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Clusters and Innovation Districts: Lessons from the United States Experience

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1. Introduction

Policymakers who wish to increase the growth of their economies and promote employment and the creation of well-paid jobs must understand the role played by place and geography and incorporate this understanding into their policy decisions. Universities who wish to commercialize their research, and businesses that wish to be more innovative, can also take advantage of place and geography.

Clusters are geographic concentrations of interconnected businesses, suppliers, and associated institutions. They can contain anchor institutions, small firms, start-ups, business incubators, and accelerators.

The key driver in the formation of clusters or districts is that firms and researchers benefit from locating near each other, which is an extensively studied phenomenon in the economic development literature. The value placed on geographic proximity is of high importance given that innovation is a deeply human and creative endeavor that requires personal networks and trust that can be built more easily with diverse and talented people close together. Clusters (or innovation districts) have been found to increase the innovation levels, efficiency, and productivity with which participating companies can compete, nationally and globally.[1]

By means of case studies and review of the literature, this paper will examine and analyze the nature of clusters and innovation districts and draw lessons for policymakers and local actors involved in developing the clusters, such as universities, businesses, and local leaders. Michael Porter and colleagues at the Harvard Business School have been instrumental in bringing the study of clusters to the fore and in identifying drivers of their success. Brookings has played an important role in both the theory and practice of small clusters and innovation districts. The Metropolitan Policy Program at Brookings has not only written extensively on the subject but has also been involved in developing the plans that many cities and states have adopted to develop their economies.[2] Their work has been an essential ingredient in this study.

1.1 The Opportunities Created by Clusters

Clusters and innovation districts are key sources of productivity growth in an economy. Productivity, the most important determinant of the growth in living standards in the long run, has experienced a significant slowdown globally in recent years. Clusters and districts have the potential to combat this slowdown. They are loci of innovation and

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1. Porter, M. (1998). *Clusters and the New Economics of Competition*. [online] Harvard Business Review. Available at: https://hbr.org/1998/11/clusters-and-the-new-economics-of-competition [Accessed 6 Dec. 2017].

2. The long-time leader of this program was Bruce Katz, which is now led by Amy Liu. Mark Muro and Julie Wagner have played central roles in the work of this program. I am indebted to all of these colleagues.

rapid economic growth and can lead to increased collaboration between firms and universities.

Increased collaboration between firms, particularly small firms, and universities is important for the diffusion of knowledge in an economy. The OECD[3] and Dan Andrews et al.[4] note that firms at the global productivity frontier have shown robust productivity growth during the 2000s, but the gap between the most productive firms and the laggard firms has increased over time. This shows that knowledge diffusion is a key part of the solution to slow productivity growth. Clusters and innovation districts, which promote collaboration between firms and universities by providing firms with access to research labs and human talent, are then a potential part of the productivity solution.

Governments can use policy to take advantage of the productivity growth opportunities presented by clusters to help clusters form and grow more rapidly. Porter's analysis of clusters looks primarily at the conditions in the private sector that gave birth to each successful cluster.[5] However, he also finds that government policies can play a powerful role in encouraging the development of industries and companies.

Innovation districts take advantage of the benefits of clustering on a much smaller scale. Bruce Katz and his team at Brookings identified a number of emerging innovation districts in the United States[6], and a recent book by Fred Bakker and Antoine van Agtmael looks at these smaller, new clusters in both the United States and in Europe.[7] They find that strong leadership from policymakers and local leaders, such as university presidents, can develop local capabilities and technology knowledge to build successful clusters of innovative start-up companies.

New work from Sasan Bakhtari of DIIS and Robert Breunig of Australian National University supports findings from other countries of the benefits of clustering. Bakhtari and Breunig developed evidence on the role of clustering on R&D spending by companies

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3. The Future of Productivity. (2015). [ebook] OECD. Available at: https://www.oecd.org/eco/OECD-2015-The-future-of-productivity-book.pdf [Accessed 6 Dec. 2017].

4. Andrews, D., Criscuolo, C. and Gal, P. (2015). *Frontier Firms, Technology Diffusion and Public Policy: Micro Evidence from OECD Countries*. The Future of Productivity. [online] OECD. Available at: https://www.oecd.org/eco/growth/Frontier-Firms-Technology-Diffusion-and-Public-Policy-Micro-Evidence-from-OECD-Countries.pdf [Accessed 6 Dec. 2017].

5. The Porter "Diamond model" uses four categories of private sector drivers, see the discussion in the next section. Porter, M. (1998). *The Competitive Advantage of Nations*. Hampshire: Palgrave.

6. The Brookings writing on innovation districts is on the Brookings website under the Metropolitan Program. Brookings. (2017). *Innovation Districts*. [online] Available at: https://www.brookings.edu/innovation-districts/ [Accessed 7 Dec. 2017].

7. van Agtmael, A. and Bakker, F. (2016). *The Smartest Places on Earth: Why Rustbelts Are the Emerging Hotspots of Global Innovation*. New York: Public Affairs.

in Australia. They find a "positive effect of clustering on R&D expenditure" by companies and that geography plays an important role in the extent of spillovers from R&D.[8]

2. The Context

There is broad agreement that clusters contribute to productivity and economic performance, but there are different schematics or frameworks used to analyze and describe them. This section details these.

Density. Economists emphasize that the density of economic activity appears to confer a productivity advantage on the firms within a cluster. Nobel Prize winner Paul Krugman is a leading voice among this group, and he and others find statistical evidence linking density to economic performance, notably productivity.

The Porter Diamond. As shown below, the main private sector drivers of successful clusters in Porter's analysis form a four-point diamond pattern. Factor conditions include human resources as well as natural resources. Related and supporting industries reflect the role of supplier industries in traditional clusters such as the steel industry. Demand conditions look at the size and sophistication of the home market. Strategy, structure, and rivalry examine how companies are managed, how they compete, and the business culture. In addition, Porter highlights the role of government as an external facilitator of cluster performance, and he notes that chance factors can be important. Chance factors might include, for example, having the right skilled people available when a new technology takes off. However, pure chance should not be overemphasized. Like the Greek god, Caerus, informed leadership can recognize the economic opportunities that appear and grab them.[9]

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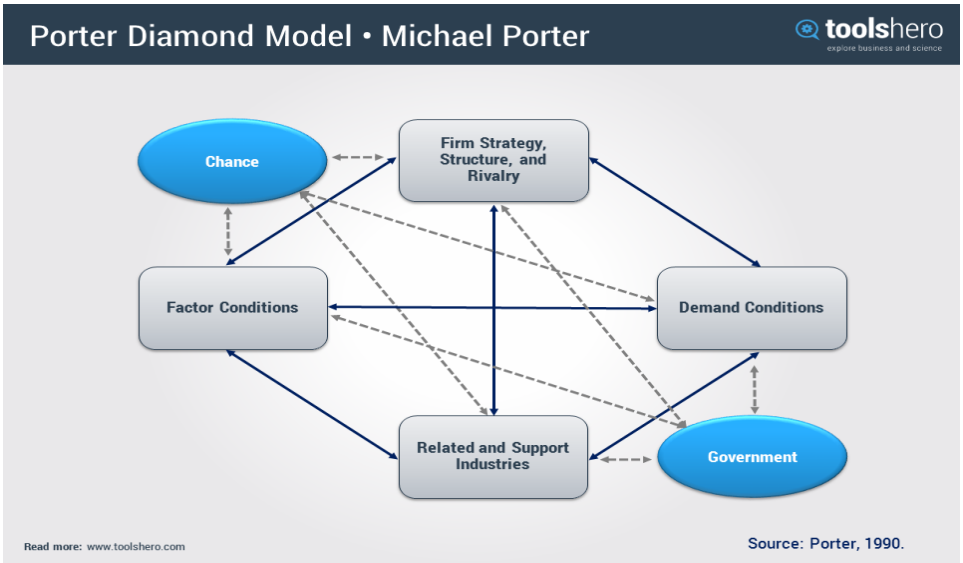
8. Bakhtiari, S. and Breunig, R. (2017). The role of spillovers in research and development expenditure in Australian industries. *Economics of Innovation and New Technology*, 27(1), pp.14-38.

9. In Greek and Roman mythology, Caerus was the personification of opportunity, a god who was always running. He had hair only on the front of his head so someone could grab him as he came towards them. Once he was past, he moved out of reach.



The Metro Program Framework. Based on their advisory work, Brookings's Metro program developed a framework to help communities nurture clusters. They find that innovation districts are built around three types of assets: physical assets, networking assets, and economic assets.[10] None of these assets by themselves can support an innovation district, but the interaction among them, illustrated in the figure below by the overlapping segment of the Venn diagram, provides the basis for sustaining or growing innovation districts.

