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HOW CAN INDUSTRY FOCUS INFLUENCE AN INNOVATION ECOSYSTEM'S DEVELOPMENT? PAST AND EMERGING LESSONS FROM THE RESEARCH TRIANGLE REGION, NORTH CAROLINA

PLENARY SESSION 2

Companies' profiles in STPs/AIs: addressing different needs

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Title: How Can Industry Focus Influence an Innovation Ecosystem's Development? Past and Emerging Lessons from the Research Triangle Region, North Carolina

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THEME 1. 2

Executive Summary
The success of Research Triangle Park (RTP), and its larger area of innovation, in igniting the IT and biotechnology industries aided the significant transformation of the region's economy. In addition to the operations of the RTP, industry support organizations played an important role in strengthening the ties between universities, industry and government to fortify the innovation ecosystem. RTP's economic developers, in focusing at the outset on "downstream" recruitment of established R&D branch plants, created an opening for supporting institutions to buttress industry and economic growth through "upstream" activities like seeding new business development and building university and industry linkages. As the region evolved, so has this development approach. We compare and contrast the support for IT and biotech with the emergence of the clean technology industry today. We then offer ideas to enhance cleantech's growth and lessons learned from the RTP innovation area's collective experience in seeding propulsive and transformative industries.

Introduction and Methods
The Research Triangle Region of North Carolina in the United States is often considered one of the world's leading success stories for transforming a low-income regional economy based in tobacco, textiles, and furniture into a region marked by highly innovative and technology-driven industry sectors, in particular, information technology (IT) and biotechnology (biotech). The impetus for this change began with the establishment of Research Triangle Park (RTP) in 1959. Today, 55 years later, the RTP region has grown into a much wider geographic "area of innovation" inclusive of multiple small to medium sized cities and marked by a diverse industry base, company mix, and workforce.

RTP is an industrial park model with a core competency of research and development (R&D). In the Park's early years, economic developers' primary strategy was to recruit the R&D branch plants of major industrials, and their strategy was highly successful. In recent years, at least 80% of RTP

companies conducted R&D and employed more than 93% of RTP's workers.[1] During this dynamic growth period, but independent of RTP's management functions, government and business leaders also formed support organizations around target industry sectors that the RTP helped ignite. These industry support organizations augmented the strategy of recruiting R&D operations by brokering alignment between academic and corporate research, supporting commercialization, funding new enterprise development, and aiding business expansion and recruitment. Thus while the RTP management recruited R&D functions within major companies and the federal government, supporting organizations served to strengthen the connective tissue between government, universities and industry.

In this paper we stress the role of these supporting institutions that evolved in tandem with the industry sectors that flourished from within the RTP. We suggest that the economic developers of RTP, in choosing at the outset to focus "downstream" on established companies engaged in R&D, created an opening for supporting institutions to buttress industry and economic growth through "upstream" activities like seeding new business development and strengthening the university and industry linkages important for technology commercialization. We examine the evolution of strategies utilized by the region's economic development delivery system to nurture leading industry sectors, biotech and IT, and then introduce an emerging industry sector—clean technology (cleantech)—that has the potential to drive future regional growth. We draw on this 55 year experience to share lessons learned from the collective experience of how the RTP area of innovation embraced emerging industries and built strategies to grow them, with lasting economic impact.

We use three methods for this research. First, we rely on published literature about the RTP region's economic history, the foundation of the RTP itself, and the institutional partnerships that have fostered the growth of specific industries over time. Next, we describe original research conducted by RTI International (RTI) on behalf of the Research Triangle Cleantech Cluster (RTCC) to define and describe the cleantech industry. Lastly, we share findings from 13 interviews with industry and economic development practitioner-thought leaders who offered their perspective on points such as:

- Key characteristics that have made the region a success to date;
- The institutional partnerships that support innovation-led industry development and how they have changed over time;
- How institutional partnerships and supportive strategies foster emerging growth sectors such as cleantech today and how this contrasts with the past;
- An ideal organizational support infrastructure for emerging industry sectors and;
- The potential economic development benefits and spillovers from embracing cleantech as a future growth sector and how this contracts with other growth sectors in the past.

The individuals interviewed have longstanding ties to the region and typically have served in several different capacities related to economic development over their careers. Thus we were able to capture multiple perspectives on these key questions from a single individual. We gratefully acknowledge our interviewees for their ideas and insights for this paper.[2]

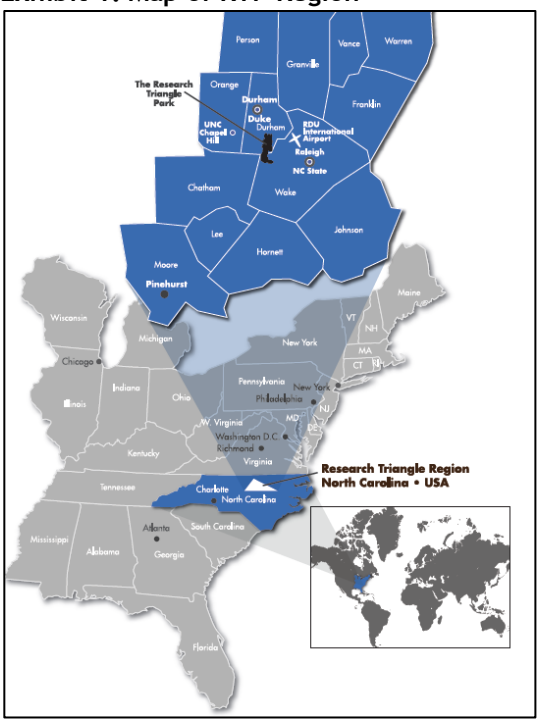
The RTP Region

[1] Hardin, J. 2008. North Carolina's Research Triangle Park: Overview, history, success factors and lessons learned. In: Hulsink, W and Dons, H. Editors. Pathways to High-tech Valleys and Research Triangles: Innovative Entrepreneurship, Knowledge Transfer and Cluster Formation in Europe and the United States: Springer. P. 27- 51.

