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Do Innovative Regions Inevitably Decline? Lessons from Cleveland's Experience in the 1920s

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Cleveland provides an example of a famous center of innovation that ultimately lost its dynamism and declined. Once a hotbed of innovative startup enterprises in a remarkable number of important Second Industrial Revolution industries, including electric light and power, steel, petroleum, chemicals, and automobiles, Cleveland now stands out for its high proportion of residents below the poverty line. In this paper, we use the case of Cleveland to further our understanding of the life cycle of high-tech regions. Using patent data, city directories, census returns, and other sources, we examine trends in the number and productivity of Cleveland inventors and in the way these inventors exploited their discoveries. We find evidence of important changes in Cleveland's economy beginning in the 1920s. Although the city continued to spawn many startup enterprises, their individual contributions to the stock of patented technology were generally much smaller. Moreover, the city no longer attracted as many inventors from other regions.

Many regions that have earned fame as centers of innovation ultimately lost their dynamism and even suffered decline. Are such reversals inevitable? Do innovative regions have life cycles analogous to those of biological organisms? Do they always mature and then suffer sclerosis? Certainly, there are cases that appear to challenge such generalizations. Silicon Valley has been an ongoing source of startup enterprises in the computer and related industries for over half a century and shows no signs of losing its cutting-edge character. Southeastern New England had rates of patenting per capita that were substantially above the national average for most of U.S. history, despite

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suffering the loss of some of its major manufacturing industries during the late nineteenth and early twentieth centuries.

The so-called Rust Belt cities of the Midwest provide another example. During the Second Industrial Revolution, those cities were dynamic places. Cleveland, the focus of this study, was a hotbed of innovative startup enterprises in a remarkable number of important Second Industrial Revolution industries, including electric light and power, steel, petroleum, chemicals, and automobiles. Now, however, we know it mainly for its high proportion of residents below the poverty line. In this paper, we use the case of Cleveland to further our understanding of the life cycle of high-tech regions. Exploiting patent data, city directories, census returns, and other sources, we examine trends over time in the number and productivity of Cleveland inventors and in the ways they earned returns from their technological discoveries. The Great Depression hit Cleveland hard, and it is possible that this shock was at the root of its subsequent decline. Hence, we focus our paper on the 1920s to see if Cleveland's economy was already losing its innovative character before the Depression struck.

Hypotheses

There are good reasons to expect that regions that stand out as particularly innovative will continue to be sources of important new enterprises and technologies over time. Perhaps most obviously, the complementary investments made to foster this level of innovation in the first place are likely to provide ongoing support for entrepreneurial activity. For example, entrepreneurs require access to finance, which in turn requires that potential investors have some means of finding out about new enterprises and assessing their potential profitability. There are various ways to solve such information problems, but once the necessary institutions are in place, entrepreneurs and investors can tap them again and again. Because these institutions raise the returns to entrepreneurship, they encourage creative individuals to devote more of their own time, energy, and capital to generating new technologies and making them commercially practicable. Moreover, creative individuals are likely to be attracted to regions where the facilities for garnering funds are superior to those elsewhere. Consequently, regions that develop institutions supportive of entrepreneurship can gain an advantage in innovation that persists over time.[1]

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[1] Naomi R. Lamoreaux and Kenneth L. Sokoloff, "Long-Term Change in the Organization of Inventive Activity," *Proceedings of the National Academy of Sciences* 93 (Nov. 1996): 12686-92; Naomi R. Lamoreaux and Kenneth L. Sokoloff,

However, there are also reasons to expect that over time regions that are centers of innovation will lose their creative edge or at least their advantage over other regions. One possibility is that the complementary institutions that sustain innovation are specific to a particular technology. Once that technology becomes outdated, the region loses its advantage. For example, the financial intermediaries that channel funds to entrepreneurs may have specialized knowledge that enables them to discern the relative value of projects in the region's core industries, but they may have difficulty assessing projects in completely new industries. Similarly, the educational or apprenticeship institutions that provide training for would-be entrepreneurs may focus on technologies most relevant to those same industries and not provide students with an adequate foundation in newer technologies.

