Vision 2025

Advancing South Carolina's Capacity and Expertise in Science and Technology

Executive Summary

Significant strides have been made in the growth and advancement of South Carolina's knowledge-base over the last decade, but more must be done to build an expanded economic base in this state. The South Carolina Science and Technology Task Force (S&T Task Force) cited four general areas for advancement of South Carolina's economy into more technology-driven areas: promotion of research and development, growth of the health, science and technology workforce, enhancement of education and outreach, and stimulation of economic development. While specific recommendations were made for each of these areas, overall success to achieve the goals will require an integrated approach to research, education, and business.

To promote research and development, South Carolina's university and college educational programs and research missions need to be aligned with the needs of technology-intensive industries within the state and globally. Programs such as SmartState™ as well as multi-disciplinary research centers are proving to be successful models, but the state needs to continue to invest and support such initiatives. Programs and organizations that foster an innovative and collaborative environment within all educational levels as well as within the greater communities, such as Innovista at the University of South Carolina which was designed to foster an entrepreneurial environment in a vibrant, mixed-use urban neighborhood in Columbia, are also essential to promote research and development. Growth of a health, science and technology workforce requires an educated and

SmartState™ as well as multi-disciplinary research centers are proving to be successful models, but the state needs to continue to invest and support such initiatives.

engaged public that participates in the South Carolina research enterprise. Increasing the state's human resource infrastructure by educating, graduating, and training more students in STEM disciplines, as well as growing the STEM workforce, particularly in industry focus areas where South Carolina can participate as a domestic and global leader, are keys to growth. South Carolina has excelled in the development of new products and processes to maintain and advance the state's global competitiveness, particularly in the areas of advanced manufacturing, advanced materials, digital technologies, and transportation, distribution, and logistics. With over a 30% minority population that is underpresented in STEM fields, it is critical to encourage and promote their training and advancement. By establishing lines-of-sight to introduce students and parents to STEM career opportunities, by encouraging a STEM education

In 2002, South Carolina ranked 33rd in the country for the number of business start-ups per 100,000 people. By emphasizing innovation and entrepreneurship at the university level and aligning university research with the needs of industry, the state improved its ranking to 4th nationally in 2008.

through public and private sector programs, such as the Governor's School for Science and Mathematics (GSSM) and Clemson University's Math Out of the Box™ and Driving Science™ programs, and by increasing access to training opportunities, the state can enhance its education and outreach, which in turn fosters growth of a technology-savvy workforce that is more representative of the state's demographics. Creating a business environment in South Carolina that is attractive to both technology-intensive companies and talented technology-competent workers is critical to stimulate economic development. Up until 1997, South Carolina had not succeeded in converting its public or private sector R&D investments into economic development assets. South Carolina universities were conducting the vast majority of licensing and patenting activity with firms located out of the state. Though the federal Small Business Innovation Research program (SBIR) had helped 15 or more South Carolina businesses start or expand their operations since 1994, South Carolina was still ranked among the least effective states in attracting SBIR funds.[1] In 2002, South Carolina ranked 33rd in the country for the number of business start-ups per 100,000 people, but through concerted efforts to emphasize innovation and entrepreneurship at the university level as well as greater alignment between the research initiatives at the state's universities and the needs of industry, the state has improved its ranking to 4th nationally in 2008. [2]

The strategies to achieve the goals for 2025 will require vision and leadership from many individuals within the state's businesses, universities, and state

government. Implementing these strategies will require the development of new collaborations for the state's economic good. Clearly, the private and public sectors must expand their partnerships and continue working together to invest in and build the strong knowledge-based economy. To accomplish this, the following goals and recommendations have been outlined below.

Research & Development

South Carolina university and college educational programs and research missions are aligned with the needs of technology-intensive industries within the state and globally.

- Develop multi-disciplinary research centers to address complex problems and opportunities that are unique to South Carolina that are nationally and globally competitive.
- Expand the SmartState™ and Endowed Chairs programs at South Carolina's Comprehensive Research Universities to further promote a critical mass of faculty expertise in key areas of research and innovation.
- Create a culture-rich environment of innovation and entrepreneurship at academic institutions at all levels (K-12, undergraduate, graduate, postdoctoral, and faculty) as well as within communities.

Health, Science, and Technology Workforce

South Carolina has an educated and engaged public that understands and participates in the state's health, science and technology research enterprise.

- Capitalize and grow existing strengths in industry focus areas by 10% (transportation, energy, life sciences and agriculture, and environment and sustainability) to promote research through collaborations between South Carolina's comprehensive research universities and colleges, technical colleges, and industry partners.
- Expand the human resource infrastructure (e.g. students with Ph.D., M.S .and B.A./B.S. degrees) in STEM by 25% at South Carolina research universities and other educational units. The South Carolina STEM workforce will be representative of the state's population demographic.
- Expand cooperative training programs through the South Carolina Technical College System to prepare the workforce needed by STEM-based industries.

Education and Outreach

Individuals having a STEM education from South Carolina are nationally and globally competitive in the health, science, and technology workforce.

- Promote science, technology, engineering, and mathematics education and literacy in K-12 education via public and private sector programs.
- Increase access to higher education and training opportunities in science and technology for all South Carolina citizens regardless of gender, race, or socioeconomic status.
- Establish lines-of-sight to introduce students and parents to STEM career opportunities and integrate STEM needs into South Carolina's educational system through increased involvement of private-sector industries.

Economic Development

The business environment in South Carolina is attractive to both technology-intensive companies and talented technology-competent workers.

- Establish the culture and environment to promote the development of intellectual property and its commercialization by research universities.
- Increase the level of business education for students pursuing a degree in STEM fields.
- Increase scale-up opportunities for high-tech start-up companies.

[1]"Creating South Carolina's Future Through Technology: Strategies for Developing a Knowledge-Based Economy," South Carolina Technology Advisory Council, December 1997.

[2]Milken Institute, State Technology and Science Index, 2011.

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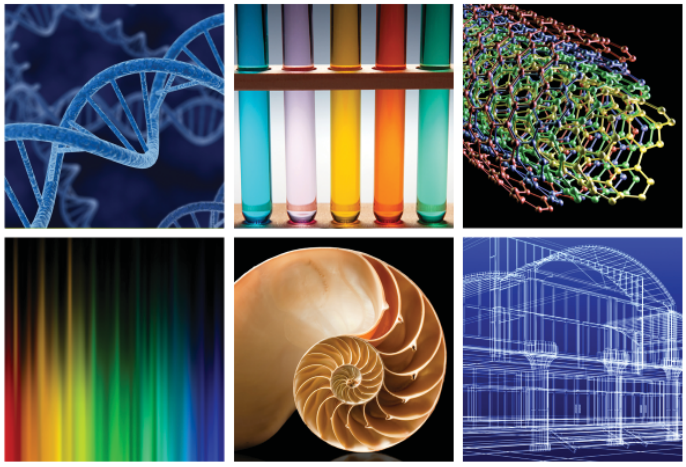
Introduction

In March 1997, Governor David M. Beasley established the 17-member South Carolina Technology Advisory Council to prepare a technology strategy, monitor results, and provide continuing guidance on technology issues for the Governor and the Secretary of Commerce. In December 1997, the Technology Advisory Council developed a plan detailing the state's economic future and knowledge-based economy. The plan entitled Strategies for Developing a Knowledge-Based Economy provided a framework for making science, technology, engineering, and mathematics (STEM) research a driving force for pursuit of higher education, developing new and enhancing existing high-technology businesses, and creating jobs.

The Council recognized that to significantly expand the South Carolina economy into more technology-driven areas, four major strategies would need to be undertaken. Technology-intensive companies from outside South Carolina had cited that the quality of education and the availability of a technology-capable workforce were inhibitors to selecting South Carolina as a site for their new facilities. Preparing a technology-capable workforce was essential and would require comprehensive improvements to the K-12 system as well as increased support for college and university educational programs and technical colleges to be aligned with the needs of technology-intensive industries. A business environment that was friendly to technology-intensive companies would be critical to attract and grow highly-skilled, knowledge workers. Improvements to the quality of government services available to technology-intensive industries and the enhancement and sustainment of a world-class telecommunications infrastructure were identified as key in forming public/private partnerships. The Council's third strategy to invest and expand the base of rapidly growing companies and start-up businesses was identified as advantageous for



Increased emphasis on the science, technology, engineering and math (STEM) disciplines in K-12 education will increase college attendance, enhance high-tech businesses and create good jobs in the state.

A technology-capable workforce requires comprehensive improvements to the K-12 system and increased alignment of college curricula with the needs of technology-based industries.

several reasons, including in the recruitment of established technology-based businesses to demonstrate the level of innovation taking place in the region. World-class university research programs directly linked to South Carolina industry was the fourth major strategy outlined to propel South Carolina in making significant strides in its knowledge-based economy.

Many inroads have been made in addressing the specific goals and recommendations outlined by the South Carolina Technology Advisory Council in its 1997 plan. Beginning in 2001, the South Carolina State Legislature passed key measures to start the state on a course towards significantly growing the knowledge economy. Core legislation that was aimed at building the science and technology enterprise in South Carolina included the Research Infrastructure Bond Act of 2004, which provided approximately $220 million in research infrastructure funds for the three research universities; the Innovation Centers Act of 2005, which established three Research Innovation Centers in South Carolina, one associated with each research university; and the Industry Partners Act of 2006, which provides revenue to be used by the South Carolina Research Authority (SCRA) and the state's research universities to commercialize university research discoveries.

In addition to enabling legislation, South Carolina boasts a lower cost of living and an attractive economic climate for businesses, which leads to higher level of job creation and, in turn, greater migration to the area. South Carolina's tax climate has been particularly favorable for mature, labor-intensive manufacturing firms. With one of the lowest tax rates in the country (9th according to the 2010 Tax Foundation State Rankings), one of the southeast's lowest priced industrial electricity rates, one of the top ten states in the U.S. for lowest labor cost, the third lowest unionization rate in

the U.S., location of the deepwater port at Charleston, and its efficient rail and interstate systems, the state makes a compelling case for businesses considering expansion or relocation. In addition to recruiting BMW to South Carolina in 1991, some of the most significant and enviable projects in the South have been won by South Carolina over the last couple of years, including, Amazon, Boeing, Bridgestone, ZF Group, First Quality Tissue, Continental Tire, TD Bank and BMW's $900 million expansion announcement in January 2012. These seven projects alone will create about 11,000 jobs. With the thousands of additional jobs Boeing created after beginning production of the 787 in North Charleston in late 2010, efforts through the South Carolina Department of Commerce and others in the state have greatly impacted the economic development and long-term sustainable growth in the state.[1]

Since 1997, South Carolina has excelled in the development of new products and processes to maintain and advance the state's global competitiveness, particularly in the areas of advanced manufacturing, advanced materials, digital technologies, and transportation, distribution and logistics. These core competencies pervade many of South Carolina's dominant industries. In addition, numerous programs and organizations have come into being over the last decade or more in South Carolina to facilitate the formation and growth of small business. Several communities, colleges, and universities have established offices to assist in the commercialization of technology and the development of high-growth potential firms. But even with these successes, it was realized that more needs to be done to advance South Carolina's global competitiveness.

In March 2011, the Vice President for Research at the University of South Carolina, who served as Principal Investigator on the EPSCoR award from the National Science Foundation, was asked to work with various institutional and state leaders to develop a State Science and Technology Plan so that the National Science Foundation could assess the direction of the EPSCoR program in light of the overall statewide S&T initiatives. To that end, the Vice Presidents for Research from South Carolina's three research universities (the University of South Carolina, Clemson University, and the Medical University of South Carolina), the Chief Executive Officer of SCRA, and representatives from industry and government formed the South Carolina Science and Technology Task Force (S&T Task Force). This group assembled in an effort to revitalize the focus on strategic planning within the science and technology community within the state. Throughout the year and into 2012, the S&T Task Force met to identify partners and invite new Task Force members that represented the state's science and technology constituencies. Strategic plans were collected from stakeholders, and themes were identified for connecting the missions of the various groups. In July 2012, the S&T Task Force collaborated to formally evaluate the State's progress and develop a plan to expand South Carolina's knowledge-based economy. The Task Force identified a clear mission and purpose for the state science and technology plan, and a careful analysis of the strengths, weaknesses, opportunities and threats was conducted. The Task Force also identified the areas of improvement and development since the South Carolina Technology Advisory Council put forth their strategic plan for science and technology in 1997. This effort has culminated in this document that both unites the goals and missions of all the state's science and technology stakeholders, and sets a course to grow the science and technology enterprise through 2025.

"The new jobs which are being created require strong minds, diversity of thought, and an ability to continue learning and embracing ever-changing technologies."