[2] Ted Abernathy, President, Economic Leadership LLC; Bob Geolas, President, Research Triangle Foundation; John Hardin, Executive Director, NC Board of Science and Technology; William Lambe, Director, Community and Economic Development Program, UNC Chapel Hill School of Government; Brent Lane, Director, Carolina Center for Competitive Economies; Nichola Lowe, Associate Professor, Department of City and Regional Planning, UNC Chapel Hill; Jonathan Morgan, Associate Professor of Public Administration and Government, UNC Chapel Hill; Lee Anne Nance, Executive Vice President, Research Triangle Regional Partnership; Brooks Raiford, President & CEO, North Carolina Technology Association; Casey Steinbacher, President and CEO, Greater Durham Chamber of Commerce; Deborah Watts, Sr. Director, Research and Grants, e-NC Authority; Ed White, Chairman and CEO, Field2Base; Tom White, Director, Economic Development Partnership Office of Extension, Engagement, and Economic Development, NC State University.

The RTP region's innovation ecosystem today has grown far past the real estate boundaries of the RTP. For the purposes of this paper we define the area of innovation as the 13- county region surrounding RTP. The locus on innovation, however, is concentrated within the geographic triangle marked by the leading research universities: North Carolina State University (NC State University) in Raleigh to the east; Duke University in Durham to the north; and the University of North Carolina—Chapel Hill (UNC Chapel Hill) in Chapel Hill to the Southwest. The RTP is located in the middle of this area of innovation (see Exhibit 1).

Exhibit 1: Map of RTP Region



Source: Research Triangle Regional Partnership

Home to just over 2 million people, the 13-county RTP region represents 21.6% of the state's population. All but three of the counties added residents between 2010 and 2012, and all but one are expected to grow between 2012 and 2017, most by at least 2%. For most of the previous decade, the RTP region enjoyed lower unemployment rates than the state and the nation. Nearly half of the region's labor force works in the Services sector, while Manufacturing represents 8%, and Government is 15%. Healthcare, Education and Professional Services have led other sectors in yearly gains since 1990. The region added 1.928 million square feet of new construction in 2012 and had office rental rates comparable to other leading U.S. metro areas such as Atlanta, Boston and Dallas. While GDP for the region is comparatively lower than other metro areas, the region saw nearly 27% GDP growth between 2006-2011. Raleigh and Durham consistently rank at or below the national average in cost of living, housing and healthcare, and earn top spots in annual best educated cities in America lists, with almost half of residents holding a bachelor's degree or higher.[3]

Leading Growth Industries for the RTP Region

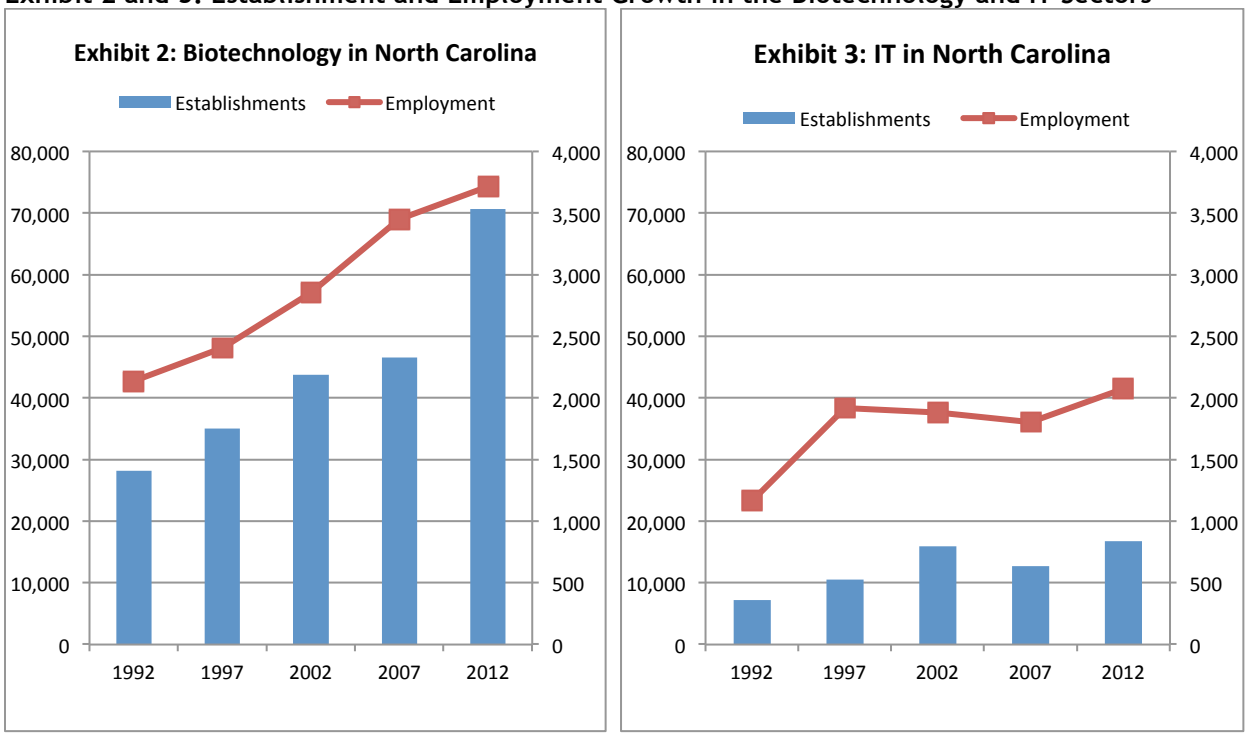
There are two primary industry sectors that have led the region's industry diversification and transformation over the past 55 years—IT and biotech. To illustrate the growth of these sectors we show state level trends for employment and establishments since 1992 in Exhibits 2 and 3.[4] Biotech

