is often referenced as the earliest recognition of the industrial cluster idea (Marshall 1891).

While the role of agglomeration and external economies on the concentration of industry has been an area of intense academic focus throughout the 20th century (beginning with the work of Alfred Weber, 1909), much of this work centered on the external economies of scale resulting from the clustering of activity that benefited individual enterprises. Given the difficulty economists faced in introducing "technology" into their understanding of factors contributing to per capital economic growth (not recognized until explained by the Solow residual in 1957), it is not surprising that the role of technology and innovation along with other "softer" factors on regional performance has taken decades to unravel. Well prior to Porter's popularization of the industrial cluster concept, others following the tradition of the economist Schumpeter, argued that the role of continuous innovation was central to the performance of firms and on the growth and development of industrial districts (e.g., Piore, M. and C. Sabel 1984). However, the relationship of

innovation and technological advances on regional competitiveness, along with an understanding of the role of social capital, entrepreneurship and government intervention in the development, continuous support, and transformation of clusters continues to offer challenging opportunities for those studying clusters and particularly those interested in creating and promoting clusters.

Much of the literature on the topic, including much of Porter's work and many government sponsored reports, newspaper and magazine articles (see, for example Strempel 2005) focuses on mapping clusters or identifying factors that have contributed to successful clusters. Hundreds of industry cluster case studies have been described in both the academic literature and in various reports printed throughout the globe that are often the result of projects commissioned by states, regions, councils, districts, or municipalities. For instance, Michael Porter's *Cluster Mapping Project* (2002) identified 12 specialized regional economies in the United States[1] and the Brookings Institution identified 14 U.S. metropolitan concentrations of high technology industry "most frequently mentioned in the popular literature" (Cortright and Mayer 2001, 2).[2] But others (who were not Harvard economists) working independent of Porter and did not receive such popular acclaim also identified clusters of technology-related activity driven by external economies through the interaction of related firms that took advantage of a division of labor in a region and the minimization of transaction costs (Scott 1988; Scott and Kwok 1989; and Coffey and Bailly 1991).

Some clusters develop without direct public policy intervention or direction. In other cases, state or regional leaders work to create a cluster in a region that does not have much industrial or supportive activity related to the future cluster. "Created" clusters are often associated with rapidly expanding knowledge-based sectors that are heavily dependent upon universities, entrepreneurship and skilled labor. But, as shown by LaFray et al in this book and other examples (see, for example, Akoorie for a good study of the New Zealand thoroughbred industry other sectors such as agriculture can be a focus of a cluster promotion program). In either case, the model is based on the notion that knowledge spills over into a local region if that region has the capacity to "absorb" the knowledge created (Breschi and Malerba 2001).

Throughout the 1980s and into the 1990s many regions were aspired to create new "silicon valleys" to capture part of the information technology boom and "biotechnology clusters" became fashionable as the growth of pharmaceuticals, medical equipment, and related technologies attracted widespread attention and huge public research investment (particularly in the U.S.). The latest trend is nanotechnology that is receiving tremendous public sector investment such that some say it will define the early part of the twenty-first century. As explained by Fromhold-Eisebith in this book, there are different approaches to cluster promotion with "public top-down" and "private bottom-up" being two major categories. A common strategy in the creation of clusters is to encourage increased agglomeration economies around a promising regional core of activities rather than to build an

entirely new foundation from which activities can flourish. This could be a major local industry, a major federal center, or even a major university research institute. It is less common, for regions to invest efforts to create clusters in an emerging technological area that needs to overcome both technical (involving investments in R&D) and competitive market conditions before profitable returns are realized.