Such industry-specific investments might explain, for instance, the relative decline of New England by the end of the nineteenth century. The region had long had patenting rates per capita well above the national average, but its position slipped by the turn of the century. New England continued to have high patenting rates in declining industries such as shoes and textiles, but it did not do nearly as well in new industries such as electricity. As Dhanoos Sutthiphisal has shown, invention in the electrical industry disproportionately originated in regions such as the Middle Atlantic where there were greater concentrations of people with the appropriate human capital.[2] More generally, it is likely that the shift toward the more knowledge-intensive industries of the Second Industrial Revolution advantaged regions with universities that offered advanced scientific training. As Zorina Khan and Kenneth Sokoloff have shown, the great inventors of the late nineteenth and early twentieth centuries were much more likely to have university degrees in science or engineering than those active earlier.[3]

We could tell a similar story about finance. The technologies of the Second Industrial Revolution required much greater amounts of physical capital for creative people to be effective researchers or successfully commercialize their

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"The Geography of the Market for Technology in the Late-Nineteenth- and Early-Twentieth Century United States," in *Advances in the Study of Entrepreneurship, Innovation, and Economic Growth*, ed. Gary D. Libecap (Greenwich, Conn., 1999) 11: 67-121; Naomi R. Lamoreaux and Kenneth L. Sokoloff, "Intermediaries in the U.S. Market for Technology, 1870-1920," in *Finance, Intermediaries, and Economic Development*, ed. Stanley L. Engerman, Philip T. Hoffman, Jean-Laurent Rosenthal, and Kenneth L. Sokoloff, (New York, 2003), 209-46; Naomi R. Lamoreaux and Kenneth L. Sokoloff, "The Geography of Invention in the American Glass Industry, 1870-1925," *Journal of Economic History* 60 (Sept. 2000): 700-29.

[2] Dhanoos Sutthiphisal, "Learning-by-Producing and the Geographic Links between Invention and Production: Experience from the Second Industrial Revolution," *Journal of Economic History* 66 (Dec. 2006): 992-1025.

[3] B. Zorina Khan and Kenneth L. Sokoloff, "Institutions and Technological Innovation during Early Economic Growth: Evidence from Great Inventors in the United States, 1790-1930" in *Institutions, Development, and Economic Growth*, ed. Theo S. Eicher and Garcia-Peñalosa Garcia (Cambridge, Mass., 2006), 123-58.

discoveries. It is likely that this increase favored regions such as the Middle Atlantic with larger pools of savings or better-organized financial markets. It may also have spurred a shift in the locus of technological discovery to large firms with in-house R&D (research and development) facilities, which were better able to tap formal financial markets for funds.[4] Large firms, moreover, were likely to have headquarters in regions such as the Middle Atlantic, so they could be close to the capital markets and to the intermediaries that would help them raise funds.

It is also possible that a location's success sows the seeds of its own decline. A region may be a hotbed of startup enterprises, but as the most successful of these enterprises grow or larger firms acquire them, two things may happen. First, the large enterprises may themselves become less innovative as their managers become excessively enamored of the particular technologies responsible for their success.[5] Second, the emergence of large firms may affect the local environment in ways that make it less conducive to startup enterprises, for example by soaking up the available capital and talent or simply by dint of their superior efficiency.[6] Steven Klepper's study of the Detroit automobile industry suggests that these two possibilities can have contradictory effects on the supply of entrepreneurial enterprises, but that ultimately the second will dominate. Employees are more likely to leave their jobs to organize new firms when they have ideas that their employers are not willing to exploit, so the increasing conservatism of incumbent automakers spurred the creation of startups. Over time, however, the growing market power of the incumbents makes it more difficult to get a foothold in the industry. After the mid-1920s, there were essentially no new successful startups in Detroit.[7]

Finally, it is possible that innovative regions can decline for exogenous reasons. For example, it may be that cities such as Cleveland, which were hotbeds of innovation in the early twentieth century, were particularly hard-hit

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[4] Lance Davis, "The Capital Markets and Industrial Concentration: The U.S. and the U.K.: A Comparative Study," *Economic History Review* 19 (Aug. 1966): 255-72; Naomi R. Lamoreaux and Kenneth L. Sokoloff, "The Market for Technology and the Organization of Invention in U.S. History," in *Entrepreneurship, Innovation, and the Growth Mechanism of the Free-Enterprise Economies*, ed. Eytan Sheshinski, Robert J. Strom, and William J. Baumol (Princeton, N.J., 2007), 213-43; Naomi R. Lamoreaux and Kenneth L. Sokoloff, "The Decline of the Independent Inventor: A Schumpeterian Story?" NBER Working Paper 11654 (2005).

[5] Joseph A. Schumpeter, *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*, trans. Redvers Opie (Cambridge, Mass., 1934).

[6] Joseph A. Schumpeter, *Capitalism, Socialism and Democracy*, 3rd ed. (New York, 1950).