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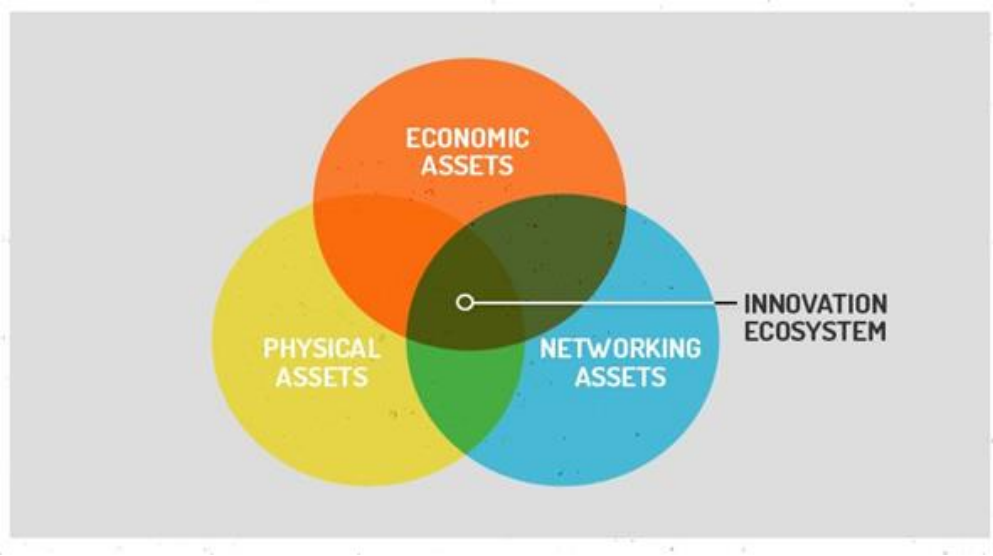
10. Katz, B. and Wagner, J. (2014). *The Rise of Innovation Districts*. [online] Brookings Institution. Available at: https://c24215cec6c97b637db6-9c0895f07c3474f6636f95b6bf3db172.ssl.cf1.rackcdn.com/content/metro-innovation-districts/~/media/programs/metro/images/innovation/innovationdistricts1.pdf [Accessed 6 Dec. 2017].

    Katz, B., Vey, J. and Wagner, J. (2015). *One Year After: Observations on the Rise of Innovation Districts*. [online] Brookings Institution. Available at: https://www.brookings.edu/research/one-year-after-observations-on-the-rise-of-innovation-districts/ [Accessed 7 Dec. 2017].

    Additional references are cited in these two papers.



Source: Bruce Katz and Julie Wagner, The Rise of Innovation Districts, Brookings 2014

The economic assets in the first circle are: 1. *Innovation drivers*, such as high value research-oriented sectors, creative fields like design and graphics, media and architecture, and specialized small-batch manufacturing; 2. *Innovation cultivators*, such as incubators, technology transfer offices, accelerators, proof of concept centers, and job training facilities; and 3. *Neighborhood-building amenities* such as medical offices, stores, restaurants, and hotels.

The key physical assets in the second circle consist of publicly held assets, such as parks, plazas, and streets, as well as privately held assets, such as lab spaces, office buildings, retail stores, and so on. Housing is becoming increasingly important as a necessary physical asset, and the universal availability of WiFi connections is essential.

The third circle highlights networking assets. Innovation districts have used formal and informal meetings as ways to foster interactions among the researchers in an innovation cluster. For example, Eindhoven in the Netherlands holds "tech regular" meetings where research problems or breakthroughs are presented and discussed. Workshops and training sessions were established along the waterfront in Boston. Barcelona has created cluster-specific meetings, industry-specific conferences, and monthly meetings.

Another important element in the Brookings-Metro framework is the need to build on existing strengths. They find that successful innovation districts are not started from scratch, but instead are built on a pre-existing economic and physical base. Policymakers or other leaders can help transform a barren landscape into fertile ground, but a seed must be available that can grow to fruition.

A recent Brookings report[11] highlighted the role of mayors in developing and supporting innovation districts in the United States. Local governments have become more

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11. The report is a handbook for U.S. mayors and their administrations on how to facilitate the rise of innovation districts. The handbook provides concrete strategies and steps for mayors to follow. Wagner

important as higher levels of government reduce their engagement and funding in cities. This puts more of the responsibility on mayors and their administrations to design, finance, and deliver economic initiatives. The case study of Seaport (Boston) later in the paper provides an example of a mayor capitalizing on this opportunity.

The Importance of Leadership and Culture. In their book, *The Smartest Places in the World,* Bakker and van Agtmael stress the importance of a strong leader or a leadership group in order to get an innovation cluster started. For example, in Akron, Ohio the president of the University of Akron saw the existing strength provided by local expertise in polymers and was determined to build on that economic seed to grow a viable innovation district around it.

The view that culture is vital to the success of technology districts and clusters derives from AnnaLee Saxenian's classic study titled *Regional Advantage: Culture and Competition in Silicon Valley and Route 128.*[12] The book examines why Silicon Valley won the race against Boston's Technology Corridor to become the hub of high tech innovation. It emphasizes the differences in culture between the two locations. Her diagnosis focused on the existence of a more freewheeling, networked-based economic system in California, more open labor markets, a lot of informal communications, a culture of cooperation rather than secrecy, and much greater flexibility.

3. Success Factors

There are strong common elements among the approaches described in the previous section, and the differences largely reflect that the researchers are looking through different lenses. Porter's work emphasizes traditional manufacturing clusters, such as steel and autos, as well as those built on historical craft skills, such as the watch industry in Switzerland or the ceramic tile industry in Italy. Brookings's Metro program looks at how to grow innovation clusters in cities, and the same is true of Bakker and van Agtmael who focus on the rebirth of cities where manufacturing jobs have gone away.

Based on these frameworks, listed below is a set of success factors to describe the characteristics that successful clusters and districts exhibit. Not all the success factors are present in every cluster, but enough must be present to allow the positive dynamics of a successful cluster to develop. The success factors are as follows:

1. *Core Competency*. There must be an economic rationale for the clusters—something that it is good at so that it can develop competitive strength.

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J., Vey, J., Davies, S. and Storring, N. (2017). *Advancing a new wave of urban competitiveness: The role of mayors in the rise of innovation districts*. [online] Brookings Institution. Available at: https://www.brookings.edu/research/advancing-a-new-wave-of-urban-competitiveness/ [Accessed 7 Dec. 2017].

12. Saxenian, A. (1994). *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*. Cambridge, Mass.: Harvard University Press.

2. *People*. There are three elements to the people requirements for a successful cluster: strong leadership, highly qualified researchers, and a skilled workforce.
3. *Culture*. There are two elements to the culture needed to develop a cluster. First a business and research culture that supports the sharing of ideas. And second, a lifestyle that attracts talented people to the cluster.
4. *Business Capabilities*. Successful start-up tech companies in a cluster must not only have good, innovative ideas, they must also acquire the business skills needed to develop the companies.
5. *Sophisticated Demand*. Innovative products and services must find a market. Ideally this market should come from within the cluster (a hospital center that provides demand for medical and biotech products, for example). Otherwise, the companies in the cluster must find a way to access such a market nationally or globally.
6. *Access to Funding*. Start-up companies require financial support. Funding is also needed for the infrastructure of the clusters, offices, labs, and so on.
7. *Infrastructure Provision*. Physical assets and public amenities such as airports, highways, housing, and building stock are the foundation of a cluster. Zoning rules must allow or encourage the development of start-up companies and labs.
8. *Regulatory Environment*. Cumbersome permitting processes can slow or stop the development of a cluster.

4. Case Studies

The best way to draw out policy lessons is to review the development of clusters in practice. The case studies identify and describe how the success factors described above apply to each of them. The case studies were chosen to highlight some of the most prominent clusters in the United States. They also illustrate that the success factors can be applied to clusters of all sizes (from Seaport Innovation District to Silicon Valley) and types (from polymers to pharmaceuticals). Also included is a summary of some of the failures encountered in trying to establish clusters and the pitfalls that contributed to these failures.

Austin, Texas (Urban Cluster)

Austin is home to the University of Texas at Austin (UT Austin), is near Texas A&M University in College Station and several two-year colleges and training institutes, and is the location of the state government of Texas. Austin has developed a strong tech cluster

and is known for its high quality of life and distinct cultural branding. Austin's GDP was $135 billion in 2016.[13]

Core Competency. Austin developed a tech cluster by building on its research university and consortia infrastructure and by the early presence of tech companies.

Infrastructure Provision. The city is well connected to the state and the rest of the country through freeways and air transport. Zoning restrictions in Texas are liberal, and there is land available for expansion. As the cluster has succeeded, this has pushed up land prices, but they remain much lower than in California.

People: Strong Leadership. Early in Austin's cluster development, UT Austin led a group that included business leaders and the state and local government to attract the first private, high-technology consortium, the Microelectronics and Computer Technology Corporation (MCC). It later attracted SEMATECH, the national research consortium of semiconductor manufacturers. These consortiums played an integral part in increasing the research capabilities of the cluster.[14]

People: Highly Qualified Researchers. Prior to attracting the research consortia, the university and state government presence attracted important companies to the area. IBM, Texas Instruments, and Motorola created a nucleus of high technology companies in the location early on.[15] In addition, Michael Dell started Dell Computer in his UT Austin dormitory.

