Advancing Innovation in North Carolina

December 2008

An Innovation Framework for Competing and Prospering in the Interconnected Global Economy

Prepared by the Office of Science and Technology
of the North Carolina Department of Commerce,
at the Direction of the North Carolina Board of Science and Technology

NC BOARD OF SCIENCE & TECHNOLOGY

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OFFICE OF SCIENCE & TECHNOLOGY
NORTH CAROLINA DEPARTMENT OF COMMERCE

December 2008

To the Citizens of North Carolina,

Our state and the world are in the midst of economic upheaval of unprecedented global scale. Triggered by the recent failures in the U.S. housing and credit markets, economies across the globe have slipped into recession in the months during which this report was written. *The most remarkable aspects of this upheaval are its scope and pace, revealing just how interconnected and dynamic the global economy is in the 21st century*. This situation reflects both the challenge and the opportunity that face North Carolina.

The challenge is that, more than ever before, North Carolina's economic development and prosperity are intertwined with global forces. We now interact and compete with others on a global scale. Thanks to innovations such as computers, cell phones, video conferencing, and the Internet, we now do business instantaneously with billions of people across the world. Increasingly, though, those innovations and others are being produced in other countries, which are challenging our competitive advantage.

The opportunity is that, more than most states and nations, North Carolina has in place the institutions and programs necessary for responding to this challenge. These simply need to be enhanced, optimized, and realigned to foster and accelerate the spread of innovation, both within government and externally throughout the state's economy to the broader society. North Carolina has successfully transformed its institutions and programs several times in response to new technologies and scientific discoveries in past decades. It can, and must, continue to do so.

This report—*Advancing Innovation in North Carolina*—is therefore a call to action. Specifically, it defines the innovation challenge facing North Carolina, assesses North Carolina's innovation performance, and recommends an innovation framework for North Carolina that leverages the state's unique strengths while addressing its specific challenges.

Faced with a dynamic and uncertain future, the best approach is to shape it rather than be shaped by it. In other words, we must continue to innovate: to create and adopt new products, services, and business models. With this report, we present an innovation framework that differentiates and positions North Carolina optimally to compete and prosper in the interconnected global economy.

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EXECUTIVE SUMMARY

CHAPTER 1: CHANGE COMPETITION, AND CHALLENGES

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Overview

North Carolina's transition from an agricultural and traditional manufacturing economy to a knowledge and innovation economy continues to evolve at a rapid pace. For more than five decades, the state has responded to this transition by making strategic investments in infrastructure, institutions, and human capital. Because of these investments, North Carolina has achieved a leading role in the "basic" and early-stage "applied" research that forms the foundation for breakthrough innovations.

The vast majority of this foundational research has occurred in the state's world-class research universities and non-profit research institutions. North Carolina has some shining examples in which this research has created innovations that generate commercial successes and advance society. Examples include advanced information and communications technologies, innovative treatments for some of the most challenging health ailments, and ground-breaking approaches to the globe's most pressing issues.

These successes, however, are not nearly numerous enough to provide best-in-class, cluster-based, innovation-driven economic development built on a strong foundation of homegrown commercialization. Additionally, we have a growing need to attract and retain innovative entrepreneurs to advance the state's innovations into commercially viable products and services upon which to build the economy of the future.

North Carolina has the intellectual capital and facilities to foster research and innovation. However, to accelerate the progression and transformation of innovative ideas into economic development and prosperity, the state must establish an institutional and policy framework that maximizes the potential of its assets.

This report, therefore, is a call to action. Specifically, it:

1. **Defines the Innovation Challenge:** Innovation—*the creation and adoption of new products, services, and business models*—is a fundamental driver of economic, governmental, and social prosperity in the 21st century. In light of the increasing pace of innovation and growing global competition, North Carolina needs to adapt, as it has done in the past, its government structures and policies to harness the opportunities that innovation presents at the pace they are presented.

2. **Assesses North Carolina's Innovation Performance:** As revealed by a comprehensive set of statistical indicators and geographic maps of North Carolina's innovation assets and activities, two significant patterns characterize the state:

   - North Carolina ranks at or below the U.S. average on several indicators of its innovation-related assets and activities.
   - North Carolina's innovation assets and activities are geographically concentrated in metropolitan areas that are distributed broadly across the state.

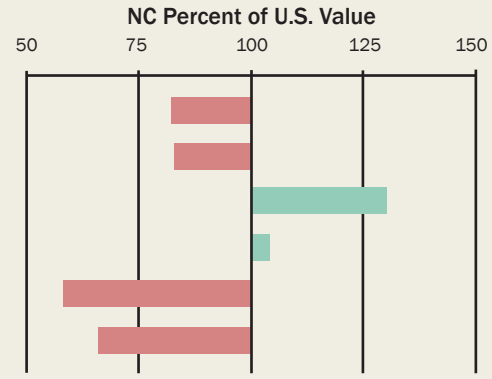
3. **Recommends an Innovation Framework for North Carolina:** To accelerate the progression of innovative ideas into economic development and prosperity throughout the state, North Carolina state government should establish a framework of strategic, ongoing, collaborative relationships with the private sector for the purpose of discovering both the underlying impediments to innovation and the opportunities to engage in strategic coordination to overcome those impediments.