Pamela P. Lackey, President of AT&T-South Carolina

This document highlights both the significant strides made in the growth and advancement of South Carolina's knowledge-base over the last decade as well as the major strategies looking forward for building an expanded economic base in our state. The Vision set for South Carolina by the S&T Task Force is that by 2025, the state will have advanced the capacity and expertise in science, technology, engineering and mathematics to ensure current and future economic growth in a global context, to sustain a high quality of life, and to provide increased opportunities for all of its citizens. The goals and recommendations presented here provide an outline for focusing the state's science and technology enterprise on a common purpose to ultimately realize this vision.

Through the efforts of many in the public, private, and nonprofit sectors working together, South Carolina has many of the pieces in place for long-term sustainable economic growth. However, the state must continue to emphasize the importance of education at the elementary, high school, community and technical college and university levels, as well as within the existing workforce.

[1]Randle, Mike, "South Carolina weighs in with some huge job and investment-generating projects" April 19, 2012, Retrieved from http://www.postandcourier.com/article/20120706/PC1002/120709523/1021/sc-economic-development-efforts-are-riding-a-wave-of-success.

Research and Development

Goal:

South Carolina university and college educational programs and research missions are aligned with the needs of technology-intensive industries within the state and globally.

Recommendation:

Develop multi-disciplinary research centers to address complex problems and opportunities that are unique to South Carolina that are nationally and globally competitive.

In a 2006 article in the journal *Academic Medicine*[1], a qualitative study suggested that centers offer many benefits to academic institutions and that the old model of a single investigator had waned while a model of collaboration and cross-disciplinary research had emerged. The study cited the benefits as aiding in faculty recruitment, facilitating research collaboration, increasing competitiveness for research resources and building a sense of community to promote continued learning. South Carolina has long had university research centers; but in the past decade, through collaboration among government, academia and industry, the state has begun to create enhanced mechanisms for building and developing centers to solve unique economic and research challenges.

In 2002, the South Carolina General Assembly had the vision to establish the SmartState™ Program, funding it with proceeds from the South Carolina Education Lottery. The legislation authorizes the state's three public research institutions—Clemson University, the Medical University of South Carolina and the University of South Carolina—to use state lottery funds to create Centers of Economic Excellence in research areas that will advance South Carolina's economy. Each Center is awarded up to $5 million in state lottery funds, which must be matched on a dollar-for-dollar basis with funds from single or multiple non-state partners (corporations or other entities).

state and industry support that each center garners have helped focus academic research into the areas critical to the state's economic development. The centers have helped form important collaborations between academia and industry through innovative applied scientific research.

South Carolina has several Centers of Biomedical Research Excellence (COBRE) that are established by the universities and supported by a combination of federal and university resources. These COBREs are thematic multidisciplinary centers that augment and strengthen institutional biomedical research capacity.

SmartState™ Centers of Economic Excellence

CLEMSON UNIVERSITY

Advanced Fiber-based Materials
CU-ICAR Automotive Design and Development
CU-ICAR Automotive Manufacturing
CU-ICAR Automotive Systems Integration
CU-ICAR Vehicle Electronic Systems Integration
CyberInstitute
Health Facilities Design and Testing (with MUSC)
Optical Materials
Optoelectronics
Supply Chain Optimization and Logistics
Sustainable Development
Urban Ecology and Restoration

MUSC MEDICAL UNIVERSITY of SOUTH CAROLINA

Advanced Tissue Biofabrication (with Clemson, USC)
Cancer Disparities (with USC, SC State University)
Cancer Drug Discovery (with USC)
Cancer Stem Cell Biology and Therapy (with Clemson)
Clinical Effectiveness and Patient Safety (with Clemson, USC)
Gastrointestinal Cancer Diagnostics
Inflammation and Fibrosis Research
Lipidomics, Pathobiology and Therapy
Marine Genomics (with College of Charleston, USC)
Medication Safety and Efficacy (with USC)
Molecular Proteomics in Cardiovascular Disease and Prevention
Neuroscience
Proteomics
Regenerative Medicine (with Clemson, USC)
Renal Disease Biomarkers
Stroke (with USC)
Tobacco-Related Malignancies
Translational Cancer Therapeutics (with USC)
Vision Science (with USC)

UNIVERSITY OF SOUTH CAROLINA

Brain Imaging (with MUSC)
Childhood Neurotherapeutics (with MUSC)
Data Analysis, Simulation, Imaging, and Visualization
Experimental Nanoscale Physics
General Atomics
Health Care Quality (with Clemson, MUSC)
Hydrogen and Fuel Cell Economy
Nanoenvironmental Research and Risk Assessment
Nuclear Science and Energy
Polymer Nanocomposites Research
Renewable Fuel Cells
Rehabilitation and Reconstruction Sciences
SeniorSMART™ (with Clemson)
Solid Oxide Fuel Cells
Strategic Approaches to the Generation of Electricity
Technology Center to Advance Healthful Lifestyles (with MUSC)
Tourism and Economic Development (with Coastal Carolina University)

Today there are 50 SmartState™ Centers in six industry-focused Smart Clusters that are critical to the world and South Carolina: Advanced Materials & Nanotechnology, Automotive and Transportation, Biomedical, Future Fuels®, Information Science, and Pharmaceutical. The

This is accomplished by expanding and developing biomedical faculty research capability and enhancing research infrastructure, including the establishment of core facilities needed to carry out the objectives of a multidisciplinary, collaborative program. Currently,

there are six COBREs within South Carolina that perform research in areas of particular interest to the state's population, including: oral health, lipidomics, cardiovascular disease, colon cancer, biomaterials, and inflammation. A 2008 evaluation of the nationwide COBRE program cited the effectiveness of the center model in strengthening the research infrastructure of the universities and the development of junior academic faculty into more productive researchers.

In addition to COBRE, the South Carolina IDeA Networks of Biomedical Excellence (SC INBRE) program has expanded biomedical research within the state. The three comprehensive research universities serve as mentors to seven predominantly undergraduate institutions, including two HBCUs. The target faculty in the INBRE network receive resources to support their research activities, ongoing training and opportunities for career advancement. Additionally, the SC INBRE program is committed to ensuring that all students, including those from underrepresented and disadvantaged groups, receive hands-on training and research opportunities. The program is rapidly expanding and the faculty are making notable contributions to our state's biomedical research capacity. In the 2011-2012 academic school year, over 100 students were trained, and the target faculty published over 50 articles and presented their research around the world.

Similar to the COBRE and INBRE programs, MUSC houses the South Carolina Clinical and Translational Research Institute (SCTR), which also receives support from the National Institutes of Health. This biomedical research focused center is designed to improve health outcomes and the quality of life for South Carolinians by translating scientific research into clinical practice. The Centers for Disease Control and Prevention rank South Carolina first in deaths from cerebrovascular disease and in the top 20 for age-adjusted death rates attributable to HIV, Alzheimer's disease, cancer, heart disease, kidney disease, accidents and violent crime. More than 25% of the population of South Carolina is obese or overweight, and more than 22% are smokers.[2] SCTR facilitates cross-disciplinary research and expertise and resource coordination to solve the state's challenges by bringing together researchers and clinicians with unique and complimentary perspectives.

At the University of South Carolina, the Institute for Partnerships to Eliminate Health Disparities has received funding from NIH and other agencies to pursue research, education, and state-wide community engagement to address health disparities. One of the major programs includes the statewide Prostate Cancer Disparities Center of Economic Excellence (CoEE). The state ranks third in the number of men who die from prostate cancer. The CoEE provides education, screenings and offers programs on proper nutrition. In addition to the CoEE, the Institute has also implemented research studies on cervical cancer and HIV/AIDS.

In 2005 the Innovation Centers Act was passed by the South Carolina Legislature. It charged SCRA with the establishment of Research Innovation Centers located throughout the state and in partnership with each of South Carolina's three research universities: the SCRA USC Innovation Center in Columbia, the SCRA MUSC Innovation Center in Charleston and the Duke Energy Innovation Center, a partnership with Clemson University, in Anderson.

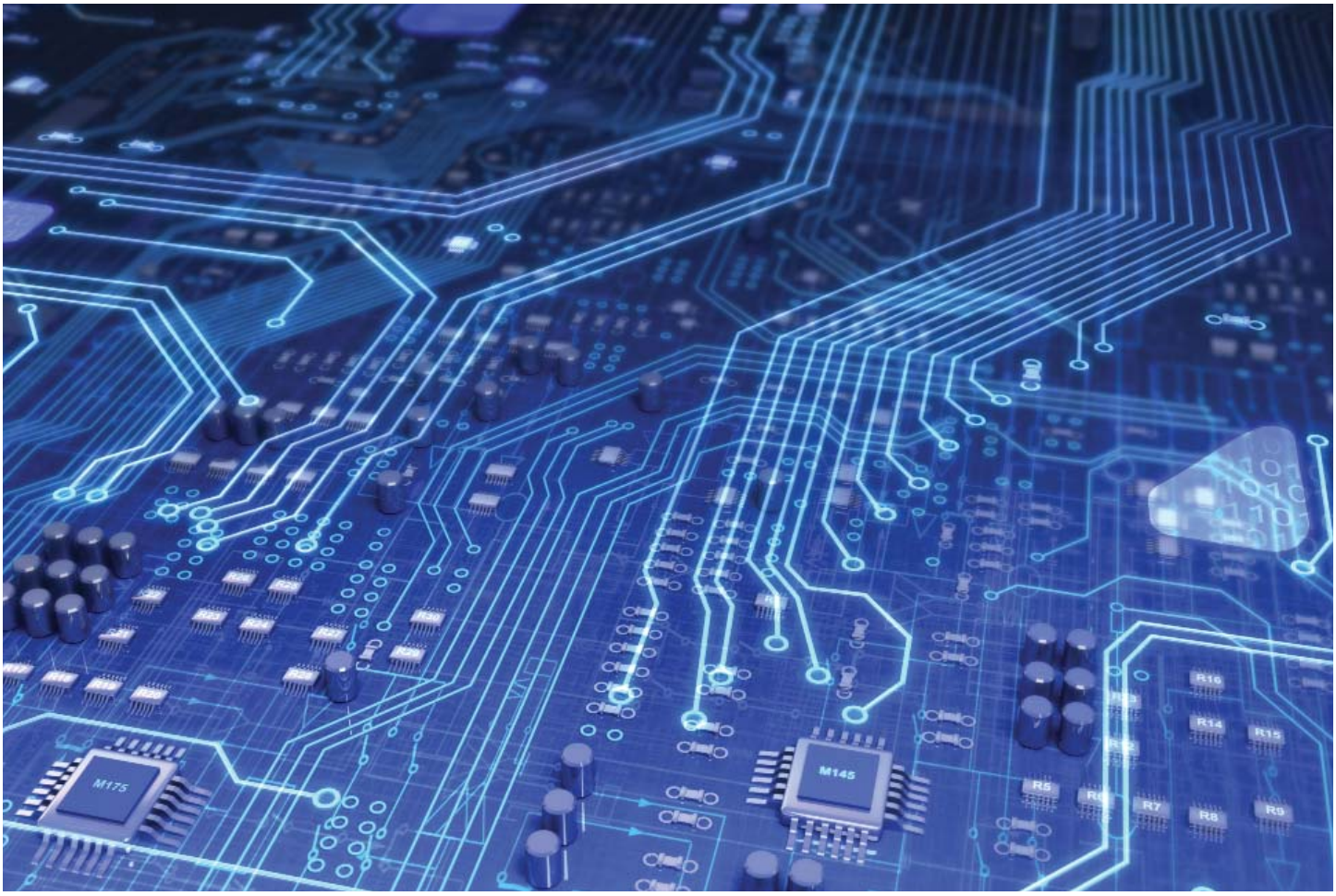
The Duke Energy Innovation Center offers space designed for wet/dry labs or offices to support advanced materials research in close proximity to Clemson's adjacent world-class Advanced Materials Research Laboratory (AMRL), as well as Clemson's high performance computing center.

The SCRA MUSC Innovation Center is a state-of-the-art research and business facility with 11 advanced wet labs and shared equipment designed to support sophisticated requirements of bioscience corporations. Innovations being commercialized at the SCRA MUSC Innovation Center include novel human antibodies by CharlestonPharma, LLC.

The SCRA USC Innovation Center is designed to accommodate business offices and clean next-generation manufacturing operations by offering fully customizable open space. Currently, the SCRA USC Innovation Center houses Immedion, a growing data storage and management provider, as well as Nitek, Inc, a pioneer in deep ultraviolet-LED lamp technology.