UT Austin made the city a desirable destination for technology companies and research consortia and, in turn, the presence of technology companies and research consortia made UT Austin more attractive to faculty and students. There was a feedback effect.

People: A Skilled Workforce. The culture and the universities in Austin attracted and supplied the skilled workforce for the cluster. As the tech cluster developed, it attracted talent from Silicon Valley and around the country to augment its own talent base.

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13. All cluster GDP numbers in the case studies are the Gross Domestic Product of the Metropolitan Area (MSA) where the cluster is located.

    U.S. Bureau of Economic Analysis, Total Gross Domestic Product for Austin-Round Rock, TX (MSA) [NGMP12420], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/NGMP12420, December 6, 2017.

14. Powers, P. (2004). *Building the Austin Technology Cluster: The Role of Government & Community Collaboration in the Human Capital*. [online] Kansas City Federal Reserve. Available at: https://www.kansascityfed.org/PUBLICAT/newgovernance04/Powers04.pdf [Accessed 7 Dec. 2017].

15. Federal Reserve Bank of Dallas (2015). *At the Heart of Texas: Cities' Industry Clusters Drive Growth*. [online] Available at: https://www.dallasfed.org/research/heart/austin [Accessed 7 Dec. 2017].

Culture: Idea Sharing. The two consortia helped foster a cooperative, idea sharing culture.[16] Capital Factory, an accelerator with co-working spaces, regularly holds networking events and meet-ups for entrepreneurs.

Culture: People Amenities. The culture and lifestyle in Austin is world-renowned—it has developed a reputation as a low-cost, trendy, music, and cultural center with a high quality of life.[17] The local government promotes and supports the culture in the city. The South by Southwest conference (SXSW) and festivals[18] held in Austin attract start-ups and investors and help the city brand itself as an innovative tech and music town.

Business Capabilities. Along with Capital Factory mentioned above, there are multiple incubator programs to aid in developing start-ups in Austin.

Access to Funding. Austin initially did not have the base of angel investors or venture capitalists that is available in Silicon Valley. The early development of the cluster relied on financial support from the state (including through the universities), the federal government, and the contributions of the companies participating in the consortia. As the cluster developed, angel and venture funds set up operations in Austin.[19]

Regulatory Environment. Texas is a business friendly state where regulatory barriers are minimal.

Summary. The Austin cluster emerged from a base of technical know-how in electronics as the result of deliberate efforts by the University of Texas and the state and local governments, funding from the federal government, a definitive culture, a business friendly regulatory environment, and help from the presence of established tech companies dating from the 1960s.

Role of Government in Austin cluster

Federal	• Provided significant funding for SEMATECH. UT Austin R&D funding:[20] • The federal government financed 53 percent ($346 million) of the R&D expenditure at UT Austin in 2015. Of this, the Department of Defense (DoD) provided $135 million, the DoE

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16. Powers op. cit.

17. It was ranked as the world's number on tech city by Savills: http://www.savills.co.uk/tech-cities/index.html#austin

18. More on the tech portion of SXSW can be found at https://www.sxsw.com/conference/startups-and-tech-sectors/.

19. Powers op. cit.

20. Detailed R&D data for all the universities in this paper are available from the NSF's Higher Education Research and Development Survey (HERD), found here: https://ncsesdata.nsf.gov/herd/2015/index.html

	provided $40 million, HHS provided $64 million, and the NSF provided $77 million.[21] [22]
State	• Funded and supported the public state university, UT Austin. • Created the Permanent University Fund, a sovereign wealth fund used to fund the UT and Texas A&M state universities. • Created the Texas Emerging Technology Fund to aid in the research, development, and commercialization of emerging technologies. • Collaborated with business leaders and the university to attract the consortia. • Texas has long been pro-business with low taxes and strong incentives for business.
Local	• Collaborated with business leaders and the university to attract the consortia. • Commissioned an economic plan for long-run growth, which emphasized science, technology, and the linkage between quality of life and economic development. It became the blueprint for Austin's economy. • Created a city with a high quality of life and strong culture branding.

Pittsburgh, Pennsylvania (Urban Cluster)[23]

Pittsburgh was known as the "steel city" because of its iron and steel industry, however employment in the steel industry collapsed in the 1980s. It has since developed technology clusters around biotech, pharmaceuticals, and information technology. Today, Pittsburgh is a symbol of renaissance following industrial decline. Pittsburgh's GDP was $138 billion in 2016.[24]

Core Competency. The research capabilities of the University of Pittsburgh (UPitt) and Carnegie Mellon University (CMU) provided the foundations of the technology clusters.

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21. Other government agencies also provided funding but I only include the notable contributors. Therefore, the sum of these will not equal the total federal funding. The same is true in subsequent government role boxes.

22. DoD is Department of Defense; DoE is Department of Energy; HHS is Department of Health and Human Services; NSF is National Science Foundation.

23. This section draws from Porter, M. (2001). Pittsburgh. Clusters of Innovation Initiative. [online] Washington, DC: Council on Competitiveness. Available at: http://www.clustermapping.us/sites/default/files/files/resource/Clusters_of_Innovation_Initiative-_Pittsburgh.pdf [Accessed 7 Dec. 2017]

24. U.S. Bureau of Economic Analysis, Total Gross Domestic Product for Pittsburgh, PA (MSA) [NGMP38300], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/NGMP38300, December 7, 2017.

Infrastructure Provision. In the very early stages of the cluster, the city government along with local business and foundations, collaborated with the Allegheny Conference, which spearheaded an initiative to revitalize the downtown. The cluster also benefited from the construction of a state-of-the-art airport. As part of the plan for cluster development, local leaders made sure that zoning rules made land available.

People: Strong Leadership. Then-Governor Dick Thornburgh laid out the key plan to recovery in 1982: The Ben Franklin Partnership Challenge Grant Program for Technological Innovation.

People: Highly Qualified Researchers. Some pieces of an innovation ecosystem already existed within universities and existing federal research programs. The state program was therefore able to build on a pre-existing nucleus of technology strength.

One of the keys to the recovery of Pittsburgh was that it was able to participate in the largest segment of the US economy, namely healthcare. The University of Pittsburgh Medical Center is a top-tier hospital and research institution and is the largest single employer in the county.[25] Another existing strength was Carnegie Mellon University (CMU), a highly regarded institution that developed expertise in computer science and artificial intelligence. These institutions allowed Pittsburgh to develop two technology clusters: one around biotech and pharmaceuticals and the other around information technology.[26]

People: A Skilled Workforce. From the legacy of workers in the steel and consumer electronics industries, there was a skilled workforce available in Pittsburgh, although the skills were not easily transferable to the new clusters. Part of the Thornburgh plan was to develop community colleges and other facilities, which provided training in health and computer sciences.

Culture: People Amenities. Pittsburgh has a strong cultural tradition dating back to the days of steel wealth and an even stronger sports tradition with leading teams in most major US sports. In addition, the city offers low cost of living.

Business Capabilities. State government established regional technology centers to seed-fund new research, start-ups, workforce training efforts, and technology incubators.

Sophisticated Demand. The University of Pittsburgh Medical Center serves as a customer for sophisticated products and services, specifically around biotech and pharmaceuticals, and provides the facilities and expertise needed to response to the increased demand for medical research, particularly from federally funded opportunities through the Department of Human and Health Services (HHS).

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25. According to the Pennsylvania Department of Labor & Industry: http://www.workstats.dli.pa.gov/Documents/Top%2050/Allegheny_County_Top_50.pdf.

26. Doyle, P. (2015). *An Innovation Case Study: Pittsburgh*. [online] Technology Review. Available at: https://www.technologyreview.com/s/543376/an-innovation-case-study-pittsburgh/ [Accessed 7 Dec. 2017].

Access to Funding. Federal funding was important to the health research institutions and Carnegie Mellon. The medical research centers have received substantial resources from the federal government and CMU has been the recipient of sizable federal research funding for its computer science, robotics, and artificial intelligence research. This, in turn, has attracted many of the leading tech companies to locate facilities in the area. In addition, the Thornburgh plan made venture capital investments in emerging companies using a mixture of public and foundation funding.

Regulatory Environment. The Technology Centers provide mentoring to start-ups to help in dealing with regulatory barriers. While Pittsburgh and Pennsylvania are not as easy on regulatory and zoning requirements as Austin and Texas, they are making a tremendous effort to address regulatory barriers to economic growth.

Summary. Pittsburgh's success has been due in large part to the Thornburgh plan, positions in fast-growing sectors, a strong existing educational and research base, large amounts of federal and state funding, high quality culture, and low cost of living.