[3] Many of these statistics were compiled for the Research Triangle State of the Region, 2013, which is available on the web at http://files.www.researchtriangle.org/sor2013event/RTRP_SOR_2013_Book_for_Web.pdf. Last accessed May 12, 2014.

[4] Tabulations were done at the state level due to data non-disclosure at the county level. Biotech industries were determined using a Battelle report on biosciences prepared for the North Carolina Biotechnology Center, 2012, which is available on the web

employment has steadily increased since 1992, growing at an annual rate of 2.8%. As of 2012, biotech companies across the state employ 74,000 workers. IT employment grew at a similar pace overall; however, growth has been more intermittent. Both sectors have experienced healthy establishment growth, with the number of establishments more than doubling in each sector since 1992. In addition to these growth trends, biotech and IT pay workers above average annual wages, $83,000 and $101,000 respectively—a critical indicator of how transformative the sectors have been to the regional economy.

Exhibit 2 and 3: Establishment and Employment Growth in the Biotechnology and IT Sectors



Source: Zachary Oliver, RTI. Tabulations of BLS Quarterly Census of Employment and Wages data

Microelectronics, the precursor to IT, was a focus for the RTP region's economic developers and practitioners because of the strengths of the engineering schools at NC State and Duke Universities and the computer science department at UNC-Chapel Hill. These three university divisions also promised a steady supply of qualified workers which helped attract related companies to the region.[5] Further, IBM's R&D presence in RTP since the mid 1960's augmented the region's attractiveness for industry growth. Initially, the main strategy practitioners used to seed and grow microelectronics was to attract R&D branch plants of major companies. For example, in 1980, General Electric (GE) announced its intent to locate an $100 million R&D semi-conductor facility that would employ 500 high wage jobs in less than five years.[6] Today, the state is home to about 100,000 tech workers employed by the 700 technology companies and affiliated organizations that are members of the North Carolina Technology Association (NCTA), including about 200 technology companies operating in the Triangle region.[7]

There are two key support organizations that have helped the IT sector advance in the RTP region. First, following the GE announcement in 1980, the state government acted swiftly to create the Microelectronics Center of North Carolina (MCNC). Then Governor Jim Hunt created the center with a $1million appropriation in direct response to GE's concerns that the silicon-related research

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at http://ncbiotech.org/sites/default/files/pages/NCBiotech_2012_full_report.pdf. IT industries were determined using the enhanced cluster definitions from the U.S. Cluster Mapping Project, which is available on the web at http://clustermapping.us/resources/research-and-methodology/?art_widemode=details&art_wideid=27.

[5] Goldstein, H, Luger M. 1987. Technology in the Garden. Chapel Hill, North Carolina: University of Chapel Hill Press.

[6] Feldman, MA, Lowe, N. 2011. Restructuring for Resilience. Innovations: 6 (1): 129-146.

[7] Michelle Calton, North Carolina Technology Association, unpublished data, 2014.

infrastructure in the region was not strong enough to support the company's growth needs. MCNC was designed to support semi-conductor R&D and production. It was a single facility intended for university researchers and students to access and to foster deep connections between industry and academia. Less than a year later, MCNC received $24.4 million from the state government. Fifteen years later, in 1995, the state ceased funding for MCNC and privatized its functions.[8] Today, MCNC has contracted into a much smaller organization with a different and narrower focus. It is a non-profit entity that serves to "build, own, and operate a leading-edge broadband infrastructure for North Carolina's research, education, non-profit healthcare, and other community institutions."[9]

As microelectronics morphed into the IT sector, the North Carolina Electronics and Information Technologies Association (NCEITA) was formed in 1993, and is the second notable organization designed to support the growth of the sector, in this case as an industry-funded trade association. Then Secretary of Revenue, Betsy Y. Justus, noted the proliferation of IT companies and the growth of IBM and urged the creation of NCEITA to help coordinate supportive efforts for this critical mass of companies. AT&T, IBM and MCNC committed three years of funding for NCEITA and the organization flourished. As technology became more pervasive, NCEITA changed its name to the North Carolina Technology Association (NCTA) in 2005, and broadened its focus to be open to organizations that both develop and use technology. It supports companies, organizations and related institutions statewide through networking and informational events, advocacy, virtual networks and resources such as business to business connections and industry information and opportunities.[10]

Biotech also helped transform the region into a globally competitive economy and it followed a somewhat similar path of growth, albeit the sector has a larger presence than IT. Biotech was built from the research asset base of biomedical research at UNC-Chapel Hill and Duke Universities in addition to NC State University's agricultural science divisions.[11] Instead of industry spearheading the organization like NCEITA, but similar to the initial public support given to MCNC, the state also invested in what would remain a primarily publicly supported institution—the North Carolina Biotechnology Center. The Biotech Center was able to take cues from the earlier-established MCNC to build off its successes and mistakes. In short, the Biotech Center was designed to forge even deeper connections between government, university and industry than MCNC. It was set up to help coordinate research and serve as a liaison between the universities and private industry research, rather than to support in-house R&D functions. Its coordinating role was emphasized and enforced by a more diverse and expansive board, which helped ensure buy-in from all sectors critical to innovation: universities, government and industry.[12]