The SCRA Innovation Centers work in conjunction with university-led economic development facilities throughout the state to serve as incubators for small businesses, especially university spin-offs. The Innovation Centers accelerate business development and commercialization of research discoveries. Wet labs and world-class manufacturing facilities are essential to establishing new knowledge-based companies and attracting landing parties. Clemson University has established research and economic development campuses to provide a rich environment where faculty, staff and graduate students can interact with researchers from industry. These campuses include the International Center for Automotive Research (CU-ICAR) in Greenville, the Advanced Materials Research Laboratory in Anderson, the Restoration Institute in Charleston and the Biomedical Engineering Innovation Campus (CUBEInC) in Greenville. Similarly, the University of South Carolina has created Innovista to spur commercialization of university-originated innovation by establishing facilities for technology-intensive companies. Innovista is designed to foster an entrepreneurial environment within a vibrant, mixed-use urban neighborhood in Columbia.

The existing SmartState centers, COBREs, SC INBRE, SCTR, and the SCRA Innovation Centers are proving to be a successful model to spur economic development and solving problems unique to South Carolina, but to keep pace, the state must continue to support the formation of research centers. These centers attract top-level researchers to the state, and serve as hubs for communication and innovation.



[1]Mallon, W., "The Benefits and Challenges of Research Centers and Institutes in Academic Medicine: Findings from Six Universities and Their Medical Schools," Academic Medicine. June 2006, 19-29.

[2]South Carolina Clinical and Translations Research Institute, Retrieved from www.sctr.musc.edu.

Recommendation:

Expand the SmartState™ and Endowed Chairs programs to further promote a critical mass of faculty expertise in key areas of research and innovation.

In 2001, the South Carolina State Legislature passed key measures to start the state on a course toward significantly growing the knowledge economy. One significant piece of core legislation that was aimed at building the science and technology enterprise in South Carolina was The South Carolina Research Centers of Economic Excellence (CoEE) Act, established in 2002, that authorized the state's three public research institutions - Clemson University, the Medical University of South Carolina and the University of South Carolina to use $200 million appropriated from the South Carolina Education Lottery to advance targeted research areas.

The core activity of each CoEE, now known as SmartState™ Centers, is the appointment of world-renowned scientists and engineers known as Endowed Chairs, who lead the Centers and are supported by groups of senior faculty members and research teams that include junior faculty and graduate students. To date, there have been 49 endowed chairs appointed out of 86 across the state's three research universities, recruited from many of the nation's top institutions such as Harvard and Duke. Each SmartState™ Center includes one or more endowed chairs, research infrastructure, technical staff, and sustainable funding sources. Centers must be supported by affiliated graduate programs that create opportunities for students and faculty. South Carolina's SmartState™ Program has been a true catalyst for economic development. In its first ten years, the Program created nearly 7,000 jobs in South Carolina. The average salary of those jobs was $63,000—more than twice the 2009 per capita income in the state. The SmartState™ Program has attracted more than $1.2 billion in non-state investment and has assembled a cadre of corporate partners, including BMW, Fluor, Michelin, Westinghouse, and SCANA. SmartState™ Endowed Chairs have also secured hundreds of millions of dollars in federal funding from the National Science Foundation, the National Institutes of Health, and the Department of Defense.

In 2010, a number of new companies announced relocations to South Carolina, including automotive companies Sage and CT&T in the Upstate. Fuel cell company Trulite announced plans to relocate to Columbia to be near the automotive research of USC's Future Fuels® Centers. Electric bus manufacturer Proterra has located its corporate headquarters and manufacturing plant near the Clemson University International Center for Automotive Research (CU-ICAR) in the Upstate. In June 2011, Proterra had 35 employees; a year later it had more than 130 employees and the goal of building 1,500 "green" buses a year in South Carolina. Timken

The Clemson University International Center for Automotive Research (CU-ICAR)

represents a template for public/private partnership, directly fueling a knowledge base critical to the automotive industry. However, success did not come overnight, nor without challenges or change from the original vision that Clemson saw for this Center. Clemson had originally explored the idea of building a wind tunnel for the auto racing industry and approached BMW to see if they were interested. They were not as they already had this function in Germany. "However, BMW was interested in helping build a local, knowledge-based workforce that could feed into its global operations and support the growing automotive cluster in South Carolina. They needed a level of engineering talent that was not currently being offered by any program in the U.S.," said Bob Geolas, Executive Director of ICAR.

Clemson re-evaluated its priorities, and with the help of a $10 million investment from BMW, matched by $10 million in SC Centers of Economic Excellence (CoEE) funds, established its graduate automotive research center. With support from Michelin and Timken, Clemson subsequently added two more CU-ICAR CoEE Endowed Chairs. Timken and Michelin also located additional R&D facilities on the campus. Other industry partners included American Titanium Works, AT&T, JTEKT Group, Proterra, and SAE. The evolution of the original plan to what ICAR has become speaks directly to Clemson's willingness to adapt to meet the needs of industry and economic development.

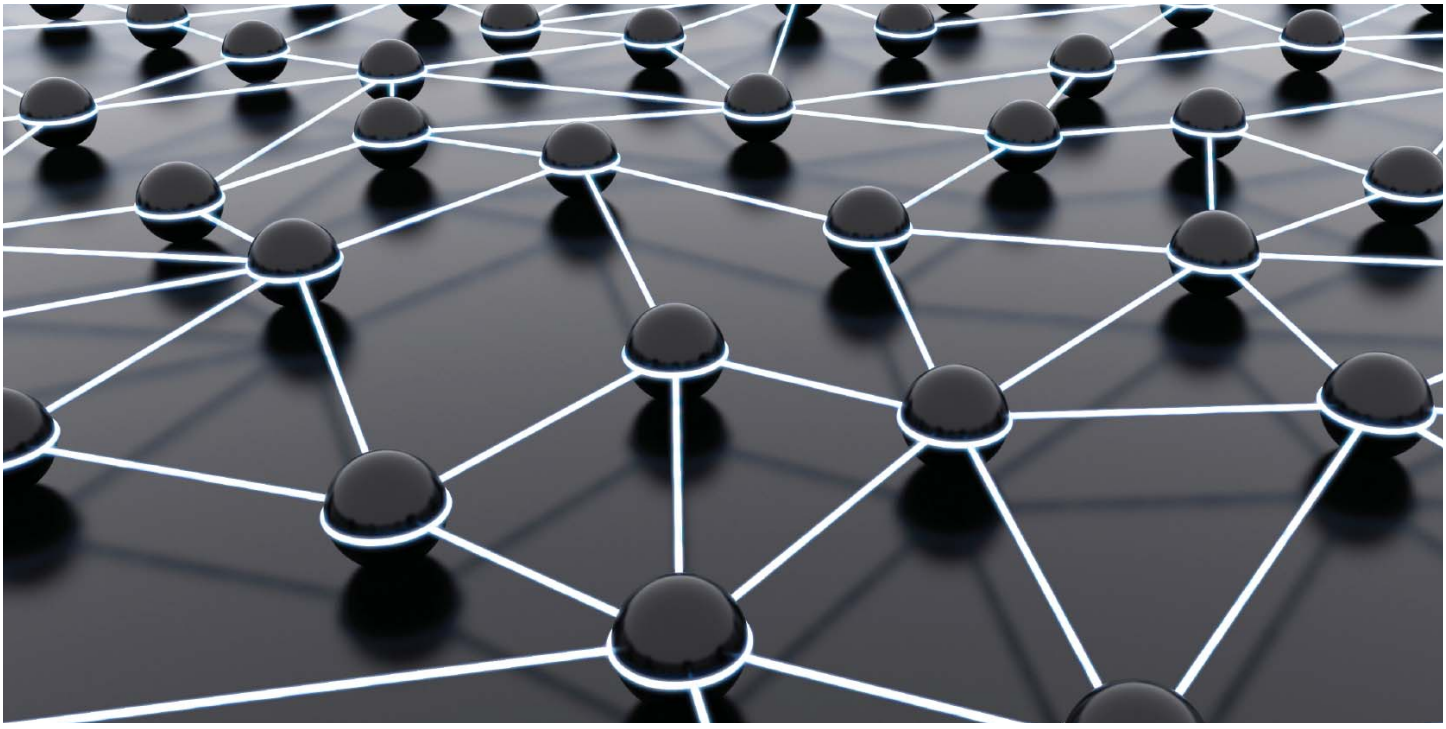
The 250-acre CU-ICAR campus is located in Greenville, S.C, midway between Charlotte, NC and Atlanta, GA on the Interstate 85 corridor. As of 2011, CU-ICAR had generated nearly $250 million in investments, with another $500 million in development. With more than 2,300 new high-wage jobs, CU-ICAR is a model of the collaborative spirit of academia, government, industry and economic development.

and BMW have located corporate research and development offices on the CU-ICAR campus that have together created 500 high-paying jobs.[1]

The SmartState™ Program is building South Carolina's competitive position in emerging high-growth industries. These sectors include aerospace and aviation, automotive engineering, health sciences, life sciences, nanotechnology, advanced materials, supply chain optimization and logistics, fuel cells, and molecular nutrition. Ken Reifsnider, an endowed SmartState™ chair at USC in Solid Oxide Fuel Cells and one of the world's foremost experts on composite materials, is working to develop a new lightning strike facility for aerospace applications in collaboration with Boeing, expected to be completed later in 2012.

More than half of funds committed to SmartState™ have been in the medical fields, followed by energy (10%), automotive (8%) and materials research (8%).[2] Marc Chimowitz, MBChB, Medical University of South Carolina (MUSC) Neurosciences professor and SmartState™ endowed chair, led a 50-center nationwide clinical trial whose results provided evidence that aggressive medical therapy is safer and more effective than placing a stent in the brain to prevent a second stroke in high-risk patients with a narrowed brain artery. These significant results, of particular importance to The National Institute of Neurological Disorders and Stroke (NINDS), part of the National Institutes of Health (NIH) which funded the trial, were published in the New England Journal of Medicine in 2011.[3] When the health sciences component of the program is fully funded and in place, as many as 40 world-class scientists will be working in South Carolina. The economic impact could range from hundreds of millions to billions of dollars in new products and jobs.

While the SmartState™ program has fostered unique collaborations among the state's research universities and has allowed South Carolina to compete in the high-tech knowledge-based global economy, expansion of the program to both maintain and advance South Carolina's position will require several elements. Restoration of state funding, including as much of the $30 million as possible, as originally prescribed, will be necessary. There needs to be a sense of urgency among the stakeholders to continue to build upon the state's established technology foothold, as well as closer alignment of the state's research universities with industry and economic development groups, including the South Carolina Department of Commerce. The current structure of the SmartState™ program requires flexibility, including consideration of industry-specific chairs and/or visiting chairs. Investment in the young talent at the universities that the endowed chairs attract as well connecting to K-12 students to retain them in the state for higher education and careers is also necessary.



[1]SmartState™, Retrieved from www.smartstatesc.org.

[2] Clayton, David, The State of the Innovation Economy in SC, April 2012.

[3]Chimowitz, M. et al, N Engl J Med 2011; 365:2140-2141.

Recommendation:

Create a culture-rich environment of innovation and entrepreneurship at academic institutions at all levels (K-12, undergraduate, graduate, postdoctoral, and faculty) as well as within communities.

Research has suggested that there is a link between education and venture creation and entrepreneurial performance. In addition, there is a direct correlation between high levels of entrepreneurship with individuals that have at least some college education.[1] As the foundation for the future of innovation in South Carolina, K-12 education, the system of predominately undergraduate and technical colleges and the state's three research universities play a vital role in developing the innovators of tomorrow. A skilled workforce educated in the sciences, technology, engineering and mathematics (STEM) disciplines is critical for building innovative products, services, and firms. Workers currently employed in STEM and related fields have the greatest propensity for starting entrepreneurial businesses with high growth potential, in fields ranging from information technology and electronics to pharmaceuticals and medical technology. STEM professionals are also the engines of innovation for existing firms where they develop new products and processes to fuel business growth.

According to the Higher Education Study Committee, "Essential to South Carolina's future prosperity is developing a culture of creativity that attracts, develops, and retains the most talented people in the world who not only adapt to change, but lead it."[2] There are programs and organizations that exist in South Carolina that foster an innovative environment within all educational levels as well as within the greater communities. Continued emphasis on these programs as well as initiatives that promote collaboration and partnerships between public and independent institutions of higher education, the K-12 community, the business community, and state government leadership is required to advance South Carolina's knowledge economy.