Role of Government in Pittsburgh cluster

Federal	• Provided $50 million for the (at the time) state-of-the-art Pittsburgh airport. • Provided funding for non-academic institutions. The Magee-Women's Research Institute, a research institute dedicated to women's health, received $45 million from the NIH in 2015.[27] UPitt R&D funding: • The federal government financed 65 percent ($561 million) of the R&D expenditure at UPitt in 2015. Of this, the HHS provided $472 million. CMU R&D funding: • The federal government financed 77 percent ($187 million) of the R&D expenditure at CMU in 2015. Of this, the DoD provided $56 million, the HHS provided $27 million, and the NSF provided $69 million.
State	• Governor Dick Thornburgh initiated the Ben Franklin Partnership Challenge Grant Program. • Supported start-ups by running the Innovation Works project. • Funded and supported the state-related university in the area, UPitt. • Provided $97 million of the $397 million to fund the Pittsburgh airport. • State and county government aided the Pittsburgh Regional Alliance with marketing as well as tax and training incentives.

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27. NIH is National Institutes of Health and is a part of the Department of Health and Human Services (HHS). For full data on NIH awards, see: https://www.report.nih.gov/award/index.cfm.

Local	• Collaborated with the Allegheny Conference to revitalize downtown. • Developed one of the most livable cities in the United States. • The city of Pittsburgh, the county of Allegheny, UPitt, and CMU came together in 1985 to create a joint economic development strategy.

Research Triangle Park (Regional Cluster)[28]

The Research Triangle occupies 7,000 acres in North Carolina, includes the cities/town of Raleigh, Durham, and Chapel Hill, and is outlined by three educational institutions: Duke University, University of North Carolina- Chapel Hill (UNC), and North Carolina State (NC State). The Park was created to increase research in the region's universities and attract companies involved in research and development. The two most prominent clusters in the park are biotech and pharmaceuticals and information technology. Research Triangle Park's GDP was $124 billion in 2016.[29]

Core Competency. Research Triangle Park was built on the strong research capabilities of the three universities. The medical centers at Duke and UNC have become premier health institutions.

Infrastructure Provision. The Park benefited from new highways and an international airport. The Park is going through redevelopment, and there will soon be a Park Center.[30] The Park is spread out and land is readily available for development.

People: Strong Leadership. Local political and business leaders in North Carolina recognized that an economy based on low-wage manufacturing and agricultural jobs was not sustainable. To reverse the trend of "brain drain," in which graduates were leaving the state for opportunities elsewhere, they developed a new path to prosperity.

The then-Governor of North Carolina commissioned a concept report on the idea of a research park to attract companies to the land in between the state's research universities. The Park was a private effort built upon the state's existing research infrastructure and strengths.

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28. This section draws from Porter, M. (2001). *Research Triangle*. Clusters of Innovation Initiative. [online] Washington, DC: Council on Competitiveness. Available at: http://www.compete.org/storage/images/uploads/File/PDF%20Files/CoC_research_tri_cluster.pdf [Accessed 7 Dec. 2017]; and Link, A. and Scott, J. (2003). The Growth of Research Triangle Park. *Small Business Economics*, 20(2), pp.167-175.

29. U.S. Bureau of Economic Analysis, Total Gross Domestic Product for Raleigh, NC (MSA) [NGMP39580], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/NGMP39580, December 7, 2017.

    U.S. Bureau of Economic Analysis, Total Gross Domestic Product for Durham-Chapel Hill, NC (MSA) [NGMP20500], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/NGMP20500, December 7, 2017.

30. See more about the park and its funding here: http://www.rtp.org/rtp-reveals-park-center-plan/

The entrepreneurial leadership and vision of Archibald Davis, an entrepreneur from Wachovia Bank and Trust, was crucial in developing the Park, growing the Park, and maintaining the Park's position as a national research leader.

People: Highly Qualified Researchers. The three research universities were at the core of the development of the Park. They provided the research infrastructure and personnel. Their research activities complemented the other research institutions in the park and together they formed strong informal groups that communicated and shared knowledge.

People: A Skilled Workforce. The universities and institutions in the park attracted and supplied skilled workers.

Culture: Idea Sharing. The research universities provided the basis for collaboration, with seminars and joint projects. This close collaboration led to an influx of federal research dollars. The basic research from these research universities and research institutions led to spillover effects and the spinning out of corporate entities, which led to further economic growth. Knowledge sharing and cooperation between institutions was crucial.

Culture: People Amenities. Research Triangle Park has a low cost of living and high quality of life.[31]

Sophisticated Demand. The Duke and UNC medical centers serve as a customer for sophisticated products and services. Federal agencies such as the Department for Human and Health Services (HHS), the Department of Defense (DoD), and the National Science Foundation (NSF) create the demand for research from the universities and other institutions in the park.

Access to Funding. The three universities in the Triangle have received a disproportionate amount of federal R&D funding compared to other national universities.[32] In addition, federal government agencies such as the Environmental Protection Agency and the Environmental Health Science Center brought contracts worth millions of dollars to the Park. This influx of federal dollars played a significant role in the development and success of the cluster.

Summary. The Research Triangle Park's success was due in large part to many of the same factors that led to success in Pittsburgh: world-class research universities, high levels of federal and state funding, positions in fast-growing sectors, forward-thinking and strong leadership, low costs of living, and a high quality of life.

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31. U.S. News currently ranks Raleigh and Durham, NC as the 7th best place to live in the USA. More info found here: https://realestate.usnews.com/places/north-carolina/raleigh-durham.

32. For 2015 data, see https://ncsesdata.nsf.gov/profiles/site?method=rankingBySource&ds=fss.

Role of Government in Research Triangle Park cluster

Federal	• Federal agencies helped establish the legitimacy of the Park by locating there in its early development years. • Provided funding for non-academic institutions. The Research Triangle Institute, a research non-profit, received $53 million from the NIH in 2015. Duke R&D funding: • The federal government financed 54 percent ($559 million) of the R&D expenditure at Duke in 2015. Of this, the DoD provided $58 million, the HHS provided $424 million, and the NSF provided $40 million. UNC R&D funding: • The federal government financed 61 percent ($586 million) of the R&D expenditure at UNC in 2015. Of this, the HHS provided $443 million and the NSF provided $40 million. NC State R&D funding: • The federal government financed 43 percent ($200 million) of the R&D expenditure at NC State in 2015. Of this, the DoD provided $27 million, the NSF provided $51 million, and the USDA[33] provided $20 million.
State	• Identified the need for a Park and commissioned a concept report. • Funded and supported the public research universities in the area, UNC and NC State. • Helped fund infrastructure projects, highways, and an international airport
Local	• Worked with industry and universities to provide an attractive place to live. • Durham County committed $20 million for redevelopment and the creation of Park Center.

Akron, Ohio (Urban Cluster)[34]

Akron, Ohio is a former industrial powerhouse and was deemed the "Rubber Capital of the World" for its tire and rubber industry. The industry moved manufacturing plants out of the city, and Akron entered a steep downturn in the 1980s and early 1990s. Akron

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33. USDA is United States Department of Agriculture.

34. This section draws from Ledebur, L. and Taylor, J. (2008). *A Restoring Prosperity Case Study: Akron, Ohio*. [online] Metropolitan Policy Program at Brookings. Available at: https://www.brookings.edu/wp-content/uploads/2016/06/200809_Akron.pdf [Accessed 7 Dec. 2017]; and van Agtmael and Bakker op. cit.

has since made an economic turnaround and has become a global leader in the polymer industry, earning the title "Polymer Valley." Akron's GDP was $37 billion in 2016.[35]

Core Competency. Akron capitalized on its previous expertise and switched from supplying tire makers to developing synthetic materials and products.

People: Strong Leadership. Two leaders were critical in transforming Akron's economy: former mayor Don Plusquellic and former president of the University of Akron, Luis Proenza. Don Plusquellic served as mayor of Akron from 1987 to 2015. Many in the region identified his continuity of leadership as an important reason for Akron's successful economic development. Pluesquellic's two highest priorities were economic development and education.

The University of Akron played a central role in jumpstarting the re-development of Akron. Proenza joined the University in 1999 and developed "The Akron Model: The University as an Engine for Economic Growth." The Akron Model stated that the University of Akron was going to take significant responsibility for growing the region economically and was dedicated to serving the community.

People: Highly Skilled Researchers. Already a leader in polymer science, the University of Akron and Kent State University (located near Akron) trained scientists and engineers in the industry. In addition, the big tire companies left their research labs in the area after their manufacturing operations left the region so there already existed a research infrastructure ready to be tapped for new opportunities.

People: Skilled Workforce. After the big tire companies left, there still existed a workforce in the area with technical skills in the rubber and steel industries.

Culture: Idea Sharing. Integral to the Akron Model was public and private collaborations and knowledge sharing. In order to facilitate the connection between research and commerce, Proenza created the University of Akron Research Foundation (UARF), an independent research foundation to allow university professors to benefit financially from their research.[36] The university made it an explicit goal to connect with businesses.

Business Capabilities. The city of Akron created the Akron Global Business Accelerator, which is home to a technology business incubator and offers on-site support, facilities, and programs for tech start-ups and early-stage companies.[37]

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35. U.S. Bureau of Economic Analysis, Total Gross Domestic Product for Akron, OH (MSA) [NGMP10420], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/NGMP10420, December 7, 2017.