[7] Steven Klepper, "The Organizing and Financing of Innovative Companies in the Evolution of the U.S. Automobile Industry," in *Financing Innovation in the United States, 1870 to the Present*, ed. Naomi R. Lamoreaux and Kenneth L. Sokoloff (Cambridge, Mass., 2007), 85-128.

by the shocks of the second quarter of the twentieth century. The Great Depression may have destroyed the local investors and financial institutions that had supported entrepreneurial startups. Moreover, the financial regulations imposed by the federal government in the wake of the Great Depression may have given New York's financial institutions such a competitive advantage that capital markets in places such as Cleveland never recovered. The rise of local venture capital markets in the late twentieth century owed a great deal to regulatory changes, particularly a clarification of the Employee Retirement Income Security Act that enabled pension funds to invest in venture capital partnerships.[8] While these chances spurred the growth of the venture capital sector in Silicon Valley, they may have been too late to help decaying Rust Belt cities regain their earlier dynamism.

We know that Cleveland was an extraordinarily innovative place during the late nineteenth century. We also know that it was subject to a series of major shocks, including the Great Depression. Although it is likely that these shocks had long-term adverse effects on Cleveland's role as a center of technological discovery, we do not explore their effects directly. Instead, our research strategy is to look for signs that the Cleveland economy's ability to spawn new entrepreneurial ventures was already declining before the first of these shocks hit.

Cleveland as a Center of Innovation in the Late Nineteenth Century

Located on Lake Erie at the terminus of the Ohio Canal, Cleveland had long been the commercial center of northeastern Ohio. Local boosters founded the city's first heavy industrial enterprise, a firm that produced steam furnaces, in the 1830s and built its first iron-rolling mills in the 1850s.[9] However, Cleveland's rise as an industrial powerhouse was largely a post–Civil War phenomenon. As late as 1870, Cuyahoga County, where Cleveland is located, ranked only twenty-second in manufacturing output among counties nationwide. By 1900, it had risen to fourteenth place, and by 1930, the county was the sixth largest producer of manufacturing goods in the country.[10] In the interim, moreover, Cleveland had become a hotbed of patenting activity. In 1900, it ranked eighth out of all U.S. cities in the total number of patents granted to residents, and if the calculation is limited to patents deemed by official examiners to have made significant contributions to the industrial art

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[8] Samuel Kortum and Josh Lerner, "Assessing the Contribution of Venture Capital to Innovation," *RAND Journal of Economics* 31 (Winter 2000): 674-92.

[9] Carol Miller Poh and Robert Wheeler, *Cleveland: A Concise History, 1796-1990* (Bloomington, Ind., 1990).

[10] *Compendium of the Ninth Census* (1870), *Twelfth Census* (1900), and *Fifteenth Census* (1930). Various dates, U.S. Census Office; Historical Census Browser at the University of Virginia, Geospatial, and Statistical Data Center; viewed May 2007. URL: http://fisher.lib. virginia.edu/collections/stats/histcensus/index.html.

of the period, Cleveland was the fifth most technologically important city in the country.[11]

Much of this patenting occurred in the "cutting-edge" industries of the time, such as electric light and power, electrical machinery, steel, petroleum, chemicals, and automobiles, which were at the center of the so-called Second Industrial Revolution. Moreover, much of it led to new enterprises organized for the explicit purpose of exploiting these new technological discoveries. In previous work, we found that by the turn of the twentieth century, a substantial portion of the patents awarded to Cleveland residents went to inventors who were officers in startup companies such as the Baker Motor Vehicle Company, manufacturer of electric automobiles; the Brown Hoisting Machinery Company, whose machines revolutionized the handling of cargo on the Great Lakes; the Wellman-Seaver Engineering Company, designer of steel mills and oil refineries; the Short Electric Railway Company, a pioneer of electric streetcars; and the White Motor Company, producer of steam and then gasoline automobiles.[12]

One of the first and most important of the Cleveland startups was the Brush Electric Company.[13] The manager of the Telegraph Supply Company of Cleveland had encouraged the inventor Charles F. Brush to work on arc lighting in the company's shops. When Brush succeeded in developing a workable system, the firm's officers (all prominent local businesspeople) arranged for a public demonstration and in 1880 launched a new company with a capitalization of $3 million, an enormous amount for a startup company at that time. The Brush Electric Company dominated the market for arc lighting until the mid-1880s and then began rapidly to lose ground to competitors. At the end of the decade, its major shareholders sold all their stock to a competing firm, the Thomson-Houston Electric Company, which joined the General Electric (GE) merger in 1891. The new owners shut down the Brush factory in the early 1890s.

During its short life, the Brush enterprise played an important role in fostering the development of new technologies in Cleveland, less because it generated large numbers of new inventions for the firm itself (although Brush continued to patent new ideas), but more because it was the hub of an overlapping network of inventors and financiers. The inventors' part of the

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[11] Michael S. Fogarty, Gasper S. Garofalo, and David Hammack, *Cleveland from Startup to the Present: Innovation and Entrepreneurship in the 19th and Early 20th Centuries* (Cleveland, Ohio, n.d.).