The Biotech Center changed over time. It started as a small-scale program within the state's Board of Science and Technology and was incorporated, a few years later, in 1984. Board members reflect the research disciplines at area universities that underpin the sector and other government and industry stakeholders. Today the Biotech Center provides a library with free access to high-dollar, high-value market research reports; a statewide hub of life-science commercialization ; loans and other support for new and growth companies; funds to recruit faculty conducting commercially viable research; coordination functions for academic, business, civic and policy leaders; workforce development support and curriculum development; and workshops for educators.[13] The state government is the main funder of the Center, although funding levels fluctuate. In 2010 the Biotech Center received $14 million from the state and in 2011 nearly $19 million.[14] Recently, however, state leadership has proposed to dramatically reduce funding for the Biotech Center indicating that the appetite to fund such endeavors is fading fast.

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[8] Ibid.
[9] MCNC on the web: https://www.mcnc.org. Last accessed May 12, 2014.
[10] NCTA on the web: http://www.nctechnology.org/about/default.aspx. Last Accessed May 5, 2014.
[11] Goldstein and Luger, 1987.
[12] Feldman and Lowe, 2011.
[13] NC Biotechnology Center on the web: http://www.ncbiotech.org/about-us/mission-history. Last accessed May 12, 2014.
[14] NC Biotechnology Center 2011 consolidated financial statement. On the web: http://www.ncbiotech.org/sICTes/default/files/pages/FY2011FinancialReport.pdf. Last accessed May 4, 2014.

It is unmistakable that both biotech and IT have yielded impressive economic development spillovers such as growth in jobs with higher-than-average salaries, research funding, enhanced quality for area universities, better job opportunities for university graduates, and company spin-outs. Interestingly, these industries have evolved and splintered into competitive niche sectors that were unpredictable 55 years ago such as gaming, informatics, big data, agricultural biotech, industrial enzymes, analytical instrumentation, and nanomaterials.

Reflecting on the success of this transformative industry growth, we conclude this section by distilling key points that our interviewees revealed as critical success factors that nurtured industry growth in the RTP region. While many of these are well understood,[15] others offer some fresh perspective on why the region has enjoyed long term, stable growth.

- The three research universities anchor the knowledge infrastructure critical for seeding and growing innovation-led industry sectors. Other colleges and universities augment the functions and capabilities of this research base.
- The presence of and collaboration among the triple helix—universities, government and industry—has created a deep-seated culture for institutional partners to work well with each other. As one interviewee said, "in this region you either play nice or you go home." This collaboration has also helped fuel a longstanding and evolving shared vision of the region which helps pave the way for seizing future growth opportunities.
- Stability in state policy, government, and the economy has resulted in a relatively steady upward growth trend.
- The regional leadership has embraced an "early adopter" approach over the years. They have been big thinkers, are not risk averse, and have been willing to make significant investments—and stick with them—to see their investments come into fruition and move on from the losses.
- Whether by luck or strategy, the region tends to be competitive at convergence points within industry sectors, thus setting the stage for continued growth once the 'core' industry has matured. For example, with IT, the region has strengths in hardware and software, so as the hardware aspects of the sector waned, the region was able rejuvenate growth in software applications. Today this is evolving into strengths for big data and data analytics.
- There is a critical mass of talent and a steady pipeline of university graduates to continue to feed the innovation workforce. Workers understand that there are enough companies and university positions to support multiple job changes if needed.
- Finally, many interviewees noted that the region's success is due to a strong blend of these ingredients mentioned above.

We revisit some of these success factors after we explore an emerging growth industry for the region and suggest if and how these success factors apply in a contemporary context with a different industry sector.

Cleantech: An Emerging Growth Industry?

The cleantech industry is emerging globally to meet market demands arising from the complex challenges at the nexus of exponential growth and dwindling natural resources. Kachan & Co., a cleantech consulting practice, describes cleantech as the "diverse range of products, services, and processes, all intended to provide superior performance at lower costs, while reducing or eliminating negative ecological impact, at the same time as making more efficient and responsible use of natural resources."[16] Kachan considers cleantech through a broad set of industry verticals including clean energy generation, energy storage, efficiency, transportation, air quality, material and design innovation, and water management and sustainable agriculture.

[15] See Goldstein and Luger, 1987, and Hardin in Hulsink and Dons, 2008, for example.
[16] Kachan & Co. on the web at: http://www.kachan.com/about/cleaner-technology-definition-cleantech. Last accessed May 12, 2014.

The RTP region targeted clean technologies in its five year growth plan and has built a cluster organization around this competitive strength called the Research Triangle Cleantech Cluster (RTCC). The RTCC focuses on areas of distinct competitive advantage: energy and the smart grid, transportation, and water. There is an emphasis within the cluster on the "smart" sensors, automation, information networks and data analytics that are driving the innovation within the three sub-sectors of competitive advantage.