36. For more on the UARF, see: https://www.uakron.edu/uarf/

37. More information on the initiative and the programs offered can be found here: http://www.akronaccelerator.com/

Sophisticated Demand. The demand for Polymer products comes anywhere from the plastics industry, to the automotive and transportation industry, to the medical industry. The demand came from outside the city primarily.

Access to Funding. The state government played a role in furthering Akron's economic development by launching Ohio's Third Frontier project in 2002. This project, renewed in 2010, is a $2.1 billion initiative that provides funding to Ohio tech companies and helps connect companies to universities and nonprofit research institutions.[38]

Summary. Akron accomplished its turnaround through a research university invested in engaging with business and the community, innovative and sustained leadership, an existing skilled workforce, a competitive advantage in the polymer industry, and a proactive local and state government.

Role of Government in Akron cluster

Federal	• The federal government financed 25 percent ($15 million) of the R&D expenditure at University of Akron in 2015. Of this, the DoD provided $4 million and the NSF provided $6 million.
State	• Provided funding and support for the University of Akron. • Governor Bob Taft launched Ohio's Third Frontier project in 2002.
Local	• Mayor Don Plusquellic provided continuity of leadership. • The city of Akron created the Akron Global Business Accelerator.

Seaport Innovation District – Boston, Massachusetts[39]

The Seaport Innovation District was a planned initiative—an officially designated and branded area. Seaport is a "re-imagined urban area" that has transit access, historic building stock, and is close to downtown Boston. Unlike in many of the other case studies we looked at, there is no anchor university or research firm in the district. Instead, the city is the main actor.

Infrastructure Provision. The Big Dig highway project revitalized the Seaport District by connecting it to downtown.[40] Funding was also provided for infrastructure improvements to the Waterfront and surrounding area.

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38. For more on Ohio Third Frontier, see: https://development.ohio.gov/bs_thirdfrontier/.

39. This section draws from The Intersector Project (2015). *The Development of Boston's Innovation District: A Case Study of Cross-Sector Collaboration and Public Entrepreneurship*. [online] Available at: http://intersector.com/wp-content/uploads/2015/10/The-Development-of-Bostons-Innovation-District.pdf [Accessed 7 Dec. 2017].

40. The Seaport area of Boston was dominated for years by overhead highways that divided the city and created an unattractive feel to the area. The Big Dig took too long and was overbudget but it moved these highways into underground tunnels changing the character of the city and keeping through traffic away.

People: Strong Leadership. Redeveloping 1,000 acres on the South Boston Waterfront, former Mayor Thomas Menino drove the creation and development of Boston's Innovation District. Serving as mayor of Boston from 1993 to 2014, Menino capitalized on an increasingly active waterfront to create a dense cluster of work buildings, dining and entertainment options, and physical spaces where entrepreneurs could converge.

In the early stages of the cluster, he worked with a local real estate agent to convince MassChallenge, a start-up accelerator with over 110 companies and 200 mentors at the time, to come to Seaport. The city government and Mayor Menino also worked to bring Vertex Pharmaceuticals, a global biotechnology drug developer, to the District. This brought significant activity to the area.[41]

People: A Skilled Workforce. Babson College (a strong business-oriented university with a focus on entrepreneurship) opened an outpost in Seaport. The university serves to attract and train talent. Greater Boston is also home to some of the world's best universities (including Harvard and MIT, among many others) and is a large source of talent.

Culture: Idea Sharing. Seaport is home to District Hall, the world's first freestanding public innovation building. It is a place for entrepreneurs to gather, work, and attend events dedicated to networking and learning.[42]

Business Capabilities. The start-up accelerator MassChallenge is a mainstay in the District. It served an important role in attracting and supporting start-ups in the early development of the cluster. The District's location also provides a wealth of other business capabilities due to its connection to the rest of Boston.

Access to Funding. Seaport is connected to downtown Boston and to Cambridge by highway and public transport. Boston receives the second most venture capital investments behind Silicon Valley.[43]

Summary. The Seaport District of Boston transformed into a hub of business and innovation mostly through strong leadership by local government.

Role of Government in Seaport Innovation District

Federal	• Provided a portion of the funding for the Big Dig project, which connected the Seaport District to downtown.
State	• Provided much of the funding for the Big Dig.

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41. Diesenhouse, S. (2011). *Spurring Growth on Boston's Waterfront*. [online] Nytimes.com. Available at: http://www.nytimes.com/2011/11/02/business/spurring-growth-on-bostons-waterfront.html [Accessed 7 Dec. 2017].

42. For more on District Hall, see: https://districthallboston.org/

43. A ranking of venture capital investment by city can be found here: https://www.theatlantic.com/technology/archive/2016/01/global-startup-cities-venture-capital/429255/

	• Provided funding for infrastructure improvements to the Waterfront and surrounding areas.
Local	• The Innovation District was a direct result of the vision and initiative of former Mayor Thomas Menino. • Menino and his team proposed the plan, attracted major tenants, engaged the community, promoted the project, created flexible housing options, and mobilized resources. • Provided a tax break to Vertex Pharmaceuticals to persuade the company to locate in the district.

Silicon Valley (Regional Cluster) – San Francisco Bay, California

Silicon Valley is the premier tech cluster in the world. It is home to some of the world's largest technology companies including Apple and Google and is renowned as a hub of innovation and entrepreneurship. Silicon Valley's GDP was $722 billion in 2016.[44]

Core Competency. Silicon Valley housed several of the pioneers of the semiconductor revolution, as well as access to faculty and research at Stanford and Berkeley.

Infrastructure Provision. In the cluster's early days, the organizations tried to work harmoniously with local authorities to make sure the infrastructure and educational needs of the community were being met. In addition, zoning was liberal allowing for rapid expansion.

People: Strong Leadership. The origin of Silicon Valley traces back to Frederick Terman, Stanford University's provost and dean of engineering, who encouraged graduate students to start their own companies. Terman created the Stanford Industrial Park, leasing land owned by Stanford for start-up companies. Another key figure was William Shockley, the creator of the transistor (while at Bell Labs), who moved to Mountain View in 1956.

People: Highly Qualified Researchers. The early development of Silicon Valley depended on the talent pool assembled at Stanford and UC Berkeley together with the private sector companies. Immigration also played an important role in bringing researchers and high-skilled workers to the area.

People: Skilled Labor Force. Entrepreneurs moved to Silicon Valley because it was the place to raise money to build technology companies. Stanford and UC Berkeley provided skilled workers. In her book, AnnaLee Saxenian emphasizes that the educational institutions in Silicon Valley supported the needs of the technology cluster for skilled

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44. U.S. Bureau of Economic Analysis, Total Gross Domestic Product for San Francisco-Oakland-Hayward, CA (MSA) [NGMP41860], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/NGMP41860, December 7, 2017.

    U.S. Bureau of Economic Analysis, Total Gross Domestic Product for San Jose-Sunnyvale-Santa Clara, CA (MSA) [NGMP41940], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/NGMP41940, December 6, 2017.

workers.[45] As it developed, the Valley attracted talent from Asian immigrants who contributed to many of the start-ups.

Culture: Idea Sharing. Saxenian also emphasizes the benefits of the culture in Silicon Valley over the culture of Boston's Technology Corrider (Route 128), which was arguably the largest tech hub up until it was eclipsed by Silicon Valley in the 1980s.[46]

Saxenian's diagnosis focuses on the existence of a more freewheeling, networked-based economic system in California, more open labor markets, a lot of informal communications, a culture of cooperation rather than secrecy, and much more flexibility. She argues that these were crucial in Silicon Valley's success.

In Silicon Valley today large companies, such as Apple, innovate *within* the company and are strict about secrecy.[47] However, small companies proliferate and participate in accelerator programs that encourage the sharing of ideas.

Culture: People Amenities. Silicon Valley as a location has natural advantages. The weather and natural resources make it an attractive place to live. San Francisco and the surrounding area have an assortment of restaurants, sports teams, and cultural activities. As the cluster has grown, this has pushed up the Bay Area's cost of living, proving to be a drag on the cluster's continued expansion, and diverted some growth to cheaper alternatives such as Austin, Texas.[48]

Business Capabilities. Silicon Valley is well known for its incubators and accelerator programs and has developed a large venture capital industry.

Sophisticated Demand. The Department of Defense, as one of the Silicon Valley's largest customers, was an important factor in the success of the Valley, creating demand for its electronic products. Also important, in 1952 IBM opened its California Research Lab in San Jose.

Access to Funding. As the emphasis of firms in the Valley shifted from defense goods to private sector goods and services, the source of funding also shifted. Silicon Valley evolved into the leading place for finding new ideas and places to invest, thus becoming the premier global location for angel investors and venture capitalists.

Regulatory Environment. Initially, there was a freewheeling environment in the Valley and easy access to land. Over time, stronger regulations, including environmental rules, . . .

45. Saxenian op. cit.

46. Saxenian op. cit.

47. The major technology companies are constantly battling in court over patents. For example, Apple has faced off with Google and Samsung, and recently had to pay over $600 billion in damages to VirnetX for infringing on their patents related to iMessage and FaceTime. Several Silicon Valley companies have also been involved in employee anti-trust litigation.