Innovation drives today's economy and a significant amount of innovation in this state stems from knowledge creation at South Carolina's research universities. It has been recognized for decades that technology transfer, defined as the transfer of research results from universities to the commercial marketplace for the public benefit, is closely linked to fundamental research activities in universities.[3] Investments in the SmartState™ program, establishment of SCLaunch™ and the SCRA Innovation Centers, and other efforts directed at promoting research, innovation, collaboration, and entrepreneurship have allowed South Carolina to not only strengthen its existing base of activity but also has resulted in job creation and workforce development. Both Clemson University's International Center for Automotive Research (CU-ICAR) and the University of South Carolina's NanoCenter represent model examples of partnerships linking both public and private entities that have the common mission to advance innovations. The USC NanoCenter represents the cooperation between university faculty with their multidisciplinary research strengths in nanotechnology, industrial partners such as Mitsubishi, Milliken, Michelin, Honeywell, Invista (formerly of DuPont), Wellman, Nan Ya Plastics, MeadWestvaco, and LAB21, Inc., and collaborative

Importance of Cyberinfrastructure in South Carolina

As society's reliance on information grows, especially in a knowledge-based economy, it will be necessary to have a computing infrastructure that can sustain a large amount of data being shared quickly across a large geographical area. South Carolina has made important advances in the development of this cyberinfrastructure by connecting institutions of higher education and hospital systems, and developing new methods of communication and research development. Continued effort must be placed on training the state's workforce of today and tomorrow in the necessary skills that a digital world will require. Students should be introduced to digital technology and the use of electronic information as early as possible in their educational career to equip them with necessary skills. Because the future will be so reliant on information technology, it is imperative that more be done to encourage students to pursue education and professional development to make them more competitive within a knowledge-based economy and to provide a necessary support workforce. To encourage the growth and attraction of small high-tech businesses, faster methods for achieving regulatory approvals and development of intellectual property will be required. Science and technology companies also require enhanced connectivity, both communication- and research-oriented. A robust communications backbone will make South Carolina more attractive to these companies. Providing open access to scientific and economic development data will encourage innovation. As the knowledge base in science and technology grows, faster delivery of content is imperative. Digital content also provides new insights and encourages creative forms of education that connect with digital natives that will make up tomorrow's STEM workforce.

organizations, SCLaunch™ and Swampfox, has helped stimulate cutting-edge research to benefit both the public good and stakeholders.

To encourage entrepreneurship at the university level, Clemson's Arthur M. Spiro Institute for Entrepreneurial Leadership supports educational, research and outreach programs that promote entrepreneurial activity and economic development of the region, state, and nation. Here inventors and entrepreneurs can find assistance with market analyses and business planning. Also, the Institute conducts a mentoring program to link entrepreneurs with experienced business executives.

Innovista at the University of South Carolina conducted a SWOT analysis and identified that the university needs a better-connected entrepreneurial support system where assets, information, resources and organizations are aligned to connect and maximize support for startups, entrepreneurs and technology commercialization. The overarching goal is to create an entrepreneurial culture both within the university and outside in the community. Innovista has established the Center for Entrepreneurial and Technological Innovation (CETi), a virtual and physical one-stop shop for entrepreneurs housed within USC's Innovista Research Campus. CETi is working with the Moore School of Business at USC to support the SC Entrepreneurial Fellows Program™. The program identifies young entrepreneurs across the university who are seeking to start a business. The students or recent graduates will participate in a full-time internship program with a university researcher under the guidance of experienced entrepreneurs. The Medical University of South Carolina (MUSC) has established a Center of Innovation and Entrepreneurship (CIE) that:

- Supports University-wide innovation and commercialization,
- Educates faculty, staff and students in technology commercialization.
- Mentors prospective and early entrepreneurs,
- Develops collaborative relationships for promoting technology commercialization state-wide, and
- Identifies and facilitates access to new sources of funding for the CIE and spin-out companies.

In addition to South Carolina's research universities, the South Carolina Technical College System plays a critical role in advancing innovation in the state. A new training program created through a consortium of three South Carolina technical colleges (Greenville Technical College, Horry-Georgetown Technical College, and Trident Technical College) and the South

Innovation, Entrepreneurship and Collaboration Across South Carolina – Success Stories

Health Sciences South Carolina (HSSC), one of the most unique research collaboratives in the nation comprised of the three research intensive universities and seven of the largest teaching hospitals in the state, is finalizing an innovative real time clinical and research data warehouse and tools for data analytics. One of their current projects involves managing clinical research permissions electronically. One mechanism to increase participation in research is to better inform participants, increasing their interest in clinical trials participation and to retain participants' preferences in a form that is readily accessible. Such research permissions and informed consents are typically collected on paper upon patient registration. A collaborative team of researchers from across the state were brought together through HSSC and developed a novel method of presenting information and capturing the participants' preferences electronically. The project involved substantial analysis focused on key areas including: review of business practices, registration processes, and permission collection workflows. The team also worked with participants to develop best practices for presenting consent information to users via tablet technology and capturing permissions data. The result of this research, funded through the National Library of Medicine, is an open source software product which can be adopted for use by institutions across the nation. An initial version of the software has been piloted at one institution in South Carolina and was well received by staff and patients. It has also recently been adopted by an out-of-state university for use in their clinical research program.

New Carolina, a non-profit organization working to increase South Carolina's economic competitiveness through a cluster development strategy, aims to integrate education, innovation and entrepreneurship into strategies of the core industries in South Carolina. One such cluster, the Columbia Insurance Technology Services Cluster (ITS|SC), is comprised of over 40 companies in the insurance, technology, and services industries that range from start-ups to Fortune 500 companies. With 6000+ insurance-related jobs in the region with an average salary at $62,000, the industry has had an economic impact of over $1 billion. The unique collaboration among ITS|SC, USC and other partners have created innovations in the way insurance is practiced by providing a portal to all online resources helpful to insurance technology, services, and outsourcing.

EngenuitySC, a public/private partnership formed to develop and grow the South Carolina Midlands' knowledge-based economy by fostering an environment where entrepreneurship, innovation, and the creation of knowledge are fundamental elements of the region's culture, identity, and economic development strategy, leads initiatives that support research development, promote commercialization, and leverage the region's assets. EngenuitySC facilitates a community-wide collaborative focused on developing and implementing strategies to increase K-12 entrepreneurship education throughout Columbia and the Midlands. As a champion for growing Columbia's knowledge economy, EngenuitySC brings together K-12 entrepreneurship organizations and providers to build a rich network and solid platform for collaboration that will prepare today's students for success and eventual leadership in the new global marketplace.

Carolina Technical College System has received the 2012 Innovation of the Year Award from the League of Innovation in the Community College, an international organization committed to improving community colleges through innovation, experimentation and institutional transformation. Located on a 146-acre segment of the Florence-Darlington Technical College, the Southeastern Institute of Manufacturing & Technology (SiMT) is a technical service provider that offers cutting-edge technology to help manufacturers with improved production as well as employee training. SiMT provides engineering, CAD and CAM, rapid prototyping, and 3D and virtual reality services, as well as manufacturing workforce and process training. Through the SiMT's Manufacturing Incubator Center (MIC), qualified startup manufacturers receive assistance in commercializing their ideas. The MIC offers space, infrastructure, and intellectual property to startup companies. In partnership with SiMT and other programs and facilities across South Carolina, USC launched the Innovista Center for Product Realization (ICPR) in July 2012 to help startups with new product development and other resources necessary to transition their ideas into the marketplace.

The community is an integral component of a culture that can enhance innovation and creativity. According to Dr. Rich Harrill, Director of USC's International Tourism Research Institute and Alfred P. Sloan Foundation Travel & Tourism Industry Center, innovation, tourism, and creativity are essential elements to spur economic development. Having a locale that features music, arts, food, architecture and entertainment alongside innovators and businesses creates an attractive environment for tourists and locals that is rich in creativity and ripe for dialogue, discovery, and innovation.[4] Innovista represents the physical manifestation of the University of South Carolina's longtime research philosophy of nurturing innovation, creativity, discovery, and opportunity. By connecting USC and university-spawned innovations with entrepreneurs, businesses and stakeholders, technology-intensive, knowledge-based companies will be attracted to the area, resulting in higher-paying jobs and an improved standard of living in South Carolina. NEXT is an initiative to build an entrepreneurial ecosystem in Upstate (Greenville) South Carolina that nurtures the start-up and growth of globally-impactful, knowledge-based companies through: Attraction & Retention, Infrastructure Development, Advocacy, and Concierge Service. NEXT clients are fast-growth technology companies that own their intellectual property and have high potential for national and international growth. Sectors currently served include Internet technology, electronic device, biomedical, software, nanotechnology, and pharmaceutical. NEXT offers entrepreneurs access to an entrepreneurial community; SBIR/STTR consultation; office space; and a portal to government, infrastructure, real estate, education, angel and venture capital, professional resources and a trained workforce. Since its inception in 2006, NEXT has served 79 companies, with a 2011 economic impact of over 670 jobs and $42 million in wages.

Dr. Harrill also goes on to say that "[w]ith appropriate investments in infrastructure, technology, and education, our state's rural areas can become new centers of growth augmenting urban economic development. Tourism can help transform empty storefronts into showcases for the arts, culture, and perhaps even business incubation. In addition, these areas must also have recreational amenities to offer new residents, such as parks, trails, and greenways. Organizations with experience and expertise in rural tourism marketing and development such as the South Carolina National Heritage Corridor can play a key role in advancing the New Economic Development."[4]

South Carolina needs to continue to foster a culture that enables, encourages, and rewards research and innovation. To remain competitive in both the domestic and the global market, the approaches require constant evaluation as well as significant investments in human, financial, and physical resources.

[1]"Entrepreneurship and Education: What is Known and Not Known about the Links Between Education and Entrepreneurial Activity", SBA: Office of Advocacy.

[2]"Leveraging Higher Education for a Stronger South Carolina", March 2009, Retrieved from http://www.che.sc.gov/InfoCntr/HESC_Files/che_2169_Leverage_Report_web.pdf.

[3]Bush, Vannevar, "Science The Endless Frontier", July 1945.

[4]Harrill, Rich, "Tourism, Innovation, Creativity, and Growth: Advancing South Carolina's New Economic Development," MidlandsBiz, April 20, 2010, Retrieved from http://www.midlandsbiz.com/news/markettrends/757/.

Health, Science and Technology Workforce

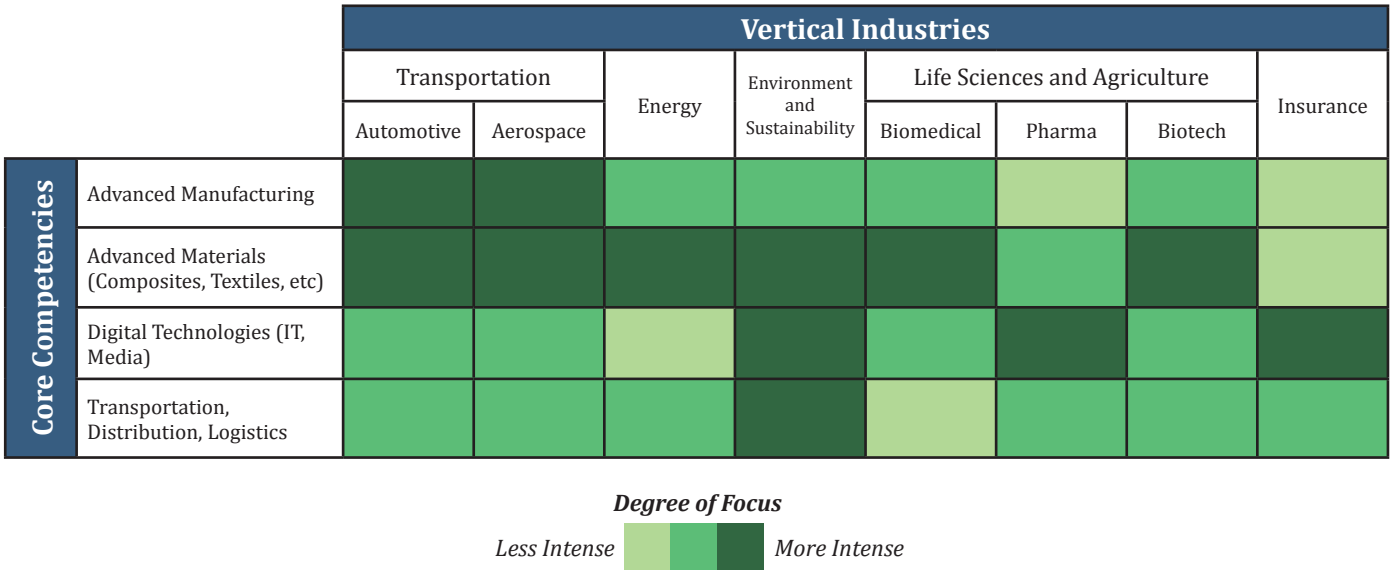
Goal:

South Carolina has an educated and engaged public that understands and participates in the state's health, science and technology research enterprise.

Recommendation:

Capitalize and grow existing strengths in industry focus areas by 10% (transportation, energy, life sciences and agriculture, and environment and sustainability) by promoting research through collaborations between South Carolina's comprehensive universities and colleges, technical colleges, and industry partners.