Creating clusters is quite popular, but has a questionable record of success, particularly where the task is to transform an "old economy" (industrial plants, hierarchical, skill-based, etc.) into a "new economy" (lifelong learning, risk-taking, teaming, etc) (Cooke 2002, 131-156). Such regions include those that are tied to traditional manufacturing or extractive industries that competed on the basis on proximity to local mineral resources, transportation assets or available labor. As these regional economies suffered with global competition (particularly in the case of rock bottom wages from developing countries) or declines in the price of the local raw material, creating new a new economy around a clusters was an attractive way to revitalize and diversity the region. "Declining" manufacturing regions pose special challenges (Boschma and Lambooy 2000; Asheim and Isaken 2002). Most important, local leadership must redirect thinking away from the view that competing on the basis of low-cost manufacturing or attracting new manufacturing operations will return the area to previous greatness. Even if leaders accept that a new model of development based upon the creation and support of innovative clusters is a means for local revitalization and transformation, the challenge is great if the area does not have knowledge creation sources or entrepreneurs with experience and staying power to develop technology through R&D before it is ready for the marketplace. Likewise, such regions are likely to have sparse investment funds or venture companies who have experience dealing with the uncertainty of technological risk in addition to the expected risk for all start-up businesses.

Despite these challenges, many regions have worked and continue to work on creating new economy clusters in areas in decline and areas lacking a tradition of entrepreneurship, sources of innovation, and financial capital. Success has been reported, for example, in Finland's efforts in building clusters centered on technology parks that link university research, industry laboratories, and linked companies. For instance, the city of Oulu has been able to transition from its traditional forest products industry to a cluster focusing on telecommunications, software, sensors, optoelectronics and lasers (Cooke 2002, 169-169). Other declining areas such as Appalachia in the U. S. (Feser and Goldstein, 2002) or cities tied to "industrial age" economies in Europe of North America have embraced the cluster approach with some success. For instance, Lehigh Valley Pennsylvania has moved away from its dependence on steel to life sciences that are grounded in university research centers at Lehigh University and elsewhere (Paytas, Gradeck and Andrews 2004, 16-17).

If innovation is central to successful long-lasting clusters, a major question is determining the source of continuous innovation. The likely source of new knowledge creation is from research and development activities (Audretsch 1998, 20).

Universities are prime candidates to produce research and development (R&D), but other sources are industry R&D laboratories, federal R&D laboratories, or even "decentralized industrial creativity" within the collective capacity of small firms within a region (Bellandi 1994 from Asheim 1995). As noted by Maskell (2001), the availability of specialized knowledge and the creation of new knowledge may attract firms from elsewhere into the region, may attract entrepreneurs into the region, and may create new firms through spinoff activities. A problem is that by most measures, knowledge creation is highly concentrated in particular metropolitan areas or regions of advanced economies. A major source of innovation in the U.S. is R&D and this is highly concentrated with the top 10 states accounting for almost two-thirds of total R&D (California accounting for more than twenty percent of the total). Of the 625 institutions surveyed by the National Science Foundation, the 20 leading institutions account for almost one-third of the total academic R&D spending (Shackelford 2004). R&D for important industries are also highly concentrated. For instance, three states (California, Massachusetts and Texas) account for over half of the nation's R&D in the computer and electronic products industry and two states (New Jersey and Pennsylvania) provide one-third of the nation's R&D in the chemical sector (National Science Foundation 2006, Chapter 4). National Institutes of Health funding is also highly concentrated as eight states account for over 18 percent of the total NIH.
Recognizing the linkage between technology clusters and R&D, technology parks have grown in popularity across the globe as a way to create sources of innovation to support clusters of activity. According to the Association of University Research Parks, in North America there are 2,900 organizations/companies located in parks that support jobs for over 235,000 people with total investment exceeding $9 billion (Dean 2005).