48. Castillo, M. (2017). *San Francisco has gotten so expensive, some tech companies can't convince employees to move there*. [online] CNBC. Available at: https://www.cnbc.com/2017/04/06/san-francisco-cost-of-living-pricing-out-tech-companies-workers.html [Accessed 7 Dec. 2017].

were imposed—as well as higher taxes—but the intrinsic dynamism in the cluster has allowed the area to sustain its growth and prosperity. State and local governments also realize that the success of the state's economy depends in large part on the success of the Valley.

Summary. In the 1950s, high technology companies in the United States developed in the post-war period due to a great deal of Department of Defense funding, followed by the growth of demand from the private sector. A culture of collaboration and idea-sharing played a large role in Silicon Valley overtaking Boston's Technology Corridor (Route 128) for the lead in high-tech. Excellent research institutions, federal and state government funding, federal laws promoting high-skilled immigration, university and private sector leadership, and coordination between government, university, and private sector actors also played a role.

Role of Government in Silicon Valley cluster

Federal	• The Department of Defense served as a large customer for electronic products. • Lowered the capital gains tax and allowed pension funds to invest in venture funds. • Immigration policy provided a large pool of high-skilled labor. Stanford R&D funding: • The federal government financed 66 percent ($676 million) of the R&D expenditure at Stanford in 2015. Of this, the DoD provided $83 million and the HHS provided $445 million. UC Berkeley R&D funding: • The federal government financed 44 percent ($346 million) of the R&D expenditure at UC Berkeley in 2015. Of this, the HHS provided $107 million, NASA[49] provided $69 million, and the NSF provided $81 million.
State	• Prohibited non-compete agreements. • Provided funding and support for the University of California (UC) public university system.
Local	• Coordinated with organizations during the early stages of the cluster.

ManufacturingUSA: Case study of a US Government Effort to Support Manufacturing[50]

This case study looks at one of the Obama Administration Initiatives, the ManufacturingUSA Institutes. The technologies they are working on include lightweight

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49. NASA is National Aeronautics and Space Administration.

50. This case study details a US government initiative to support manufacturing. It is not a geographically concentrated cluster and is therefore somewhat different.

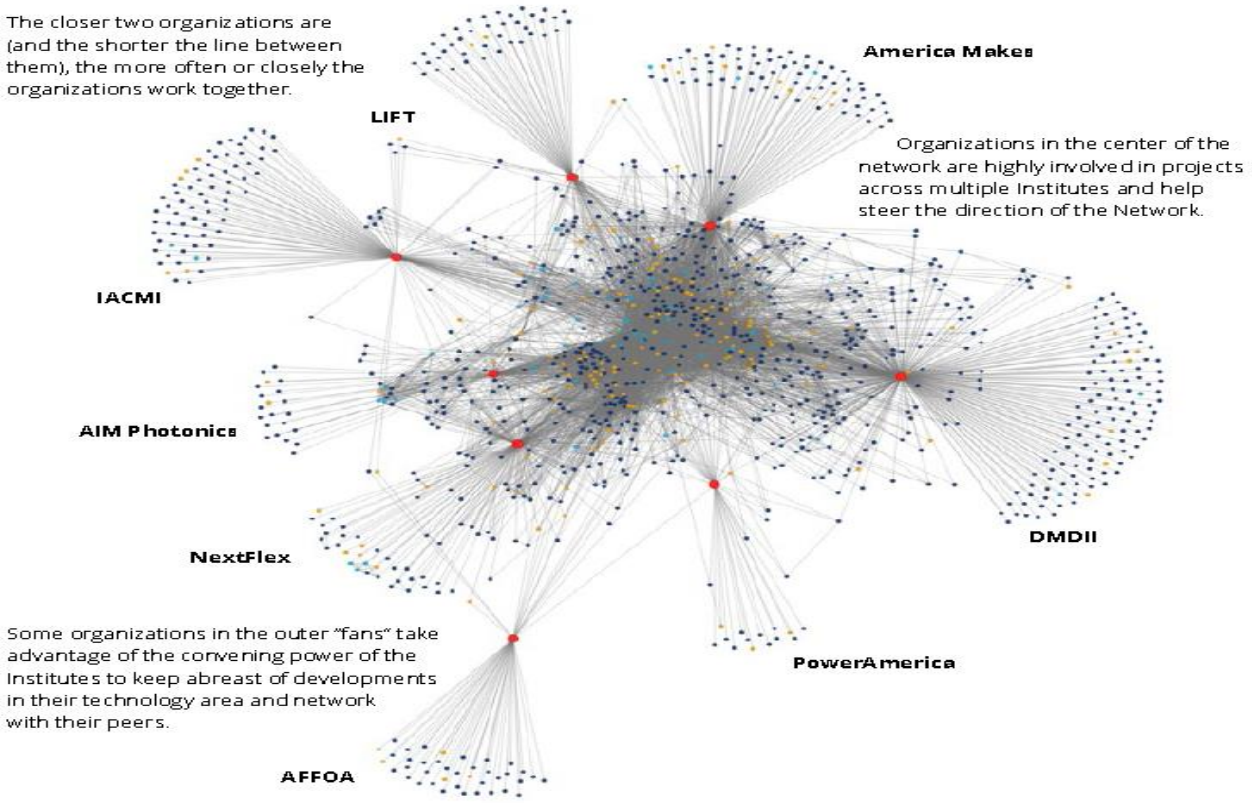
materials for automobiles, integrating virtual reality in the workplace, wearable fabrics, synthetic blood vessels, and robotics. By 2016 there were eight institutes in operation covering different areas of advanced manufacturing.

Core Competency. The goals of the initiative are to encourage collaborative research, by bringing together academic and private sector researchers and entrepreneurs to develop advanced industry products, and to develop the capability to manufacture these products in the United States.

Culture: Idea Sharing. A major effort is underway to create links both between the different centers as well as between the centers and companies or academics located in a different geography. The goal is to get some of the advantages of an innovation district or a cluster even if the people and companies involved are spread out.

The figure on the next page shows the network connections that have been made among the institutes and the participating companies, universities, and research facilities. The extent of the connections is shown with the organization names listed around the circumference of the figure and the lines illustrating the connections among them and with the member organizations. Obviously, geography remains very important. Giving people the opportunity to interact formally and informally in the same place provides the best option for productive outcomes. The institutes do this, but they are also trying to create virtual districts to allow interaction and cooperation among researchers that are spread out across the country.

Manufacturing USA: An Interconnected Network



Source: Manufacturing USA: A Third-Party Evaluation of Program Design and Process. Deloitte Consulting, LLP and Deloitte Services, LP. January 2017.

Network Connections among the Institutes and Participating Organizations

Business Capabilities. There is an active mentoring program within the organizations, and the institutes foster joint R&D. Another benefit of the institutes is to allow researchers and entrepreneurs to access machinery tools and facilities that would be too expensive for them to purchase during the early stage of development. This lowers the cost of research, experimentation, and development.

Access to Funding. The program launched in 2012 with various federal government agencies committing funding from existing appropriations, totaling $600 million.

Additional funding was sought from state governments and from private industry in an amount totaling $1.3 billion[51].

Summary. It is too early to tell how well this initiative is working, but the progress to date is very impressive, specifically in terms of the participation from states, universities, and companies. There are 1,174 organizations involved with the program and 753 that have formal membership, which requires financial contributions. The institutes are working on a range of very promising projects.[52]

Failed Efforts to Create Innovation Districts or Promote Start-up Tech Companies.*[53]*

This section looks at some of the problems that have arisen when policymakers have attempted to promote technology companies. The examples include policies designed specifically for clusters as well as policies designed to support an innovation ecosystem more generally.

Malaysia Science Park. In an effort to create a biotech cluster in their economy, in 2003 Malaysia announced a science park for this purpose (BioValley). Government planners managed the project from the top down. The science park was a failure and now stands idle. This project was lacking in several of the success factors found in other cluster efforts.

The idea and plan for the science park came from leading politicians who lacked understanding of the science and technology involved and the capacity to generate interest for the project from the private sector. While funding was made available from the government, private industry was not ready to put up its own funding.

Furthermore, Malaysia lacked a pool of skilled scientists with qualifications in life sciences, and the location made it difficult to attract skills from outside.

The private sector lacked business skills to start a cluster in science and biotech, and there was not a strong demand within the economy for the products and services that might be produced by such a cluster.

US Clean-Tech. The Obama Administration sought to encourage clean-tech firms to contribute to the economic recovery after the Great Recession and create a competitive

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51. Deloitte (2017). *Manufacturing USA: A Third-Party Evaluation of Program Design and Progress*. [online] Available at: https://www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/us-mfg-manufacturing-USA-program-and-process.pdf [Accessed 7 Dec. 2017].

52. The home page for the institutes is at https://www.manufacturing.gov/nnmi/ . Deloitte op. cit. did a third-party evaluation of the program.