A significant motivation for launching a cluster program was a new understanding about the concentration of firms relative to other regions in the United States and the world. The RTP region is home to several hundred companies that span the vast spectrum of the electric power industry value chain including such prominent multinationals as ABB Inc., Siemens AG, Schneider Electric SA, Itron Inc., and Sensus, which join high growth, homegrown companies like PowerSecure International and Cree, Inc. Together with major IT players, all with growing utility/smart grid practice areas, such as IBM Corp., Cisco Systems, Inc. and SAS Institute, Inc., the region is at the center of a compelling intersection of both the traditional and emerging electric power industry. North Carolina is also unique at the junctures of these sub-sectors because it is home to the largest investor-owned utility in the United States, Duke Energy. Duke's testing, approval and adoption of technology offers significant market opportunities to develop products and solutions both domestically and internationally.

To help document and further characterize the cleantech industry within the region, RTI worked for the RTCC to research additional firms, innovation assets, and potential growth opportunities in cleantech for the region. The research was completed in June 2013 and focused on three niche sectors of cleantech, as identified and named by the RTCC: smart grid; smart transportation (with an emphasis on electric vehicles); and smart water.[17] To complete this work RTI collected firm level data and then mapped these firms onto carefully designed value chains for each sub-sector.[18] This allowed for a detailed understanding about specific concentrations of firm activity within each sub-sector's value chain. Innovation analysts then reviewed market drivers and barriers of each sub-sector to augment the understanding of growth opportunities. Finally, the research summarized the related innovation and entrepreneurial assets that are positioned to nurture this sector's evolution.

The research found:

- A total of 169 unique firms with 189 locations within the Research Triangle Region. There is a mix of established and emerging firms: 16 (9%) of these firms are Fortune 500 companies; 39 (23%) of these companies have been established within the last 10 years; 24 (14%) of these firms have been established in the last 5 years.
- Firms by subsector include[19],[20]:
    - Smart grid: 96 firms (17 pure play firms)
    - Smart transportation: 47 firms (7 pure play firms)
    - Smart water: 60 firms (19 pure play)
- Over 17 centers and institutes focused on water research and policy issues; four centers and institutes relevant for EV research and development; and a minimum of 16 entrepreneurial support entities that innovators can tap for resources to help grow enterprises in these clusters.
- In smart grid there has been a 60% increase in identified firms since 2011 (59 to 96).[21]

[17] Lawrence, Watson, Casey. 2013. Characterizing Smart Transportation, Smart Water and Smart Grid in the Research Triangle Region. A summary of RTI's research is on the web at: http://files.www.researchtrianglecleantech.org/get-info/RTI_Final_Report_for_RTCC_public_version.pdf

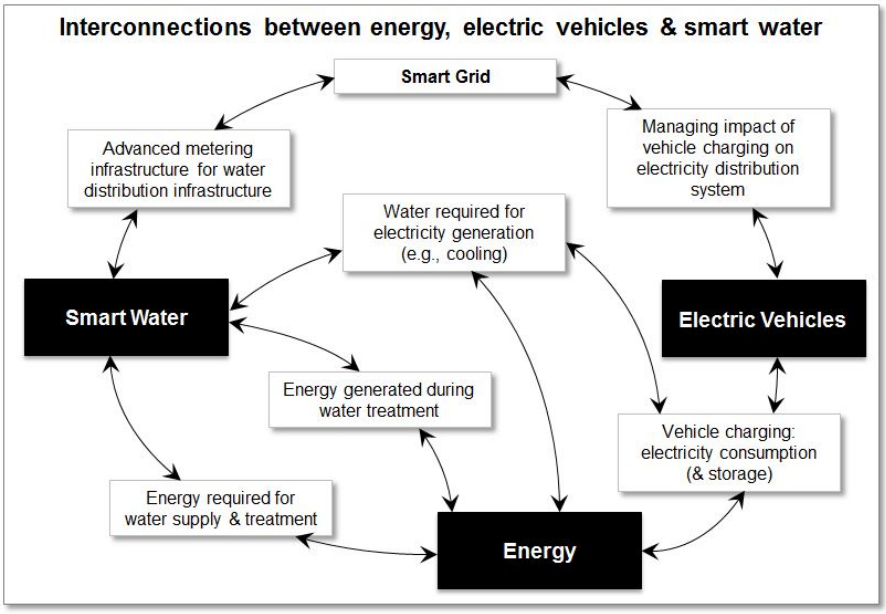
[18] Because the cleantech industry is new and cross-cutting in nature, RTI analysts used an organic "bottom-up" approach for data collection to accentuate the understanding about the specific conditions of the region. Imposing nationally driven industry taxonomies at this point in the industry characterization process may have excluded or included firms inaccurately creating "noise" in the dataset.

[19] Some firms have business lines inclusive of the three sub-sectors. Others solely produce within one sector. We refer to these as "pure play" firms.

[20] Some firms fall within multiple sectors and thus are not mutually exclusive. As a result, these figures (including the pure players) should not be totaled. This number would incorporate double counting and be inaccurate.

To advance the understanding of industry growth potential in cleantech, RTI analysts also examined the intersections within the industry. A preliminary review of these synergies is shown in Exhibit 4.

Exhibit 4. Preliminary Cleantech Industry Interconnections in the RTP Region



Source: Philip Watson, RTI

From this research, it is evident that cleantech holds promise as an emerging growth industry that can propel the RTP region's innovation-led development and continue fuel its transformation in future decades.