[12] Naomi R. Lamoreaux, Margaret Levenstein, and Kenneth L. Sokoloff, "Financing Invention during the Second Industrial Revolution: Cleveland, Ohio, 1870-1920," in *Financing Innovation in the United States*, ed. Lamoreaux and Sokoloff, 39-84; Naomi R. Lamoreaux, Margaret Levenstein, and Kenneth L. Sokoloff, "Mobilizing Venture Capital during the Second Industrial Revolution: Cleveland, Ohio, 1870-1920," *Capitalism and Society* 1 (2006); viewed Oct. 11, 2007. URL: http://www.bepress.com/cas/vol1/iss3/art5/.

[13] We base the remainder of this section on Lamoreaux et al., "Financing Invention" and Lamoreaux et al., "Mobilizing Venture Capital."

network included Brush employees who obtained valuable technological training in the course of their work, learned about opportunities for spin-off enterprises, and launched their own companies. Brush supervisor W. H. Bolton, for example, realized that the growth of arc lighting meant rising demand for the carbon electrodes that burned to produce the light. He left Brush to form the Bolton Carbon Company, which grew into National Carbon (later one of the main constituents of Union Carbide). Another Brush employee, John C. Lincoln, left to form a business manufacturing electric motors. After a couple of false starts, Lincoln's enterprise grew and prospered, splitting into two companies: Reliant Electric, which specialized in electric motors, and Lincoln Electric, a pioneering supplier of electric arc-welding equipment.

The inventors' part of the network also included creative individuals who were not Brush employees, but who worked inside the Brush factory developing technologies that were complementary to its main dynamo and lighting businesses. Sidney Short, for instance, moved to Cleveland and to Brush in order to supervise the building of the custom generators he needed for his electric streetcar invention. He stayed and ran the Short Electric Railway Company out of the Brush factory. For Short and others like him, the inventors who gathered at the Brush facility provided a useful vetting function. The conversations they had about each other's inventions—which ones were likely to work and which to prove economically valuable—provided the financiers who plugged into these networks with the information they needed to decide where to put their funds and how to advise others about investing in cutting-edge technology. Thus, Short was able, with Brush's help, to find financial backing for his enterprise. Similarly, Alfred and Eugene Cowles benefited from building their experimental electric aluminum-smelting furnace at Brush. Brush had originally scoffed at their ideas, dismissing their smelting process as just an expensive way to burn coal, but after they built their furnace at the factory, he became a believer and used their aluminum in the manufacture of his dynamos. The conversion of Brush and other observers at the factory helped the Cowles brothers raise capital, as did their ability to invite potential backers to come to the Brush facility and see their furnace in operation.

As the hub of these overlapping networks of inventors and financiers, the Brush facility became the site of a set of complementary, albeit informal, institutions that facilitated the development and economic exploitation of new technologies. Intriguingly, it continued to function as such a hub even after Thomson-Houston acquired the Brush enterprise and shut down the factory. Hence, when Elmer Sperry accepted the invitation of a group of financiers to come to Cleveland in the mid-1890s to develop an electric streetcar system, he set up shop at the Brush facility. He stayed on there until the turn of the century to work on other inventions, most notably an electric car and a related system of storage batteries that he sold, respectively, to the American Bicycle Company and the National Battery Company. Around the same time, Walter C. Baker also developed his electric car at Brush, and Alexander Winton worked

on his gasoline-powered automobile there. Both inventions led to the formation of companies bearing the inventors' names.

Other Cleveland enterprises played a similar role in incubating new firms. The overlapping networks that formed around the White Sewing Machine Company, for example, either directly spawned or facilitated the formation of companies that ranged from the machine-tool firm of Warner and Swasey to the White Motor Company, a producer of automobiles. The Brown Hoisting Machine Company and Wellman Seaver Engineering Company seem also to have functioned in this way, spawning startups and spin-offs in industries related to their core businesses, though our research on these companies is not as complete. As in other cities, moreover, telegraph facilities and hardware stores also functioned as gathering places for inventors and, as such, facilitated the same kinds of conversations and information flows as hub enterprises.