53. This section draws on Lerner, J. (2009). *Boulevard of broken dreams*. Princeton, N.J.: Princeton University Press; *Lerner, J. (2012). The Architecture of Innovation. Boston, Mass.: Harvard Business Review Press*; and Economist Intelligence Unit (2011). *Fostering innovation-led clusters: A review of leading global practices*. The Economist.

clean technology industry. Loan guaranties for clean-tech totaled $35.9 billion cumulatively from September 2009 through November 2011.

The most widely publicized difficulty with this program involved loan guaranties made to Solyndra, a company that manufactured an innovative form of solar panels. The loan guaranties given in 2010 were for $535 million, which added to $198 million of private sector funding. But the company declared bankruptcy in August 2011 soon after the funding was provided. Following the bankruptcy, the company was raided by the FBI because of concerns about criminal behavior in the handling of public and private funds. Bloomberg reported in 2011 on signs of extravagant spending by the company. There was also an investigation by the US Treasury which revealed that the Obama Administration had serious concerns about the company and the legality of the loan guaranties before they were made.[54]

The Solyndra example is the most serious, but there were concerns about other awards made under this program. The process of selection for the awards was not transparent and both companies and venture capital investors hired lobbyists to improve their chances. Some awards were given to those who turned out to be political donors.

The underlying problem with this program is that policymakers were in too much of a hurry to develop a clean-tech program while the political climate was still favorable. The policymakers lacked the skills needed to determine which projects would succeed, and there was favoritism in the selection of projects.[55]

Canadian Tax Credits. In the 1990s the Canadian government introduced tax credits in an effort to boost industry under the Labor Fund Initiative. As a result, there was a surge in funds available for innovative companies, an amount ten times the previous availability. The funds ended up being allocated by managers who were inexperienced and not able to judge the viability of the projects. Established VC funds decided to exit the Canadian market and looked for US investments instead.

US Small Business Investment Company. The Small Business Investment Company was started in the United States in 1958 because it was perceived that small businesses lacked access to the capital market without government support. The program has suffered from many problems since its inception. In the early days, venture capital funds that were incompetent or even fraudulent were given funding. More recently, a 2009 report by the General Accountability Office stated that "by failing to hold firms accountable, Small Business Association and contracting agencies have sent a message to the contracting community that there is no punishment or consequences for committing

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54. Leonnig, C. and Stephens, J. (2011). *Chu takes responsibility for a loan deal that put more taxpayer money at risk in Solyndra*. [online] The Washington Post. Available at: https://www.washingtonpost.com/politics/chu-takes-responsibility-for-a-loan-deal-that-put-more-taxpayer-money-at-risk-in-solyndra/2011/09/29/gIQArdYQ8K_story.html?utm_term=.01f203647f60 [Accessed 7 Dec. 2017].

55. See the discussion in Lerner 2009, op. cit. and Morris, A., Nivola, P. and Schultze, C. (2012). Clean energy: Revisiting the challenges of industrial policy. *Energy Economics*, 34, pp.S34-S42.

fraud."[56] [57] The problems came from poor project selection, favoritism, and lack of accountability.

Michigan, US Hybrid Vehicles. In the early years of this century, the state government in Michigan decided to create a hybrid vehicle initiative. It was perceived, correctly, that the US companies (GM, Ford and Chrysler) had fallen behind Toyota in hybrid technology and the initiative was designed to help the Detroit companies catch up. However, the main automakers in the state had already developed their own plans, either for a newly designed hybrid vehicle (the Chevy Volt), or they had licensed hybrid technology from Toyota, which had pioneered this type of vehicle with the Prius. There was no support for the initiative from the companies that were supposed to be helped.

5. Learnings: Success Factors

This section describes what can be learned from the case studies, the significance of each success factor, and the role of government. The learnings provide insight for policymakers as well as the people, businesses, universities, and others located in the cluster.

The success factors are listed in the order of their importance based on the case studies and the literature. Despite the lack of statistical evidence to inform which success factors are the most important, the case studies provide compelling evidence regarding the set of characteristics that are essential to success and the set of factors that are helpful to sustain the growth of a cluster. Note, however, that the Porter Diamond and the Metro framework both stress interactions among the causal factors rather than setting out a causal ordering. They take a holistic approach where there must be a critical mass of positive contributors in order to sustain cluster growth.

Core Competency. This is essential to the development of a cluster, but there is some flexibility in what makes up a core competency. In essence this means that a cluster must have the skills and technical capability to produce products and services that are demanded in the marketplace and that give the companies in the cluster a competitive advantage. Some clusters, rely on a major technological step forward, such as the integrated circuit for Silicon Valley. However, modest incremental innovations are often just as important. Scientists and engineers who develop expertise in one area have been

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56. Government Accountability Office (2009). Case Studies Show Fraud and Abuse Allowed Ineligible Firms to Obtain Millions of Dollars in Contracts.

57. Author's note: In my first paper for MIIS (below), I cited favorably the SBIC program and I stand by that assessment. There have been serious problems in its administration, however.

    Baily, M. (2016). Policies to enhance Australia's growth: A U.S. Perspective. [online] Brookings Institution. Available at: https://www.brookings.edu/wp-content/uploads/2016/12/baily_australiagrowth_122016_final.pdf [Accessed 7 Dec. 2017].

able to redirect and repurpose that knowledge to create a new core competency, as in the case of Akron. The government's role is to work with university and business leaders as they identify the core competency of a potential cluster, or as a portfolio of potential competencies are developed. This point intersects with the section below on leadership.

Access to Funding. In order for a cluster to grow there has to be a source of growth funding. In order for an innovation district to get started there must be start-up funds available. In all of the case studies, there was funding provided by some governmental entity. Silicon Valley relied on Department of Defense funding in its formative period. The revival of Pittsburgh got started through an initiative from the State of Pennsylvania that provided seed funding. Research Triangle Park was funded by a state initiative and received major funding from the federal government for health sciences research.

However, if the only source of funding is from federal or state government, it is easy to waste taxpayer dollars. It is important that private entities give buy-in by putting up some of their own funds, people, or physical assets. This lesson about co-funding is based on the failures described earlier, where the government handed out funding, and companies were happy to take the money. But these companies had not put up their own resources and capabilities and were not committed to the success of the project.

Angel investors and venture capitalists have played an important role in the funding of start-up companies in the United States and elsewhere. A problem for an early-stage cluster is that these funders are not close by, which is why government start-up funding is often needed. Angel investors and venture capitalists take a hands-on approach to investing. They want to get to know the entrepreneur and look at his or her demonstrations or learn about the ideas. Given the importance of private funding as a cluster grows and matures, it is important to advise and mentor entrepreneurs as they seek such funding. Young people with good ideas do not necessarily know how to pitch their ideas well and thus gain the confidence of funders, especially if the funders are located in a different geography.

People: Strong Leadership. Having good people committed to develop a cluster is essential, and the first element of people success is to have a strong leader, or leadership team, that will be able to bring together the different resources needed. Bakker and van Agtmael draw this lesson for all the locations they look at, whether in North America or in Europe. The leadership can come from a university, a business background, government, or a partnership. The leadership team must have a passionate commitment to the development of a successful cluster or innovation district. Once a cluster becomes self-sustaining this leadership role changes, and the economic advantages of clustering take over and market incentives drive further growth. Good policy is needed to ensure adequate education and infrastructure is available to support endogenous growth in the cluster.

People: Highly Qualified Researchers. To develop an innovation-based cluster, it is essential to have highly qualified researchers. The existence of a strong research community—a university, or research hospital, or research lab—may determine whether it is possible to start an innovation cluster in that location. Some locations that lacked

such a research base have been able to bring in talent from outside, although that can be hard to do successfully. Singapore used high salaries to attract several leading edge researchers to their biotech center, which now seems to be a sustainable innovation cluster. Policymakers can assist in finding the resources needed to attract and retain strong researchers.

Business Capabilities. The people who have great ideas for start-ups are not necessarily the people that know how to run a growing a company that has to manage hiring, firing, payroll, advertising and so on. One solution is to use venture capital companies, which can guide the business decisions of a company as it grows. Another solution is to have mentors that can play this role at a lower cost to the company. Many US states have developed mentoring programs, bringing retired business executives into the process to give advice and counseling.

Sophisticated Demand. Innovative products and services must find demand that can make use of the technology embodied in them. Michael Porter stresses demand factors to cluster success. The case studies also point to this factor. The US government was the major purchaser of Silicon Valley products in its formative years. Health centers are customers for sophisticated products and services. It is essential to have a source of demand for the products and services developed in an innovation cluster. What is less clear is whether that demand has to be located in or near the cluster. The Australian aerospace cluster in South Australia, for example, accesses demand from Boeing and Airbus, companies that are headquartered many miles away. The relationships with these large companies is helped by the presence of facilities in Australia[58], notably Boeing that has its largest footprint outside the United States in Australia, with 3,500 employees. Airbus manufactures military helicopters in Australia. Government has often been an important source of demand but is not the only option.

Infrastructure Provision. Airports, highways, housing, and building stock provide the foundation on which a successful cluster is built. Transportation infrastructure is necessary to ship goods and connect people. Affordable housing is necessary to attract workers. Without a satisfactory building stock, businesses and institutions will not want to locate in the area.