Supporting the Cleantech Cluster for Long-Term Growth

In contrast to the biotech and IT sectors, cleantech's support organizations have largely been "business led, business engaged and business owned" as one of our interviewees stated, clearly indicating that industry is taking the lead to ensure that a collaborative and supportive growth environment exists for cleantech businesses. Several conditions have likely led to this industry-driven support over government-led support:

- State government budgets declined during the 2007-2008 recession, and the sluggish growth since has made it difficult for government to invest in new activities. Further, in 2010 and 2012, North Carolina's political landscape changed with a switch in political party leadership across all branches of government, which ushered in new attitudes and approaches toward the state's economic development delivery system. With such significant political-economic shifts, "no one is writing large checks anymore," noted one longtime political observer.
- Cleantech's industry potential is difficult to concisely communicate to state government leaders due to cleantech's diffusive nature and longer time horizons for development as compared to industries that are easier to grasp conceptually, such as advanced manufacturing or pharmaceuticals.
- Like many emerging industries, cleantech battles perception problems. This issue was exacerbated by the billion dollar loss in 2011 for major institutional investors and the U.S.

[21] Lowe, Fan, Gereffi. 2011. Smart Grid: Core Firms in the Research Triangle Region, North Carolina. Research Triangle Cleantech Cluster. On the web: http://files.www.researchtriangle.org/resources/regional-resource-center/reports/smart-grid-core-firms-in-the-research-triangle-region-nc/Smart_Grid_Core_Firms_in_the_Research_Triangle_Region_NC.pdf. This study documented the concentration of smart grid firms that has previously been unknown to economic development practitioners.

government in the high profile failure of the solar startup Solyndra, a phenomena that was dubbed "the Solyndra effect" to mark a sudden aversion to cleantech investing.[22]

- Others counter that the confluence of market drivers propelling the cleantech sector are strong such as: declining costs; rising domestic and international venture capital; demands in emerging markets like China accelerating innovation and speed to market; and consumer adoption of a broad swath of design and user-friendly products like Google's Nest thermostats and LED lights. Moreover, "connectivity" could become the driving force for advancing the industry; wireless networks improve the efficiency of electricity generation, distribution and usage, and harness the power of the Internet to connect global innovators to one another.[23] (This is a competency in which the RTP region excels).

Even as these dynamics play out in the global market, it is important to note for how long, and how deeply, local business, industry, government and research have invested in activities related to cleantech. Below we note organizations in the ecosystem that work to bolster different segments of the cleantech and clean energy sector in North Carolina. They are:

- The North Carolina Solar Center, a 25 year old public service center in the College of Engineering at NC State University. The Center is funded by state appropriation, fee for service, and federal, state and private research grants and focuses on education, demonstration and support for clean energy technologies, practices, and policies.
- The North Carolina Sustainable Energy Association, founded in 1978, as a public policy advocacy organization with an affiliated industry trade association and political action fund focused on state-level sustainable energy policy.
- E4 Carolinas (Energy Environment Efficiency Economy), an industry trade association established in early 2012 that serves the 200 companies and 20,000 employees of energy-related firms in the 16 county Charlotte-Mecklenburg region, North Carolina.
- An array of environmental advocacy groups established in the state policy arena.

In addition, regional university research activity, much of it recently funded through federal government grants, is a strong indicator of the credibility the region has developed as an area of innovation for the energy and electronics sector. Key clean technology and energy research programs include the:

- National Science Foundation Future Renewable Electric and Energy Delivery Systems Management Center (FREEDM Center), which is working to transform the nation's electric power grid into a smart grid that will store and distribute renewable energy produced from solar panels, wind farms, and other energy sources.
- UNC Chapel Hill Energy Frontiers Research Center, which includes research teams from UNC Chapel Hill, Duke University, NC State University, NC Central University and RTI to develop molecular catalysts and light absorbers and integrate them with nanoscale architectures, generating fuels and electricity from sunlight.
- U.S. Department of Energy and industry funded Next Generation Power Electronics Manufacturing Innovation Institute, announced in 2014, which is designed to accelerate the commercialization of wide bandgap (WBG) technologies to improve the efficiency of power and larger-scale applications such as industrial motor and electricity conversion and transmission systems. The Institute will develop critical WBG power electronics technologies; encourage early commercialization; support and grow the domestic manufacturing base; and nurture the national WBG semiconductor industry through education programs and training.

[22] Chernova, Y. 31 August 2011. After Investing $1B, Solyndra's Backers Finally Lose Their Grip. WSJ online. Available from: http://blogs.wsj.com/venturecapital/2011/08/31/after-investing-1b-solyndras-backers-finally-lose-their-grip/. Last accessed May 19, 2014.
[23] Pernick, R., Wilder, C. 2012. Clean Tech Nation. New York: Harper Collins.

To capitalize on this growing research capacity and translate it into positive upstream productivity for the industry, we suggest links between the research institutions and the economic development network should be prioritized in order to enhance spinout and commercialization. The region's history is instructive, as this need is similar to what the emerging IT and biotech industries required decades ago.

Serving as the main coordinator for the cleantech industry sector in the RTP region is the RTCC. Somewhat similar in function to the Biotechnology Center and NCTA, but still early in its development, RTCC focuses on cultivating this sector's growth in the region in partnership with business, government, academic and nonprofit leaders. After a multi-year period of unfunded meetings and events, private industry approached the regional private, nonprofit economic development organization, the Research Triangle Regional Partnership (RTRP), and committed to help design and launch a collaborative effort to communicate the industry's importance to the region and drive the advancement of the industry's technology at a global scale.

The board of directors of the RTCC first met in the winter of 2012, having each committed to three years of seed capital and identified a C-suite executive as well as other employees to participate in the board and program activities respectively. They are: ABB Inc., Cisco Systems Inc., Duke Energy, Field2Base Inc., Itron Inc., Power Analytics Corp., Piedmont Natural Gas, PowerSecure International, RTI International, SAS Institute, Inc., Schneider Electric, Sensus and Siemens Smart Grid Division. The RTCC has since grown and added a membership program for industry, professional services and pre-revenue entrepreneurial companies.