Innovation plays a vital role in the development of South Carolina's economy, and South Carolina's system of comprehensive and technical colleges, and the state's three research universities (the University of South Carolina, Clemson University, and the Medical University of South Carolina) are integral in developing the innovators of tomorrow. A highly skilled workforce is key to economic prosperity in South Carolina. Maximizing the educational potential of South Carolinians through higher education and/or training in the industries expected to grow over the next decade will prepare a workforce that is able to effectively compete in the global economy. Academic and industry leaders have identified both South Carolina's core competencies as well as industry focus areas slated for growth, both born out of new and existing businesses in the state. An intimate understanding of how these competencies and industry focus areas intersect will drive the development of a competitive workforce for the knowledge economy. By enhancing its four core competencies – Advanced Manufacturing; Advanced Materials; Digital Technologies; and Transportation, Distribution, and Logistics - South Carolina can foster the growth of four vertical industries - Transportation; Energy; Life Sciences and Agriculture; and Environment and Sustainability - identified as strategic areas where South Carolina can be a domestic and global leader. Increased support for alignment between college and university educational programs and technical colleges with the needs of these vertical technology-intensive industries, as well as direct linkages between South Carolina's world-class university research programs and industry are critical to capitalize and grow the industry focus areas.



Manufacturing is the main driver for innovation in South Carolina. Most of the state's largest manufacturing employers, including Michelin, GE, BMW, Milliken, and Sonoco, have made substantial investments in research and development centers or university partnerships to develop their products in South Carolina or improve their manufacturing processes. While these businesses develop intellectual property themselves, with advanced products and processes, they also benefit the ecosystem of entrepreneurship by providing opportunities for technical collaboration or participation within their supply chains. These large industry anchors interact with the state's colleges and universities to help drive fundamental research efforts and coordinate on training and education to prepare the innovative workforce they need. The automotive sector continues to be the dominant sector in economic development recruitment activities since ground was

broken at the BMW plant in Spartanburg County in 1992. Most of the capital investment and job recruitment in that sector has been tied either to BMW itself, BMW suppliers or several large investments by tire manufacturers Michelin, Bridgestone and Continental. The Port of Charleston and South Carolina's rail and road infrastructure draw a large number of warehousing and distribution projects each year, including Amazon.com among many others. Information Services includes a plethora of mostly smaller firms conducting a range of activities from the information technology from BenefitFocus in the human resources management industry to the internet based marketing firm Red Ventures. There are several manufacturing subsectors that are both high wage and have experienced employment growth over the past decade. Aerospace products and parts, in particular, stands out in terms of overall growth rate in the past 10 years as well as weekly wages that significantly outpace the state average weekly wage. The announcement of the Boeing Company to locate its 787 Dreamliner™ factory in Charleston will continue to spur growth in this valuable subsector.

Other manufacturing areas of strength in South Carolina include motor vehicle body, engine turbine, and power equipment, pharmaceutical and medicine, medical equipment, and agriculture, construction, and mining machine manufacturing. Aside from advanced manufacturing growth, another bright spot in South Carolina's employment mix is the growing fields of computer systems, software, telecommunications, scientific research and technical consulting.

Economic growth is driven by the creation of new technologies, new company formation, the expansion of existing businesses, and job creation. A skilled workforce educated in the sciences, technology, engineering and mathematics disciplines is critical for building innovative products, services, and firms, which in turn drives economic growth. South Carolina's level of employment in high-technology sectors is an indicator of innovation. According to the Milken Institute, South Carolina was ranked 35th nationally in 2010 in the make-up of its technology and science workforce, up from a ranking of 38th in 2008.[1] However, a closer look at South Carolina's workforce broken down by more specific occupations reveals that South Carolina has a significantly high concentration of workers in engineering disciplines, yet ranks poorly in its workforce employed in the sciences (physics, chemistry, microbiology, and environment science). According to the South Carolina Department of Commerce, South Carolina ranked 2nd, 3rd, 3rd, and 5th nationally for the number of industrial engineers, chemical engineers, mechanical engineers, and nuclear engineers, respectively, in 2010.South Carolina ranked 43rd and 41st in 2010 for the concentration of employees in the sciences disciplines and computer and mathematics disciplines, respectively.[2] Job creation will continue only if a suitable workforce is available, and all sectors of higher education play distinct, yet complementary roles in workforce development. Continued collaboration, communication and alignment between academia and industry is essential if South Carolina wants to capitalize and grow its industry focus areas, including its human workforce capital in industry focus areas, by 10%.

To meet the needs of innovative businesses in the state, South Carolina's educational system, including its three world-class comprehensive, research universities and its public, private, and technical colleges, must continue their strong emphasis on science and engineering disciplines. South Carolina needs to continue to foster an integrated approach to research, education, and business to develop new products and processes that maintain and advance the state's global competitiveness. A key component to position South Carolina as a global leader in its strategic industry focus areas is a workforce prepared to participate in, enhance and advance the core competencies that will drive further innovation.

South Carolina Collaborations

SmartState™, with heavy investment from corporate partners, has created 50 research centers of excellence at the state's three research universities to advance research and boost the state's economy.

University of South Carolina NanoCenter (USC) fosters nanoscale science and research, commercialization, education, and technical outreach.

South Carolina Clinical and Translational Research Institute (SCTR) at MUSC facilitates the sharing of resources and expertise in biomedical research.

Health Sciences South Carolina, the nation's first statewide biomedical research collaborative, was formed with the vision of transforming the state's public health and economic well-being through research, and educating and training the health care workforce. Its members include six of the state's largest health systems and the state's three research universities.

Southeastern Institute of Manufacturing Technology (SiMT) provides premier technical service and training facility for industry in the southeastern U.S.

New Carolina is a non-profit organization working to increase South Carolina's economic competitiveness through a cluster development strategy.

SCRA Innovation Centers in partnership with each of South Carolina's three universities serve as incubators for small businesses, especially university spin-offs.

Midlands Technical College Enterprise Campus and Innovista have collaborated to offer an environment where business and education are co-located.

[1]Milken Institute, State Technology and Science Index, 2011.

[2] Clayton, David , The State of the Innovation Economy in SC, April 2012.

Recommendation:

Expand the human resource infrastructure (e.g. students with PhD, MS and BA/BS degrees) in STEM by 25% at South Carolina universities and other educational units. The South Carolina STEM workforce will be representative of the state's population demographic.

It is evident that obtaining a higher level of education results in greater prosperity and competitiveness in a knowledge-based economy. As the state progresses in attracting and creating more high tech industries, the needs for an educated STEM workforce will significantly grow. In order to meet these needs, the state's universities must increase the number of students receiving STEM degrees. It is also critical that the state train graduate students in these areas so that such students stay on in the state and continue to innovate and pursue research with direct impact on high tech industries of the state. To this end, an increase in the number of STEM graduates and graduate students will require additional support in the form of state funding to South Carolina's universities and colleges. State funding has dropped most dramatically since 2007.[1] An annual study of state spending on higher education found that state appropriations for South Carolina colleges and students declined by 7.5% from 2010-2011 to 2011-2012 (nationwide, an average drop of 7.6% over the same time period occurred, which was the largest such decline in at least a half century).[2] While this situation is not unique to South Carolina as other states are experiencing similar declines, to train the students in STEM areas with immediate impact on our local high tech industry would necessitate investments in specific areas with potential impact on STEM education, research training, and ultimately workforce development.[3]

Despite low levels of college attainment for the working-age population of South Carolina relative to other states, South Carolina is making strides to increase the numbers of college educated citizens. Home to three research universities, Clemson University, the University of South Carolina (USC) and the Medical University of South Carolina (MUSC), South Carolina matriculates tens of thousands of undergraduate and graduate students each year. With four schools of medicine, numerous graduate programs, 12 public four-year colleges and universities, 22 private colleges, and 16 technical colleges, South Carolina's has opportunities for its residents for higher education and specialized technical training.

Since 2006, South Carolina's institutions of higher education have awarded over 21,000 STEM bachelor's degrees with an overall increase of 13% in STEM degrees awarded between 2006 and 2011.[4] As outlined in the 2009 South Carolina Higher Education Study Committee Action Plan *Leveraging Higher Education for a Stronger South Carolina*, to achieve the goals to increase degrees awarded, the state's colleges and universities should focus their efforts on retention programs, especially orientation, advisement and tutoring; transition programs for high school and technical college students; increasing opportunities for receiving financial aid; accelerated learning programs, such as dual enrollment or Project Lead the Way; college readiness programs including developmental studies/remedial courses; and, bridge programs that offer a seamless pathway for transfer students.

While the state still ranks somewhat average in the percentage of bachelor's degrees granted in science and engineering (30), the state is much lower ranked in the percentage of graduate students in STEM (49) and the number of masters degrees awarded (46).[5] To meet the needs of the STEM workforce, emphasis should be placed on awarding more postsecondary degrees within the state. Since 2006, the number of masters degrees awarded in STEM fields in South Carolina has declined by 16%, while the number of STEM doctoral degrees awarded since 2006 has remained stagnant.[4]

In *Diversifying the Faculty: A Guidebook for Search Committees* (2002) faculty diversification is cited as a direct contributor to educational quality. A more diverse faculty will also result in greater inclusion and retention among the student population, thus enabling the state's institutions to award a greater number of degrees. In 2011, the state's public institutions of higher education only employed 17% minority faculty teaching credit courses across all fields.[6] Minority representation in the STEM fields is considerably smaller. In an effort to improve the minority representation in the professoriate, the universities have developed programs such as Call Me Doctor® at Clemson University and the African American Professors Program at the University of South Carolina. Also, USC has hosted President's Brunch pro-

gram in which world renowned URM administrators including Dr. Freeman Hrabowski, President of UMBC were invited to discuss recruitment of URM faculty. This function was also attended by all Presidents and Chancellors of institutions participating in the South Carolina NSF Research Infrastructure Improvement Award. USC has also organized a Diversity Summit focused on prospecting, recruiting and retaining diverse faculty in STEM areas, which was attended by Deans and Chairs from 10 South Carolina colleges and universities. The universities should increase the support for programs like these to facilitate "growing our own" and investigate new methods for the recruitment of minorities into STEM faculty positions from outside the state.

Having a diverse STEM workforce both in academia and industry will result in more perspectives and greater innovation through the exchange of ideas and points of view. Since 2006, the state has awarded 27% of the STEM bachelor's degrees awarded to minorities and 46% to women. The attrition rate for minorities increases for the masters and doctoral level of STEM degrees awarded. Since 2006, the average percentage of STEM degrees awarded to minorities was 10% and the average awarded to women was 43%. Even fewer doctoral degrees went to minorities (average of 9% since 2006) and women (average of 37% since 2006).[4] Increasing the number of degrees awarded to minorities and women will result in a more diverse and inclusive STEM workforce.

[1]CHE Staff Response to Prepared in Mind and Resources A Report on Public Higher Education in South Carolina, November 30, 2011.

[2]Lederman, Doug, "State Support Slumps Again" Inside Higher Ed, January 23, 2012.

[3]National Science Board, Second Companion National Release, September 25, 2012.

[4]South Carolina Commission on Higher Education, 2011, Retrieved from http://www.che.sc.gov/New_Web/Rep&Pubs/Completions.htm.

[5]Milken Institute, State Technology and Science Index, 2011.

[6]South Carolina Commission on Higher Education, 2011, Retrieved from http://www.che.sc.gov/New_Web/Rep&Pubs/Faculty/2011.htm.

Recommendation:

Expand cooperative training programs through the South Carolina Technical College System to prepare the workforce needed by STEM-based industries.

Technology-based jobs require skilled workers, and though excellent job opportunities abound in South Carolina, particularly with large companies like BMW, Timken, Duke Energy and others, employers often are forced to hire out-of-state employees due to the lack of local skilled workers. South Carolina has a considerable number of adults who are unemployed or underemployed because they lack the foundation and technical skills to perform in the industry areas identified as significant to the future of the state. Training programs to prepare students and train unskilled or unemployed workers for a career in a technology or manufacturing-based jobs are essential, and South Carolina has responded with its commitment to innovative education and training through its South Carolina Technical College system (SCTCS). The System is comprised of 16 technical colleges located strategically across the state and its statewide affiliate programs: the Center for Accelerated Technology Training's readySC™ program and Apprenticeship Carolina™.

SCTCS pioneered readySC™, one of the oldest and most developed workforce training programs in the United States, which helps prepare employees to work at select qualifying companies that invested in the state. readySC™ includes recruitment, screening and training, and creation of new guidelines and curriculum to fit a company's needs. In FY10-11, over 5,900 employees were trained, serving 76 companies including BMW, Michelin, Firestone and Boeing. In April 2011, readySC™, Boeing and Trident Technical College partnered to open the Boeing North Charleston Training Center, which trains as many as 120 employees daily. In addition and in response to the growth in the aerospace industry in the state, Trident Technical College has begun to offer an associate degree in Aircraft Maintenance Technology.