One might hypothesize that the networks to which these various hub enterprises gave rise were highly specific to the technologies in which each particular firm was engaged (electrical equipment at Brush, for example, and machine tools at White), and as such should be considered complementary institutions that might well have been rendered obsolete over time by technological progress. Two circumstances, however, suggest that that this kind of technological obsolescence was unlikely to be an important cause of Cleveland's decline. First, firms capable of performing this hub function emerged in a number of different industries in Cleveland during the late nineteenth century: electricity, machine tools, steel, chemicals, petroleum, and automobiles. As a result, the city could boast creative talent in virtually every area of Second Industrial Revolution technology. This diversity helped wealthy Cleveland investors develop an interest in investing in entrepreneurial ventures generally, not just in one "hot" sector. It also gave them the ability to learn about (that is, tap into the expertise needed to assess) new developments in a wide range of industries.

Second, in addition to the informal networks that coalesced around important enterprises, Cleveland could boast during this period an increasing number of more formal institutions that potentially served as ongoing supports for innovation. On the educational front, the most important was the Case Institute of Applied Science. Founded in 1880, it provided training to a number of important Cleveland inventors and had close connections to local entrepreneurs. Its first president, Cady Staley, took a personal interest in Herbert Dow during his undergraduate years and was a stockholder and member of the board of directors of the Dow Chemical Company from its founding in 1897. Case's second president, Charles S. Howe, was closely associated with two of Cleveland's most important inventor-entrepreneurs, Worcester Warner and Ambrose Swasey. Both served on Case's board. Their donations to Case financed its astronomy building (and a state-of-the-art

telescope built by Warner and Swasey), and the Warner Mechanics and Hydraulics Building, as well as endowed a chair in physics.[14]

Local engineering societies also provided forums at which inventors could discuss technical problems and assess the merits of new technologies. In 1880, a small group of engineers, who had been debating whether the country should adopt the metric system and other controversial topics, organized the Civil Engineers Club of Cleveland. By 1908, the club had transformed itself into the Cleveland Engineering Society, which published a journal intermixing reports on the doings of local engineers, minutes of the organization's bimonthly meetings, and serious articles on topics such as "The Electric Furnace and Its Use," "Some Recent Improvements in Electric Motor Control," "The Manufacture of Iron and Steel," and "Modern Machine Shop Milling Processes."[15] The city's growing numbers of patent attorneys also provided advice and technical expertise and sometimes helped to match inventors with buyers for their patents or recruit investors for entrepreneurial ventures.[16]

On the financial front, there were increasing numbers of banks and other similar financial institutions, many organized by the same men who founded startup companies. In 1870, the city was home to five banks and one savings institution. By 1920, there were thirty-eight banks, savings institutions, and trust companies with total deposits amounting to more than $800 million. The number of local brokerage houses and the amount of trading in local securities also grew during the late nineteenth century, leading in 1900 to the formal organization of the Cleveland Stock Exchange (CSE). From early on, the listings on the CSE included relatively more industrials than did its much larger counterpart in New York, and the number of manufacturing firms whose securities were traded on the CSE continued to grow, more than doubling between 1910 and 1914, for example. The newly listed manufacturers included some of the most successful of the innovative firms formed during the previous several decades, including National Carbon, Brown Hoisting Machine, Wellman-Seaver-Morgan (formerly, Wellman-Seaver Engineering), and the White Motor Company. One would expect that the creation of a formal exchange encouraged investors to put more money in cutting-edge enterprises,

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[14] C. H. Cramer, *Case Western Reserve: A History of the University* (Boston, Mass., 1976), 226, 242; Don Whitehead, *The Dow Story: The History of the Dow Chemical Company* (New York, 1968), 38, 43.

[15] See the Society's webpage for a history of the organization; viewed Oct. 11, 2007. URL: http://www.cesnet.org/about.asp. The articles are from, respectively, the *Journal of the Cleveland Engineering Society* 3 (Sept. 1910): 12-27; 4 (Sept. 1911): 17-27 and 46-64; and 4 (March 1912): 145-62.

[16] One of the organizers of the Brush Electric Company was a patent attorney and former U.S. Commissioner of Patents. For a history of patent attorneys in the city of Cleveland, see Hal D. Cooper and Thomas M. Schmitz, *A History of Inventions, Patents and Patent Lawyers in the Western Reserve* (Cleveland, Ohio 1993). For a more general discussion of patent attorneys' roles as intermediaries in the market for technology, see Lamoreaux and Sokoloff, "Intermediaries."

We still have much work to do to understand the patterns in our data. In addition to getting a better grasp of the national context for our findings, we need to study the complementary institutions that previously had supported entrepreneurial enterprises in Cleveland, especially the hub firms that had played so central a role in creating, vetting, and commercializing important new technologies. Whatever the explanation, however, it does seem that by the 1920s, Cleveland's economic environment was not as supportive of new high-tech enterprises as it had been earlier around the turn of the century.