An important component in cluster formation is entrepreneurship that is required to take new ideas forward and develop them locally so they are introduced into the marketplace (Feldman and Francis 2004, 131). Independent of clusters entrepreneurship and small and medium sized business have been shown to be a major factor in job creation in the United States (Birch, 1981; Roacha, 2004). Although research shows that entrepreneurship is positively associated with economic growth, but outstanding questions remain on the relationship between clusters and entrepreneurship and particularly how entrepreneurship is measured (Rocha 2004). But fostering entrepreneurship is generally a central feature in cluster promotion efforts. A popular way to support entrepreneurship is through business incubators that provide opportunities for collaborative research with universities and industry, assistance with business plan development, legal assistance, IT assistance, mentoring, information about opportunities, and opportunities for entrepreneurs to sharpen their argument as they approach various sources of financial capital. For the most part, however, academicians and practitioners consider entrepreneurship in the context of new firm formation and not entrepreneurship within firms, universities, or research institutes (see Fromhold-Eisebith's contribution in this book) that can have a profound impact on regional development.

It appears unlikely that public policy interest in clusters will diminish. What is likely to happen is that the term "clusters" will lose its fascination as communities and regions fail to achieve outcomes as development plans fall short of expectations. Regional concentrations of economic activity will continue to exist as they have for centuries, but new terminology will replace "clusters" and perhaps capture the enthusiasm of academicians and policy planners in the process.

The space limitation of this brief introduction can not possibly do justice to the breadth and depth of theory and practice reported on clusters. However, a reasonable question one may ask is with so much written and spoken about clusters, why is the topic still of great academic interest? Despite the volumes written on the topic, many challenging questions still remain and some are addressed in this book. These include (1) the need for more work on clusters in sectors that are generally outside major technology-based industries (see contribution by LaFary et al in this book); (2) a need for a deeper understanding of the different types of entrepreneurship and how they are promoted by clusters and different forms of cluster promotion (see Fromhold-Eisebith in this book); (3) guidance on how to promote clusters in rural areas lacking sources of innovation; (4) more guidance on ways to change development trajectories in declining manufacturing cities toward innovation-based cluster formation; (4) models of building new clusters in emerging technological arenas to gain an national/international advantage; (5) ways to use the knowledge created by local universities in areas that are unlikely candidates to absorb this new knowledge; (6) competitiveness of clusters in an increasingly global village; and finally (7) a need for longitudinal studies that show with detailed data on new firm formation, job creation, wage rates, and development (not just growth) how clusters have developed and performed over time.

1 These are: Atlanta (Construction Materials; Transportation and Logistics; and Business Services), Boston (Analytical Instruments; Education and Knowledge Creation; and Communications Equipment), Chicago (Communications Equipment; Processed Food; and Heavy Machinery), Denver (Leather and Sporting Goods; Oil and Gas; Aerospace Vehicles and Defense), Houston (Heavy Construction Services, Oil an Gas, Aerospace Vehicles and Defense), Los Angeles (Apparel, Building Fixtures, Equipment and Services, Entertainment), Pittsburgh (Construction Materials, Metal Manufacturing, Education and Knowledge Creation), Raleigh-Durham (Communications Equipment, Information Technology, Education and Knowledge Creation), San Diego (Leather and Sporting Goods, Power Generation, Education and Knowledge Creation), San Francisco area (Communications Equipment, Agricultural Products, Information Technology), Seattle area (Aerospace Vehicles and Defense, Fishing and Fishing Products, Analytical Instruments), Wichita (Aerospace Vehicles and Defense, Heavy Machinery, Oil and Gas).

[2] The 14 areas identified by the Brookings Institution study does not overlap with those of Porter either on the cities mentioned or their major product specialization. Brookings identified the following metropolitan areas: Atlanta (databases), Austin

(semiconductors, computers, SME), Boston (computers, medical devices, software), Denver (data storage, telecommunications equipment and software), Minneapolis-St. Paul (computers, peripherals, medical devices), Phoenix (semiconductors), Portland (semiconductors, display technology, SME, EDA, wafers), Raleigh-Durham (computers, databases), Sacramento (computers, semiconductors), Salt Lake City (software, medical devices), San Diego (communications equipment), San Jose (semiconductors, computers, communications equipment, SME, EDA, data storage), Seattle (software), and Washington, D.C. (databases, internet services).

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