Apprenticeship Carolina™ is an employer-sponsored flexible training program that cultivates highly skilled workers who meet the workforce demands of a competitive global economy by offering both on-the-job training and related technical instruction. In March 2011, Biowatch Medical Inc. registered the state's first federally-recognized apprenticeship program for Cardiac Care Technicians. Working closely with Midlands Technical College, Biowatch Medical's apprentice program provides in-depth education and training on cardiac care, medical terminology, CPR and computer skills, as well as prepares apprentices for industry certification from Cardiovascular Credentialing International.

Despite the fact that South Carolina was recently ranked 5th nationally for workforce development programs by both *Area Development* magazine and CNBC, the South Carolina Technical College system needs to remain flexible, agile, and with access to sufficient resources to respond to the evolving needs of specific businesses and industries, while also building and expanding general skills that enhance overall workforce readiness. The South Carolina Technical College System needs partners who are willing to invest in providing opportunities and enhancements that will help the System and the Technical Colleges be truly exceptional. Traditional sources of funding cannot keep pace with the rising costs in higher education, nor provide funds needed to complement targeted economic initiatives in the state with development of new and innovative programs. Private sector funds can provide the margin of excellence in achieving their vision to be the premier provider of educational opportunity and a leading force for the social and economic vitality of the region.

"I've had experience with training across many of our facilities and what we have here in South Carolina is by far the best I've seen."

Tim Coyle, Vice President of the Boeing North Charleston facility in regards to readySC™

The University of South Carolina (USC) partners with the SCTCS to offer students opportunities to pursue undergraduate degrees through the Bridge Program and Gamecock Gateway, which allow first time college attendees to transition into a degree program at USC. Programs such as these enable bright students to take their education further, preparing them for high-level positions in STEM fields and beyond, and encouraging a culture of innovation in the region.

Education and Outreach

Goal:

Individuals having a STEM education from South Carolina are nationally and globally competitive in the health, science, and technology workforce.

Recommendation:

Promote science, technology, engineering, and mathematics education and literacy in K-12 education via public and private sector programs.

While South Carolina's K-12 education system perennially ranks poorly compared to other states, test scores and educational attainment have made drastic improvements over the last decade. Many studies have compared and ranked the U.S. states on various aspects of education and several are applicable to science, engineering and entrepreneurship. A studied titled SERI, for "Science and Engineering Readiness Index," compared the 50 states according to their success in preparing K-12 students in careers in science and engineering. The composite score used for the state rankings reflects each state's performance in the NAEP, or National Assessment of Educational Progress, tests (8th grade math and science), the number of students passing Advanced Placement (AP) tests in calculus and physics and a teacher qualification score based on whether a state has discipline-specific certifications for each science subject. By this composite ranking, South Carolina placed in the "Below Average" category along with eleven other states and ten states rated "Far Below Average." South Carolina's ranking on NAEP tests pulls the composite score below average; the state's AP test performance is closer to the national median.[1]

Disparity in educational attainment is widespread across the state. The metro areas of Greenville, Charleston, Columbia, Myrtle Beach and around Charlotte have high school educational attainment levels above the state and national averages, whereas in many rural counties, more than a quarter of the population over 25 years old lacks a high school diploma or equivalent. Overall, *US News and World Report* ranked South Carolina's high schools 33rd in 2011.

The Governor's School for Science and Mathematics (GSSM) is the only high school in South Carolina that offers a residential experience focused on science, technology, engineering and math education, with additional emphasis on economics and entrepreneurship. This two-year program is recognized as one the nation's top 24 public elite high schools. The school offers a college-level curriculum, platform for research opportunities and exposure to business leaders. The school enrolls 128 students annually with future plans to grow to 300. Their students rank among the top in the state among SAT scores and 100% of their graduates attend college and 80% pursue advanced degrees. The school is also recognized for their award winning faculty. All teachers hold masters degrees and 80% have earned PhDs.

South Carolina Governor's School for the Arts and Humanities (SCGSAH) is the only fully accredited public arts high school in the country, having achieved national accreditation by both ACCPAS and SACS. The SCGSAH received the state's Palmetto Gold award for the 10th consecutive year and ranked third among South Carolina's public schools for achievement on the SAT and ACT. The students receive an intense and innovative education that fosters connections to the arts while meeting all the requirements necessary for a South Carolina high school diploma. Among the 2011 graduating class, every student received some level of financial assistance to continue their education which totaled $18.3 million.

In April 2009, the statewide Committee to Increase South Carolina's Math and Science Teaching Force was established to increase the pipeline of math and science teachers within the state. As a result of the initiative, Clemson University and the University of South Carolina have joined the Science and Mathematics Teacher Imperative in a national effort to identify and address key constraints which impede the formation of effective STEM teacher preparation programs. In addition, Newberry College was awarded a NOYCE Grant to assist with their Recruit and Engage Math and Science Teachers (RE-MAST) project. The five-year, $900,000 grant from the National Science Foundation's Robert Noyce Teacher Scholarship Program is designed to encourage STEM majors and professionals to become middle and high school mathematics and science teachers.

South Carolina's comprehensive research universities have developed partnerships with industries and local schools to improve the quality of the state's K-12 education system. In 2002, the University of South Carolina became a Project Lead the Way (PLTW) affiliate to prepare K-12 students to enter STEM fields. PLTW is the leading provider of rigorous and innovative STEM education curriculum programs used in middle and high school across the country. As of 2012, there are 76 middle and 100 high school PLTW engineering programs and 18 Biomedical Sciences high school programs across the state. Approximately 400 teach-

ers have been trained to teach PLTW courses and 58 of the 80 school districts in South Carolina have PLTW schools. Since its inception, the program has been successful in training students in pre-engineering courses at high schools and five technical colleges. In 2011, 473 students completed PLTW courses and 46 students received transcripted college credit from the College of Engineering and Computing (COEC) at USC Columbia. A survey of incoming freshmen (2010) at the COEC indicated that approximately 1/3 (128/395) of the students had taken PLTW courses while in high school.[2] A USC Columbia report indicated that of the freshmen who majored in engineering in 2009, approximately 70% returned to the COEC as sophomores in 2010.[2] Currently the College of Education and the College of Science Academy are exploring ways to collaborate to enhance underrepresented groups in the Columbia area.

Clemson University created Math Out of the Box™ when they recognized that South Carolina's math education was insufficient at meeting the nation's ability to compete economically in a high-tech world. The standards-based K-5 curriculum allows students to work with hands-on materials and engage in fun, yet challenging learning. According to Carolina Curriculum, students in Title I schools using Math Out of the Box™ performed better on the South Carolina Palmetto Achievement Test (PACT) than students who had not received the curriculum. Additionally, Clemson hosts Driving Science™, an annual program that introduces over 1,500 students to STEM and motorsports. The university also sponsors a host of customized math, science and literacy workshops that help K-12 instructors with pedagogical content knowledge required to successfully teach the Common Core State Standards.

In order to advance the state's K-12 education system, the research universities must continue to invest their time, resources and expertise. Programs such as PLTW must be expanded to be included in all South Carolina schools.

[1]White, Susan and Cottle, Paul, "A State-by-State Science and Engineering Readiness Index (SERI): Grading States on Their K-12 Preparation of Future Scientists and Engineers", Retrieved from http://www.aps.org/units/fed/newsletters/summer2011/white-cottle.cfm.

[2]Project Lead the Way, University of South Carolina, 2012.

Recommendation:

Increase access to higher education and training opportunities in science and technology for all South Carolina citizens regardless of gender, race, or socioeconomic status.

Research, innovation, and a strong, talented workforce well-schooled in the STEM disciplines are critical to achieve global economic leadership. However, US dominance in science and technology has weakened compared to the rest of the world, where investments in "local" research and education have been stressed. A real key to ensure economic dominance is to expand the STEM talent pool, which in turn creates the challenge of increasing participation in these fields by underrepresented minority groups. Underrepresented minority groups made up almost 29% of the national population in 2006, but only 9% of college-educated Americans in STEM fields. There is a progressive loss of representation as one moves up the academic ladder. In 2007, underrepresented minorities comprised 39% of K-12 public enrollment. Of the 33% of the college-age population, 26% were enrolled in an undergraduate program with only 18% earning a STEM bachelor's degree. With 18% overall enrollment in graduate school, 14% earned STEM master's degrees and 5% earned STEM doctorate degrees.[1]

In 2011, the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline published a series of recommendations to develop a strong and diverse workforce. The report suggests that to increase minority access to and demand for post-secondary STEM education and technical training, the federal government, industry, and post-secondary institutions must work collaboratively with K-12 schools and school systems. Specific recommendations focused on higher quality K-12 preparation, identified as critical for later success; greater access and motivation; affordability; and academic and social support.[1]

On a state level, the SC education system has a strong emphasis on science and engineering disciplines to meet the needs of innovative businesses in the state. The number of STEM Associate, Baccalaureate, and Doctoral degrees awarded in South Carolina has increased dramatically over the last decade. In 2000, the state's colleges and universities graduated 4,116 in the STEM fields. That figure grew 25 percent over the next 10 years to 4,905 in 2010.[2] Most of the increase was due to more bachelor's degrees awarded in engineering and biological sciences fields.

South Carolina is working diligently to ensure that the STEM workforce is representative of the state's population demographics. Although the numbers have increased, African Americans, Hispanics and Native Americans remain underrepresented in the STEM fields. In 2008-2009, 1/3 of all bachelor's degrees awarded to African American students in South Carolina were from South Carolina's six historically black colleges and universities (HBCUs).[2]

The comprehensive research universities are working to align themselves with SC HBCUs to bridge the achievement gaps. The University of South Carolina offers fellowships, scholarships and development programs to faculty and underrepresented minorities enrolled at HBCUs. Participants receive mentoring, training and opportunities to expand their research efforts. One of USC's most recognized programs is the Post-Baccalaureate Research Education Program (PREP) for minority students which began in 2006. Because fewer than 10% of African Americans apply to Biomedical Sciences PhD programs, the PREP program was developed to increase the number of minority applicants by offering opportunities to work in biomedical research laboratories while preparing for graduate school. Through the IMSD (Initiative for Minority Student Development) program, support is extended to students from the PREP program through their first year of graduate school and beyond. Other programs at USC include the Louis Stokes Alliance for Minority Participation (LSAMP) program which pairs minority undergraduate students with mentors who guide them in the transition into STEM fields and encourages them to pursue graduate education beyond the baccalaureate. The TRiO McNair Post-Baccalaureate Achievement Program was designed to increase the number of PhD recipients among individuals who are first-generation/low-income students (2/3) and who are from groups underrepresented in graduate education (1/3). The USC-Morris College Mentoring Program funds up to 10 students from Morris College (HBCU) to live on campus at USC and to conduct research over a 10 week period. The NSF-Research Experience for Undergraduates is a 10 week summer research program for 10 undergraduate students, usually from colleges or universities other than the host institution, encouraged specifically for

women and underrepresented minorities and persons with disabilities, in STEM areas. Other graduate programs, such as GAANN fellowships (Graduate Assistance in Areas of National Need) in STEM fields as well as SC Graduate Steps to STEM, a program funded by NSF and designed to facilitate the recruitment of graduate students to MS or PhD programs in science and mathematics, are also offered as support for unrepresented minorities.

Clemson University is nationally known for increasing the number of underrepresented minorities in STEM fields through their Call Me Doctor® (CMD®) and Call Me MISTER® Programs. CMD® is a graduate fellows program that supports high-achieving PhD students who have an interest in pursuing doctoral studies in STEM fields. Graduate fellows receive up to $30,000 over four years, mentoring and a team-based research environment. Similarly, the Call Me MISTER® program trains and provides tuition assistance for college students who are studying to become K-12 teachers in South Carolina. Student participants are largely selected from underserved, socio-economically disadvantaged and educationally at-risk communities.

The College of Medicine at the Medical University of South Carolina has increased its underrepresented in medicine student population dramatically since 2002. In 2002, underrepresented minority students comprised 11% of the College's medical school's student body, whereas in 2011 these students accounted for 21% of the student body. Current students, minority and majority alike promote a collegial, collaborative environment where all students feel welcome. For instance, MUSC made concerted efforts to recruit African American males, successfully matriculating 10 African American males in 2006, 10 in 2007, 2008 and 2009. While, the majority of medical schools admit 2 African American males in its matriculating class, MUSC's College of Medicine has matriculated 7 times the national average for African American males. In addition, the College of Medicine launched a major recruitment effort for underrepresented in medicine residents in 2003, at which time these residents comprised 3% (16 out of 522) of total residents. The efforts of the Graduate Medical Education (GME) office, residency training directors and faculty directly impacted their recruitment. Today, the resident house-staff is comprised of more than 8% underrepresented individuals with representation in more than 74% of the clinical departments.[3]

In addition to the research universities, South Carolina's 16 technical colleges provide training and educational opportunities to individuals around the state. Over 52% of all undergraduates in SC public higher education during the fall 2011 semester were enrolled at one of the state's technical colleges.[4] The technical schools are located around the state, including rural and lower socioeconomic areas, which makes higher education accessible to all SC residents. In fall 2011, 39% of the students enrolled were minorities and over 40% were over the age of 25.[4] By offering a myriad of career programs and distance learning opportunities, the technical schools are working to ensure that all South Carolina residents are afforded an opportunity to expand the state's STEM workforce and knowledge based economy.