It is notable that the seeds of what the RTCC would become were sown much earlier with the 1954 relocation of Westinghouse Corp.'s electric meter division from New Jersey. RTCC's Managing Director Lee Anne Nance summarizes the history of mergers, acquisitions and company spinouts in an article published on *WRAL TechWire*. In it she describes how industries with specializations in power generation, transmission, distribution and automation; net metering; and software-based energy measurement and management gained presence in the region. Companies such as Westinghouse, ABB, Elster, Sensus, Invensys, American Micro Detection Systems Inc., Telemetric, Itron, Utility Translation Systems Inc., Siemens, Allis Chalmers Manufacturing Co., Schneider Electric, and Square D were involved in either mergers, acquisitions, or spin out activities. "At the same time leading technology companies were also starting-up or locating to the region, including IBM, SAS, Cisco and EMC," Nance writes. "The marriage of hardware and software enabled technological advances in power generation, distribution and management as well as new products, processes and services… the result is a cluster that is transforming the energy industry and the way consumers live, work and play.[24]

The main activities of the RTCC are marketing and communications about regional business activity, entrepreneurship, and market intelligence. The RTCC also convenes cleantech industries and partner organizations to build a new and robust network to bolster the sector's growth. Building off the longstanding culture of collaboration in the region that was described above as a success factor, RTCC has notably brought together direct market competitors regularly to set a mutually beneficial agenda around talent and workforce development, regional reputation building, and local project development. RTCC's strategic plan and program of work outlining its initiatives is published on its website.[25]

Ideas for Fostering Cleantech's Growth

Like biotech and IT, advancing growth in cleantech will require coordinated efforts to nurture the connections, attract research and business investments, and seed new enterprises. We summarize insights from our interviews to relay ideas to help accomplish industry growth goals such as job creation, business growth, increase in state GDP, and enterprise development.

[24] Nance, L. May 30, 2013. Tomorrow's energy innovations emerging today in Research Triangle Region. WRAL TechWire. Available from: http://wraltechwire.com/tomorrow-s-energy-innovations-emerging-today-in-research-triangle-region/12497808/. Last accessed May 12, 2014.

[25] The Research Triangle Cleantech Cluster is on the web at: www.researchtrianglecleantech.org

Foremost, all of our interviewees recognized the need for support organizations to fortify the growth of cleantech. There were, however, diverging opinions about the extent to which state government should be involved. On the one hand, interviewees recognized that divisive politics at all levels of government in the U.S., and in North Carolina, makes any economic development effort supported by government subject to much greater uncertainty and funding vulnerability. Other interviewees countered that the cluster would not grow to scale if government resources were not employed. One interviewee thought it was an appropriate time for government support because the convening work already done by the RTCC and its industry partners have proven a significant industry and R&D presence in the region. "The risk is out from the state's perspective," this interviewee commented. Noting the role that the Biotech Center has had on cultivating and strengthening that industry across the state, some interviewees had strong opinions that a similar support structure should be set up for cleantech. Still others commented that instead of focusing on a specific industry, a support organization structure should be retooled to help technology and innovation intensive start-ups, agnostic of industry orientation. Finally, one interviewee did not dispute that government involvement was critical, but he was more concerned about which level of government—local, regional and state—was most important to drive this support effort. He thought local governments should have a more prominent role in identifying and cultivating emerging industry because local economic developers are more aware of new business activity "bubbling up." Regardless of which perspective interviewees agreed with, all acknowledged that government funding to support economic development is fading and emerging industries will not likely have the same level of support that biotech and IT received in decades past.

The second point interviewees stressed to enhance industry growth is the need to focus on strengths within the cross-cutting junctures of cleantech with *established* industries. Several of our interviewees observed that cleantech has much to gain from the foundation created by industries already present here. As biotech has evolved into cross-over industries like health informatics, agricultural biotech and industrial enzymes, likewise the growth drivers in cleantech depend on innovation in information technology, materials, and manufacturing. Instead of importing new industry via an industrial recruitment strategy that enhances the core of the cleantech industry, "the RTCC will be the cluster that figures out how to leverage what is already here," one interviewee noted. While biotech and IT took several decades to become established, another observer believes cleantech will rise to prominence in a much shorter time frame given the existing regional assets that cleantech can build from. Another interviewee noted that while the IT sector "chose" the RTP region for more general competitive factors, the RTCC has enabled companies to more rapidly leverage assets off each other and create new connections for innovation and growth, such as between utilities and IT companies. Thus, the suggestion is for the region to leverage the assets within the cluster, and across industries, in a more intense, proactive, and dynamic way.

Similar, but somewhat distinct from the suggestion that the region leverage innovation assets across industries, is the need to continue to strengthen the connective tissue that fosters interaction among key individuals, organizations and institutions. Some interviewees noted that the RTCC's regular convening of high-level executives in the cleantech cluster has enhanced the business and innovation networks for cleantech and increased the speed of business development. The RTCC has anecdotal feedback that introductions made through RTCC events have elevated the knowledge about clients, investors and other important relationships for business development. These kinds of observations closely align with an "axiom" put forth by Hwang and Horowitt about how to create successful innovation ecosystems like Silicon Valley. They state that healthy ecosystems rely on "people who actively bridge social distances and connect disparate parties together" thus enhancing the interconnectivity that lowers transaction costs.[26] Hwang and Horowitt suggest that practitioners strive to lay the groundwork for highly interactive networks by facilitating access among people and organizations with ideas to advance the industry. They also stress that "real life linkages are human-to-human, not group-to group" meaning that connections have to be grounded in the actual people who

[26] Hwang, VW., Greg H. 2012. The Rainforest: The Secret to Building the Next Silicon Valley. Los Altos Hills, California: Regenwald. p. 78.

do the work, not necessarily the organizational leaders.[27] Thus, continuing to build on existing mechanisms to increase the regular interaction among cleatech players will be important to nurturing the industry's growth. It is interesting to note that NCTA evolved its mission over time for similar reasons; it became increasingly important for that support organization to act as a translator, champion and home for all related IT firms and users, rather than just pure play IT firms. Serving this broader need to strengthen larger industry networks may be instructive for the RTCC and other cleantech support organizations in the future.