Zoning rules are an essential part of infrastructure provision. Older cities have a land ownership structure that makes it difficult to amass a large enough space to permit the development of a viable innovation district. City authorities have to use eminent domain to put together the desired parcels of land. (Without the power of eminent domain it is difficult to pull together a large enough parcel of land that can be devoted to the cluster.) Restrictive zoning can be a barrier to mixed-use locations. Labor regulations can be important.

Culture: Idea Sharing. All the technology incubators build in facilities to encourage such idea exchanges, both in the US and Europe. For example, innovation districts in Barcelona and Stockholm have developed seminars and informal meeting places to

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58. Boeing in Melbourne and Brisbane and Airbus in Brisbane and Sydney.

encourage such interactions. Research Triangle Park in North Carolina is a successful cluster, but they have found that the lack of spaces where ideas can be exchanged is limiting their success. They are trying to re-develop their physical space in ways that allow for much greater interaction. Policymakers will not play a decisive role in building culture, but they can insist that the physical infrastructure facilitates idea sharing.

Regulatory Environment. In some jurisdictions, regulatory barriers can be problematic. Permitting can be slow and may involve different levels of government if federal, state, and local authorities are involved. Employment regulation can also be a barrier. Start-up companies cannot guarantee permanent employment, and some countries or districts have strict rules on labor contracts.

People: A Skilled Workforce. The third element of the people agenda is to build a skilled workforce, including lab assistants, nurses, skilled tradespeople, and skilled STEM workers. It is not necessary to have a large skilled blue-collar workforce in the early stages of an innovation district. However, the absence of skilled workers will become a constraint if the cluster expands. Nevada has attracted technology companies—and has business IT systems companies and a health center. However, a study by Brookings's Metropolitan Program[59] found that the economic development of the state has stalled because there are not sufficient skilled workers, especially workers having STEM skills. Policymakers must anticipate the need for skilled blue-collar and STEM workers and ensure the pipeline of workers with technical education is available.

Culture: People Amenities. As well as the culture of interactions among researchers, the provision of cultural attractions is important and is part of the infrastructure assets that the Metro group describes. An innovation district is more likely to succeed if it is an attractive place to live and work. People amenities contribute to the availability of skilled and talented people.

Patience. The case studies described in this paper range from Silicon Valley, that has been developing since the 1950s, to the Boston Innovation District, which was started when 1,000 acres was set aside in 2010. There is no fixed timetable for the development of technology clusters, and they may take time before they reach critical mass and become fully self-sustaining. Policymakers must build patience into their strategic plans for technology clusters.

To provide additional insight into the way in which the key success factors were important to the clusters described in this paper, the Appendix gives a table showing which success factors applied to which cases.

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59. Lee, J., Muro, M., Rothwell, J., Andes, S. and Kulkarni, S. (2014). *Cracking the Code on STEM: A People Strategy for Nevada's Economy*. [online] Brookings Institution. Available at: https://www.brookings.edu/research/cracking-the-code-on-stem-a-people-strategy-for-nevadas-economy/ [Accessed 7 Dec. 2017].

6. Learnings: Problems

Based on the examples given earlier in this paper and on the work of the Economist Intelligence Unit, the problems that emerge in efforts to create clusters can be described in the following four categories.

White elephants. A cluster effort is unlikely to succeed if it is started to create prestige for policymakers or government leaders. Malaysia decided that it would add luster to their country to have a biotech district and did not examine the feasibility of what it would take to make it work and prosper.

Picking winners from the top down. If policymakers want to develop a cluster they must seek out the judgments of the scientists and business men and women who are on the ground and have the knowledge of the technology and the value of the cluster effort. The attempt by Michigan to create a hybrid vehicle initiative is an example of a top-down effort that failed.

Incompetence. The cluster leadership must have the level of competence required for what they are trying to achieve, and they must step back and leave to others the decisions and tasks for which they do not have either the necessary information or the necessary level of capability. The Obama clean tech initiative suffered from this problem.

Capture. This occurs if government actors place their own interests above the public interest, perhaps by diverting funds to friends or associates, or by making decisions favorable to certain interest groups as a way of being hired when they leave government. There can be a trade-off between competence and capture—the answer is a matter of balance and judgment.[60]

7. Conclusions and the Role for Government and other Actors

There are many successful clusters in the United States and policymakers—universities and local leaders have contributed to that success. To be sure, there have been failures, but the more remarkable fact is that Pittsburgh has been able to transform into a vibrant economic city following the collapse of the steel industry. North Carolina has created a thriving research park, and Boston has been able to bring innovative start-up companies to the Seaport district. All levels of government—local, state, and federal—have played a role in supporting and developing these clusters, and non-profit and philanthropic support has been valuable also.

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60. If in fact the cleantech projects were decided on the basis of who had given money to the Obama campaign, then this is an example of capture.

Clusters are critical to US innovation because they are home to some of the country's leading universities, research labs, and high-value companies, and they generate outsized economic output. For example, modern high-tech clusters often gather around prestigious universities on whose research they can piggyback.

Local leadership is a key success factor that allows clusters to harness and build upon competitive strengths. Strengths can be a combination of local research and education institutions and firms, physical assets, and infrastructure. Place and amenity for the community is also important to facilitate interactions and industry and research engagement. Regions that are progressing and transitioning have successfully developed clusters or districts. They have emerged in dozens of cities and metropolitan areas in the United States.

The United States has a strong tradition of philanthropic giving, which is often funneled through universities. A number of these universities have built up large endowments that enable them to undertake research and economic development initiatives. Stanford University played an important role in the creation of Silicon Valley. Paul Allen, the co-founder of Microsoft and a private philanthropist, was instrumental in the development of the innovation district in Seattle.

Summary conclusions from the case studies on how government and other actors can help promote successful clusters:

Local leadership is essential. Successful clusters generally have a strategic plan that identifies a strong and capable leadership team. In turn, this team identifies a core competency around which the cluster will be built. Successful plans build on a genuine business capability. Unsuccessful plans are driven by an aspiration without real economic foundation.

Start-up funding from governments is important and may be essential. As the cluster evolves it is vital that it is able to attract private funding.

Local and regional government funding is helpful for infrastructure investment, such as incubators, transportations linkages and WiFi service. A successful cluster is an attractive place to work and live for talented people and fosters a sharing community. It is best for the private sector to be involved in the infrastructure creation process.

Access to skilled professionals is important for nascent technology clusters, which may require government supported university programs. As a cluster grows, it will require more skilled blue-collar workers and technicians, creating the need for training programs.

All levels of government, from the federal to the local level, should support collaboration and cluster development. It is beneficial to have clarity and transparency around the roles of the different levels of government and coordination among them.

Government funding in the form of R&D support for universities is important,[61] and successful clusters are often co-located with universities, public labs, or hospitals. These institutions should encourage cooperation with private businesses and start-ups.

It is helpful to a nascent cluster if the government is a buyer of the sophisticated products or services created in the cluster. Mapping out the market and the buyers should be part of the strategic plan for the cluster at the outset.

Local or regional government can facilitate mentorship programs where established or retired business leaders can help new entrepreneurs.

It is important to have measures in place to make sure that government funding (from any level of government) is allocated on the basis of merit and economic rationale.

Clusters often take several years before they become large enough to have an impact on the economy of a country or region. Policymakers need patience.

Have clusters and innovation districts been of sufficient importance to move the needle of economic growth in a large economy such as that of the United States? In the case of mature clusters, the answer is certainly yes. Clusters with leading universities, research labs, and high-value companies are crucial to the United States innovation system and generate outsized economic output. The early industrial clusters in autos and steel were central to the development of the US economy. More recently, there was a surge in growth and productivity in the US economy starting in 1996 that lifted living standards, and much of that growth was attributable to innovations occurring in Silicon Valley.

With the small innovation clusters or districts, it is harder to say they have moved the needle in such a large economy as that of the United States. Some of them will remain small and their contribution to the total will be small. But if even a very few grow into dynamic and innovative clusters, they will have justified the investment in all of them. Even those that remain small can contribute to their local economies.

Productivity, the most important determinant of the growth in living standards in the long run, has experienced a significant slowdown in recent years. Diffusion of ideas can help close the productivity gap between frontier firms and lagging firms. Innovation districts and clusters can play a role in addressing the productivity slowdown by increasing the diffusion of ideas and collaboration between firms.

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61. Bakhtiari and Breunig op. cit. find that academic R&D in Australia has had a positive impact on company R&D but that R&D performed directly by government may crowd out firm R&D. This result probably stems from the type of R&D involved and may not apply across the board. For example, research carried out at the National Institutes of Health in the United States generates a lot of private sector R&D on new drugs and devices (although it may crowd out basic research by private companies).

The Brookings Economic Studies program analyzes current and emerging economic issues facing the United States and the world, focusing on ideas to achieve broad-based economic growth, a strong labor market, sound fiscal and monetary policy, and economic opportunity and social mobility. The research aims to increase understanding of how the economy works and what can be done to make it work better.

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