While the state has made strides to increase access to higher education and training opportunities in science and technology for underrepresented minorities in South Carolina, opportunities for improvement and enhancement still exist. There are many outlets for public research universities, industry, and state government to participate in helping students at HBCUs increase their participation and success in STEM fields. These include allocation of university funding as well as state funding to cover summer research internships, both at public research institutions as well as in industry, for HBCU undergraduate and graduate students. With the participation of competent and engaged summer research mentors, ample testing preparation (GRE/MCAT), aggressive recruiting, and implementation of both a visiting professors program and a feeder institutions program between public universities and HBCUs, overall representation of minorities in STEM disciplines can be realized.

[1]Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads, National Academy of Sciences, National Academy of Engineering, Institute of Medicine, National Research Council, 2011.

[2]South Carolina Commission on Higher Education, Retrieved from http://www.che.sc.gov/New_Web/Rep&Pubs/Completions.htm.

[3]Medical University of South Carolina, Retrieved from www.academicdepartments.musc.edu.

[4]South Carolina Technical College System, Retrieved from http://www.sctechsystem.com/facts.html.

Recommendation:

Establish lines-of-sight to introduce students and parents to STEM career opportunities and integrate STEM needs into South Carolina's educational system through increased involvement of private-sector industries.

According to the U.S. Department of Labor, jobs requiring science, engineering and technical training will increase by 34% between 2008 and 2018. The vast majority of these jobs will require an advanced education. In order to meet the growing demand, students and parents must be educated on STEM career opportunities. Careers in the STEM fields remain among the highest paying jobs and they also serve as the foundation for South Carolina's globally competitive and innovative economy.

With the passage of the 2005 Education and Economic Development Act in South Carolina, also known as Personal *Pathways to Success*™, the state has made the concerted effort to drive the relationship between a rigorous education and the aspirations and abilities of both youths and adults. All students in the state's public high schools must develop individual graduation plans that include selection of a career major through a course of study in one of 16 career clusters. School partnerships with area businesses provide students opportunities for hands-on, real-world work experience in the field of their choice. While many of these students may not ultimately enter careers in their chosen field of study, data from individual graduate plans provide some insight into the interests and early intent of South Carolina's high school students. In 2010, 11.3% of the state's eighth- through twelfth-graders selected the broad category of science, technology, engineering, and mathematics. Roughly 3% selected information services. The most popular choice was health science, attracting 22.6% of all high school students.[1]

South Carolina's Coalition for Mathematics & Science (SCCMS) partners with businesses to design and disseminate curricula and instructional tools to schools. SCCMS also trains teachers new strategies to promote student engagement. The result has been a remarkable improvement in mathematics and science PASS scores. Scores in science at Scott's Branch Middle School in Clarendon County increased by almost 25 percent.

South Carolina's Coalition for Mathematics & Science (SCCMS) brings together advocates for business/industry, education, government and community organization through advocacy, support and innovation. The SCCMS has partnered with businesses such as BMW, Michelin and FLUOR to design and disseminate curricula and instructional tools to schools around the state. Teachers trained through SCCMS experience hands-on activities, plan for effective instruction, and learn classroom strategies that promote student engagement. Additionally, they demonstrate a deep and rich understanding of relevant content in the subject they teach.

Since 2009, the SCCMS has supported schools through the STEM Centers SC Initiatives. As a result, the schools have noted remarkable improvement among the students' mathematics and science PASS scores. For example, for the 2008/2009 – 2010/2011 school year, the student scores in science at Scott's Branch Middle School in Clarendon County increased by almost 25 percentage points.[2]

In addition to SCCMS, Boeing and IT-oLogy have partnered with local school districts to bring awareness to STEM opportunities. Boeing collaborated with SCCMS and Clemson University to develop *Inquiring Minds: Reading to Learn and Innovate in Mathematics and Science* (IQ-MS), a research and innovation program that identifies reading, writing, and communication strategies that make science and math more accessible to middle school students. The state's assessment test results showed that there is a strong correlation between students' difficulties with reading informational texts and failure to meet standards in mathematics and science. This program is implemented at ten schools throughout the state. IT-oLogy is a nonprofit collaboration of businesses, academic institutions and organizations dedicated to fostering economic development and advancing the IT profession. One of their major partnerships is with K-12 schools throughout the state. Through camps and job shadowing programs, IT-oLogy has educated over 5,000 K-12 students and parents about the IT profession. Their camps feature hands-on activities along with a variety of topics covering the IT spectrum. The company also sends IT specialists to visit classrooms and conduct workshops

for middle and high school students. Students attending IT-oLogy events are more informed about postsecondary education and career opportunities.

There are several other initiatives and organizations in South Carolina that are actively engaged in promoting academic achievement and college awareness. SC GEAR UP (Gaining Early Awareness and Readiness for Undergraduate Programs), federally funded by the U.S. Department of Education and administered by the SC Commission on Higher Education, focuses on improving college access, preparation, and attendance. SC GEAR UP encourages partnerships between a business and a group of students at a particular school who commit themselves to specific goals and participate in defined activities. SC GEAR UP partnerships encourage learning while providing real-world experience in the workplace. When partners combine resources to integrate school curriculum with real world lessons, both earn positive recognition in the community. Lexington Medical Center offers an intensive summer internship for Lexington County high school students inside the hospital called the Partners Program. In its 22nd year, the Partners Program has become a popular tradition at the hospital. "The goal is to give students an inside look at what they can expect in a health care career," said Kelli Bennett, workforce coordinator at Lexington Medical Center, who conducts the Partners Program. "It's a glimpse into our world."

In certain geographical areas of the state, especially where agriculture has been the primary source of employment, there are many adults without a college education. Ironically, while South Carolina ranks 48th among the states in the percentage of ninth graders who graduate from high school in four years and then enter directly into higher education, the state ranks 4th in the percentage of high school graduates who go on directly to college. For the state to increase educational levels as well as concurrently introduce students to STEM needs and opportunities, the K-12 education pipeline needs to be strengthened as well as the rate of high school graduation. Students need to be prepared academically and understand the relationship between academics and their abilities and interests. For many K-12 students, having role models that emphasize the importance and value of having a college education is a necessity to keep them in the pipeline for completing a postsecondary education. In order to demonstrate the opportunities that higher education can offer, it is necessary to promote aspiration to a postsecondary education throughout local industries and state educational programs.

[1]Clayton, David, The State of the Innovation Economy in SC, April 2012.

[2]South Carolina Coalition for Math and Science, Retrieved from http://www.clemson.edu/aophub/.

Economic Development

Goal:

The business environment in South Carolina is attractive to both technology-intensive companies and talented technology-competent workers.

Recommendation:

Establish the culture and environment to promote the development of intellectual property and its commercialization by research universities.

A very good indication of R&D activity, outputs, and innovation are patents and licenses. Only a few firms account for a large portion of patent awards in South Carolina and South Carolina is ranked 40th in the number of patents issued per 100,000 people.[1] The principal weakness in the number of patents issued in South Carolina is due to the output and number of key research and development anchor firms and the state's research universities. The patent output of Duke University, the University of North Carolina, North Carolina State University and Georgia Tech more than doubles the outputs of both Clemson and USC.

South Carolina needs to continue to invest in its science and technology-based economic development, and its research universities provide a significant foundation for innovation. Recruitment of world-renowned scientists and engineers as endowed chairs at the universities as part of the SmartState™ program has been a catalyst to further fuel cutting edge research and ultimately the state's knowledge economy. Greater alignment between the research initiatives at the state's universities and the needs of industry that make South Carolina domestically and globally competitive is critical. The relationship between business and higher education should become more "peer-to-peer" in nature where areas of common interest are emphasized. In a more collaborative relationship, higher education and businesses together can define key research programs to ensure that technology gaps are being addressed and ultimately play a role in the development of intellectual property (IP). By investing in the recruitment and retention of post-graduate scientists and engineers at the universities, new expertise in high-technology fields is continually strengthened. And when both work together, further advancements in intellectual property, including increased numbers of patent applications and awards, start-up companies, and industry partnerships can be realized.

The state's universities are leaders in developing technology and have established offices that assist in commercialization. The Clemson University Research Foundation, the Office of Technology Commercialization at USC, and the MUSC Foundation for Research Development manage the technology transfer functions at the universities and work with business and entrepreneurial interests to help identify, protect, and commercialize intellectual property. USC is also actively engaged in a search to fill the Innovation Chair in the Darla Moore School of Business. The Innovation Chair is an endowed chair, part of the SmartState™ program. The holder of the Innovation Chair will be asked to facilitate commercialization processes within the University and innovation within the region more generally. To more effectively disseminate research findings and their impact on economic growth, continued improvements in the overall management of the technology transfer process is required. A framework should be developed for efficiently managing intellectual property as collaboration among the universities and between the universities and industry takes place. Specific guidelines regarding intellectual property that is the result of collaborative work should be developed that account for ownership, protection, institutional responsibilities, and liability.

"Universities should improve management of intellectual property to improve technology transfer."

Research Universities and the Future of America

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) are two three-phase award systems that provide small businesses with opportunities to propose innovative ideas that meet specific federal R&D needs. The SBIR program supports small businesses by funding research at the critical startup and development stages and encouraging commercialization of the technology, product, or service. The STTR program supports small businesses in partnership with nonprofit research institutions to move ideas from the research laboratory to the marketplace. Both SBIR and STTR funds provide small businesses with a unique source of funding to explore and develop novel concepts with no impairment of debt structure, no equity participation, and most intellectual property rights generated through funded projects are retained by the

small business. Traditionally, South Carolina has lagged in the number of SBIR and STTR awards. In recent years, however, several programs have been successful at increasing the awards made to small businesses within the state. The SBIR Phase-0 program offered by SC EPSCoR/IDeA provides seed money to assist small businesses in drafting competitive proposals for Phase I and Phase II awards. In the past three years, the program has made 46 awards totalling over $270,000 to 25 different high-tech companies.[2] While the SBIR Phase-0 program has helped companies increase their competitiveness for Phase I and Phase II awards, the SC Launch® SBIR Matching Program helps the businesses bridge the gap between a smaller Phase I award to the much larger Phase II level. As a result of these programs and others, the state has seen an increase of SBIR and STTR awards from only 71 being received within the state between 1984 and 1999 to 346 being received between 2000 and 2011.[3] Despite this level of growth in awards, the state only ranks 45th in the average annual number of SBIR awards and 33rd in the average annual number of STTR awards.[1] There is also a disparity in the number of businesses making a transition between Phase I and Phase II of the technology commercialization process, as South Carolina ranks 33rd in the number of SBIR Phase I awards, but only 47th in the number of SBIR Phase II awards.[1]

The state's universities must continue to encourage faculty to develop competitive intellectual property, as well as providing services and education of the IP commercialization process. The universities should also encourage entrepreneurship by accepting such initiatives as one of the criteria for tenure and promotion processes, as well as providing facilities and services related to the development of small businesses based on potentially profitable intellectual property.

[1]Milken Institute, State Technology and Science Index, 2011.

[2]South Carolina EPSCoR/IDeA.

[3]Small Business Innovation Research (SBIR)/ Small Business Technology Transfer (STTR), Retrieved from http://www.sbir.gov/sbirsearch/technology?state=SC.

Recommendation:

Increase the level of business education for students pursuing a degree in STEM fields.

As the world's economy has become less labor-based and more knowledge-based, the number of jobs requiring only a high school diploma is declining. According to the Georgetown University Center on Education and the Workforce, between 2008 and 2018, new jobs in South Carolina requiring postsecondary education and training will grow by 94,000, with 56% of all jobs in South Carolina (1.2 million jobs) requiring some postsecondary training beyond high school in 2018.[1]

Science, technology, engineering and mathematics will each be necessary for economic development in South Carolina's future. A science and technology-based economy requires a higher educated workforce who understands the relationship between education and the developing economy. But as important as STEM-training is, training a STEM-savvy workforce that understands how work translates to and impacts the world is just as critical. According to the Kingsborough and City University of New York (CUNY) Institute who established the STEM-based Virtual Enterprise (VE), an active-learning pedagogy that can exist as a free-standing course or be embedded within any STEM-discipline course, "[research universities, as well as] [c]ommunity and [t]echnical [c]olleges need to nurture this symbiotic connection of skills between the business discipline and the various disciplines that form STEM."[2]

"An entrepreneurial center helps develop, teach, and mentor those people involved in starting a small business, and many states have those centers. The Faber Center will create a formalized mechanism for perpetuating an entrepreneurial culture in this state."