Lessons Learned and Conclusion

The region's legacy of collaboration is well documented and demonstrated through practice over the past five decades. Collaboration has proven to be the glue that forges vision and commitment from the university, industry and government leaders to ensure the elements are in place for industry to flourish. A relatively recent example of how collaboration can multiply outcomes is the regional industry cluster analysis spearheaded by Michael Porter's research in 2000. This study led to the regional economic development organization, RTRP, taking the lead in ongoing cluster activities, engaging hundreds of regional stakeholders in the process. In addition to knowledge creation, these efforts gave all participants a vested interest in creating outcomes that helped cement the economic development culture in the 21st century where synergy is the norm. An interviewee underscored the importance of this culture for RTP's competitiveness by stating that in this area of innovation there is constant "mixing of ingredients, not just the ingredients themselves." Over time, the social norms within the region enforce a "play nice or go home" approach to collaboration as another interviewee noted. In the past, the social norms have enforced this collaborative spirit, but some interviewees mentioned that the recent drop in funding for the economic development delivery system coupled with negative remarks from state political leaders about the delivery system's effectiveness is having a chilling effect on the confidence and culture that has often worked to the RTP region's advantage. It will be important to the region's business, university and government leadership to perpetuate the collaborative leadership despite current difficulties if industry sectors and their support organizations are to work well in the future.

A second lesson we distill from this research is that there is repeated evidence of the value in focusing on the industry "edge" not just the industry core. Interviewees said, for example, that the RTP region was well positioned from an IT industry perspective in hardware which then bridged into software development, spawning growth in niche sectors such as gaming and simulation, which were then followed by "big data" and analytics. With a core competency in informatics, the region continues to be attractive to software developers, and can attract new industries that need related capabilities like financial services and utilities. Strategizing to play to the edge matters especially for cleantech. As we have shown, cleantech is a highly diffuse and disruptive sector, reliant on large infusions of capital. Similar to what the region experienced in the evolution of IT and biotech, a caution for our region moving forward – and a lesson for others – is the value of patience to ride the waves of uncertain industry growth trajectories.

What we did not expect to find among nearly all the experts we interviewed was a common reflection that cleantech is evolving as a "converging" rather than "emerging" sector. It suggests an intriguing opportunity to spark collaboration among existing institutional actors from the other established industries to expand cluster involvement beyond the current sector-based leadership. There is also potential to hybridize the conventional "upstream" versus "downstream" approach to innovation-led development. Cleantech Cluster actors can focus on pairing the promising research from the two federally funded laboratories described above with the market-shaping leadership of the multinational industries the region already enjoys, to drive a two-pronged strategy of industry expansion and R&D related enterprise development.

We draw on other scholars for our fourth lesson. Based on their research about the evolution of the MCNC and NC Biotech Center, Feldman and Lowe relay that "the best advice for policy-makers is to

[27] Ibid. p. 207.

follow a strategy of regional improvisation, continuous adaptation, and appreciation of context…the best economic development strategy may be to become educated about an industry by following a process that is inclusive, transparent and open to criticism and debate…build consensus around a vision for an industry, and…implement that vision."[28] From our work, we suggest that policymakers also review the region's economic history to learn about what worked and what did not, as up and coming support organizations seek to derive the positive economic impacts from transformative industry growth of the past.

The RTCC is heeding some of this advice and appears to be the next viable example of this industry model the RTP region has seen emerge since the biotech and IT clusters matured. As a case in point, RTCC incorporates an "open source" strategy to membership because it regularly engages with a larger community of industry players including and aside from its primary financial investors. The experts we interviewed underscored that sound capital structures, policy support, engaged professional services and well-supported mechanisms to nurture small enterprise are valuable inputs that attract and retain larger companies—all of which is sound public policy for cultivating an area of innovation. It is richly instructive, however, to note that the assembly of top corporate players—who are director competitors in the marketplace—embrace deliberate organization and collaboration to bolster the industry cluster. Science park managers and economic developers within innovation ecosystems may find it useful to explore this model of convening firms, and allowing self-directed leadership and a shared agenda to develop organically for the benefit of industry sector growth.

In conclusion, we have learned from the experiences of the growth in IT, biotech and cleantech industries that while leaders have had a striking vision for transformative regional growth, in reality organizations and stakeholders have engaged in an iterative yet dedicated process to champion these industries over time. The evolution of this process for each industry has been somewhat similar in that there has been a concerted effort to concentrate resources around industry clusters. Today many of the dynamics have changed in terms of how champions within the industry are organizing, indicating a level of adaptability to the current political and economic context. It will be interesting to track the evolution of cleantech over time and see if and how resources to support its growth can be brought to scale. Above all, it is evident that regional industry cluster leaders should strive to maintain the active engagement of the triple helix of industry, universities and government, and the overall collaborative spirit that has helped bring so much success to the RTP region over the last 55 years.

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[28] Feldman and Lowe. 2011. p. 145.