Tim Faber

In their article "IT Managers' Requisite Skills" in the April 2006 edition of the *Communications of the ACM*, Sang M. Lee and Choong Kwon Lee conducted a review of 555 job-postings for high-tech leadership positions from Fortune 500 companies to understand job seekers' qualifications in relation to employers' skill requirements. Of the companies polled, 92.4% cited the need for social skills, specifically, interpersonal skills, communication skills, and self motivation. 87% cited the need for a general knowledge of business and management. More than 60% cited the need for organization and leadership skills, and knowledge of technological trends.[2]

Examination of the traditional educational system has revealed that several skills are notably absent from STEM curricula that are critical for success in today's knowledge-based economy. These are problem-solving, leadership, creativity, and entrepreneurship, more likely to be found integrated into traditional business course curricula. But the merging of the two, technical knowledge and market and business knowledge is what is necessary to develop the research enterprise, particularly in South Carolina.

In 2009, the South Carolina Higher Education Study Committee (HESC) recommended that entrepreneurship education be integrated into curricula at colleges and universities, especially in liberal arts and STEM disciplines. The comprehensive research universities have recognized and addressed this need by establishing centers that provide education, training, resources and mentorship to students. The Faber Entrepreneurship Center at the University of South Carolina is helping to develop USC's entrepreneurship program to encourage and prepare students to take their entrepreneurial skills into the new global economy. The center provides USC students with intensive exposure to entrepreneurial concepts, small business management training, and interaction with a network of successful entrepreneurs in South Carolina. Every year, nearly 200 undergraduate and graduate students work on semester-long consulting projects for entrepreneurial firms in a broad range of industry sectors. Students work on business plans, conducted market research, and assess market opportunities for a broad array of entrepreneurial ventures. A sample of firms participating in these faculty-led student projects includes: Fabrisource, DrukenDragon, Craftsman Restoration-Kentucky, Optica360, Pure Fishing, Interactive Pet Solutions, Orangeburg Pecan Company, Healing Icons, Sheex, Ox Enterprises, Voterheads.com, Ride-post.com, GoCulture International, LivLive.com, PassageMaker, CarbonForecast, EyezChina, Helium 3, Glucose Marketing Technology, Inc., MusicEnergy, Engencore, Parallel Permeation, and Condition-Based Maintenance.

Substantial attention has been given to technology commercialization as well as intellectual property concerns. For example, through the Polymer Nanocomposite Manufacturing Partnership (sponsored by an NSF grant), faculty and students from both engineering and business served on consulting teams focused on technology commercialization. Working with firms in the automotive and paper and packaging sector, teams examined how best to leverage advances in nancomposites. Similarly, faculty teams have worked closely with firms in the energy and defense sector, providing research and consulting expertise regarding ways to leverage via commercialization prior R&D investments.

Clemson University offers a Technology Entrepreneurship Certificate available to graduate students in engineering and science disciplines across campus. The certificate is intended to serve students who envision an entrepreneurial career as their long-range career goal, want to be involved in new product and business activities within a corporate setting, and/or seek a better understanding of the process of commercializing inventions. In addition, Clemson offers an MBA in Entrepreneurship and Innovation, a one-year intense experiential program where students begin with an idea, apply rigorous business principles, and graduate with both an MBA degree and a market-ready business. This MBA is a new kind of degree for the innovation economy. It combines the foundational MBA skill set required by innovative corporate managers with the creative experiences, technological toolkit and start-up network required to develop innovative start-up businesses.

By expanding these newly developed programs, STEM students can receive the educational framework needed to become successful entrepreneurs enabled to navigate within the new global economy. Entrepreneurship learning opportunities should be offered both within two-year and four-year institutions. The connection between such programs and STEM academic programs is necessary. In addition, the onus to prepare tomorrow's knowledge-based workforce doesn't rely solely on the educational system, but with collaboration with economic development and workforce development agencies.

Dr. Andrew Clark, founder of SensorTech, a Clemson start-up, was one of the pioneering graduates of the Technology Entrepreneurship Certificate. While working on his PhD, Andrew Clark enrolled in Spiro entrepreneurship classes. "The entrepreneurship classes were an extremely useful start to forming the company. In them I learned many of the skills needed to embark on this process." In addition, Dr. Clark has used Spiro MBAs to help conduct market research and write grants. "The Spiro Institute was particularly valuable in conducting market research to help highlight these markets."

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[1] Projections of Jobs and Education Requirements Through 2018, The Georgetown University Center on Education and the Workforce, Retrieved from http://www9.georgetown.edu/grad/gppi/hpi/cew/pdfs/southcarolina.pdf.

[2] Troudt, E.E., and Winkler, C., 2010, "The Entrepreneurship Technician," HI-TEC 2010, Orlando, FL.

Recommendation:

Increase scale-up opportunities for high-tech start-up companies.

South Carolina has made tremendous strides in growing and mentoring high-tech start-up companies. In 2002, South Carolina ranked 33th in the country for the number of business start-ups per 100,000 people. The state ranked 4th nationally in 2008, and their vast improvement can be attributed to an environment where academia, industry, government, and economic development collaborate together.[1]

Large manufacturers and multinational corporations contribute to the development of the ecosystem of entrepreneurship in the state. Most founders of companies in innovative, high-technology businesses have significant industry and management team experience when starting their own companies. Over the last five years, South Carolina has been successful in recruiting large firms to open or expand new manufacturing and back-office operations in the state. Many of the managers, innovators, and funders of future technology-based entrepreneurial efforts may have come from the large firms that these industrial recruitment efforts attract. Another avenue for business development of high-impact firms is through the supply chain of larger corporations. The automotive sector continues to be the dominant sector in economic development recruitment activities, since ground was broken at the BMW plant in Spartanburg County in 1992. Today, there are more than 40 companies participating in BMW's supply chain versus one supplier when they first opened their doors in South Carolina. Several of these firms are locally-owned businesses with high growth potential. Workers currently employed in STEM and related fields have the greatest propensity for starting entrepreneurial businesses with high growth potential. STEM professionals are also the engines of innovation for existing firms where they develop new products and processes to fuel business growth.

Small business and entrepreneurship are drivers of job growth and economic development. There are numerous programs and organizations that exist in South Carolina to facilitate the formation and growth of small businesses, including SCRA and SC Launch®, the South Carolina Small Business Development Center, as well as angel and venture capital groups. In addition, several communities, colleges, and universities have established offices to assist in the commercialization of technology and the development of high-growth potential firms.

Though South Carolina has successfully created a framework for new start-ups throughout the state, these high-tech start-ups have typically been very small firms (20 or fewer employees) and the state underperforms in scaling these high-potential firms into larger companies that trade outside the state's borders or expand beyond a small regional footprint. Many of these firms may lack access to capital or management expertise to navigate growth from a small business to a medium- or large-size enterprise. For instance, between 2000 and 2010, South Carolina small businesses received 327 SBIR/STTR awards totaling nearly $86 million in research grants. Over the 11 years, these awards were made to 70 small businesses in the state. In contrast, only 18 small businesses in South Carolina have received SBIR Phase II awards of $1 million or more over the last decade.[2]

Approximately half of the total SBIR/STTR allocations each year come from the Department of Defense, along with significant contributions to these programs from the Department of Health and Human Services/ National Institutes of Health, NASA, the Department of Energy,

South Carolina Support for High-Tech Start Ups

SCRA Innovation Centers in partnership with each of South Carolina's three universities: the SCRA USC Innovation Center, the SCRA MUSC Innovation Center, and the Duke Energy Innovation Center with Clemson University serve as incubators for small businesses, especially university spin-offs.

SC Launch® provides seed funding and support services for start-ups, including early stage funding and commercialization support to over 250 enterprises to date.

Innovista, an entrepreneurial environment within a vibrant, mixed-use urban neighborhood in Columbia, was developed by USC to spur commercialization of university-originated innovation by establishing facilities for technology-intensive companies.

New Carolina, a non-profit organization working to increase South Carolina's economic competitiveness through a cluster development strategy, aims to integrate education, innovation and entrepreneurship into strategies of the core industries in South Carolina.

NEXT is an initiative to build an entrepreneurial ecosystem in Upstate (Greenville) South Carolina that nurtures the start-up and growth of globally-impactful, knowledge-based companies.

and the National Science Foundation. Although South Carolina's manufacturing sector is the main driver for innovation in the state, many of the most innovative manufacturing subsectors in the state do not have a relatively high level of employment or economic activity. By investing in growing the infrastructure at the university level to support high tech research in subsectors in manufacturing and other industry focus areas; by promoting faculty and student entrepreneurship; and by promoting greater collaboration and alignment of university research priorities with the needs and priorities of both industry and federal agencies, an increase in the number and award of SBIR and STTR proposals should be realized.

Venture capital (VC) can be an important piece of financing strategy for early-state, high-potential firms. However, greater support and resources needs to be provided and a focus should be made on increasing the number of companies, particularly those in early stage development, receiving venture capital investments. In South Carolina, three deals totaled $22 million in 2011, an increase of 10% over the previous year's $20 million from eight smaller deals. However, South Carolina's VC activity in 2011 made up just 0.077% of the total U.S. financed amount. Software was the dominate sector in South Carolina from 2001-2011, making up 32% of all deals and accounting for more than 72% of the value of all investments. By contrast, South Carolina had very little VC activity in two industries that employed a large number of workers in the state in numerous, high-tech, industry-leading firms: the industry/energy sector and electronics/instrumentation sector. South Carolina also had a relatively small proportion of its VC activity in biotechnology and medical devices and equipment, though the state doesn't have a large number of firms or significant employment concentration in these industries.[2]

From 2001-2011, South Carolina firms characterized as start-up/seed investments received only two investments, totaling $200,000. South Carolina's VC activity has largely skewed towards investments in more mature and revenue-generating firms. Over the last decade, 87% of all VC dollars invested were either expansion or later stage investments, compared to 75% nationwide. Moreover, 53% of VC funds in South Carolina were directed to later stage companies that were typically already profitable and more than four years old.[2] To help fuel growth in high-tech start-ups, more VC funds need to be invested earlier in their development.

[1]Milken Institute, State Technology and Science Index, 2011.

[2]Clayton, David, The State of the Innovation Economy in SC, April 2012.

Afterword

In 2011, the state's universities, industry leaders, and economic development groups were asked by the National Science Foundation in support of South Carolina's Experimental Program to Stimulate Competitive Research (EPSCoR) to assemble and collaborate on a statewide Science & Technology plan; out of this group was born the South Carolina Science and Technology Task Force (S&T Task Force). Throughout 2012, the S&T Task Force formally evaluated the state's progress over the last decade, identified a clear mission and purpose for the state's science and technology plan, and identified areas of improvement and development. This plan has been developed keeping primarily in mind how the three comprehensive universities in the state of South Carolina will work with technical colleges, the K-12 education system, HBCUs, industry partners and the like, in developing an education and research mission that would be aligned with the statewide need for developing the S&T driven workforce leading to innovation and economic prosperity.

The development of the plan has been one of several statewide initiatives undertaken to address long-term sustainable economic growth in South Carolina. The South Carolina Department of Commerce is compiling a series of reports on the state of the innovation economy in South Carolina, and New Carolina is addressing various facets of South Carolina's current and future economic conditions in a capital markets study. While these efforts are directed at promoting the knowledge economy in SC, they have been driven by varying points of view. As the evolution of the S&T plan occurred, it became obvious to many of the S&T task force members, some of whom also participate in other statewide initiatives, that translating science and technology into job creation requires a broad-based, comprehensive effort. This type of effort reaches beyond the scope of any individual plan, but rather is a culmination of many plans – the whole is greater than the sum of its parts. Building an ecosystem of partners across South Carolina that will develop and significantly grow the South Carolina research enterprise will require alignment among universities, industries, economic development groups and government agencies in South Carolina. The S&T plan is one step among many other steps in bringing an awareness of what it will take for South Carolina to become a domestic and global leader in identified strategic industries for the state. Integral to the achievement of this statewide endeavor, however, is the requirement of a higher degree of specificity with regards to the recommendations presented in the S&T Plan, an alignment between South Carolina universities' research agendas and the needs of South Carolina industries, and an accountability among stakeholders for both the Plan's measure and success. The roadmap towards achieving the goals has been sketched out by the S&T Plan, but other, complementary initiatives must seek to further define how the state gets there.

While the primary objective of the development of the South Carolina S&T plan has been met, the passion and fervor generated as a result of the content has been outstanding. Though this plan does not address every concern of the S&T Task Force, the overarching goal is to improve the South Carolina research enterprise. For that reason among others, this document will be revisited and updated on a regular basis; the current S&T Task Force which represents a wide range of stakeholders will continue to participate in the evolution of the document and work with the key leadership (industry, state, universities, etc) to develop metrics of recommendation and implementation. This document will also serve as a springboard for other initiatives that address sustainable economic growth in South Carolina.

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