The intent of this report is to provide a blueprint to develop such a framework, which will help all regions of North Carolina thrive in the innovation economy. The timing of the report offers a roadmap to the new administration and the legislature that will assume office in January 2009.

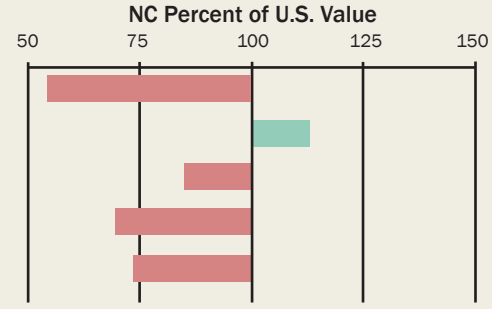
Key Innovation Indicators for North Carolina

The following indicators, which are discussed in more detail in Chapter 2 of the report, summarize North Carolina's performance in the innovation economy relative to other states. For each indicator, the U.S. average is 100, and North Carolina's value shows its performance relative to what would be expected based on national patterns of activity. The indicators show the need for improvement in North Carolina and provide the basis for understanding how the state's leadership can uniquely equip North Carolina and its regions to build and maintain a leadership position in the innovation economy.

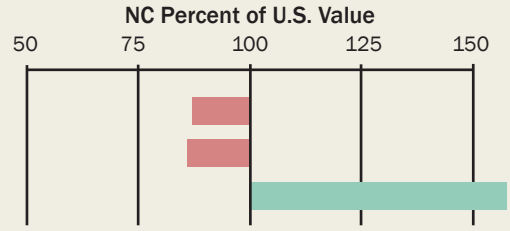
R&D Activity	NC Rank
Total R&D as Share of Gross State Product (2004)	23
Industry-Performed R&D as Share of Private-Industry Output (2005)	19
Academic R&D per $1,000 of Gross State Product (2005)	10
Academic Articles per 1,000 S&E Doctorate Holders in Academia (2006)	15
Federal R&D Obligations per Civilian Worker (2005)	24
Federal R&D Obligations per Individual in S&E Occupation (2005)	27



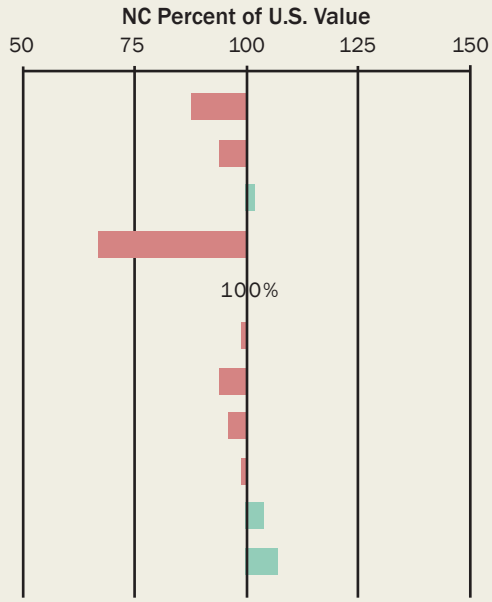
Commercialization Activity	NC Rank
Average Annual SBIR $ per $1 Million of Gross State Product (2003-05)	31
Academic Patents per 1,000 S&E Doctorate Holders in Academia (2006)	8
Patents per 1,000 Individuals in S&E Occupations (2006)	23
Venture Capital Disbursed per $1,000 of Gross State Product (2006)	10
Venture Capital Deals as Share of High-Tech Business Establishments (2004)	12



High-Tech Economic Activity	NC Rank
High-Tech Share of All Business Establishments (2004)	25
Employment in High-Tech Establishments as Share of All Employment (2004)	29
Net High-Tech Business Formations as Share of All Businesses (2004)	10



Human Capital Resources	NC Rank
Individuals in S&E Occupations as Share of Workforce (2006)	29
Computer Specialists as Share of Workforce (2006)	20
Employed S&E Doctorate Holders as Share of Workforce (2006)	17
Engineers as Share of Workforce (2006)	39
High School Graduates or Higher Among Individuals 25-44 Years Old (2005)	35
AA Degree Holders or Higher Among 25-44 Year Olds (2005)	23
BA Degree Holders Potentially in the Workforce (2005)	23
BA Degree Holders or Higher Among 25-44 Year Olds (2005)	26
BA Degrees Conferred per 1,000 18-24 Year Olds (2005)	29
BA in Natural Sci. and Eng. Conferred per 1,000 18-24 Year Olds (2005)	25
S&E Degrees as Share of Higher Education Degrees Conferred (2005)	16



A Framework for Competing and Prospering

North Carolina's existing innovation framework has several strengths but could be made even stronger with an enhanced and better-aligned framework that leverages the state's unique strengths while addressing its specific challenges:

Strengths

1. Substantial investment in academic R&D, from inside and outside the state
2. A higher-education system with substantial potential to support statewide innovation
3. Strong potential for commercialization and increased high-tech economic activity

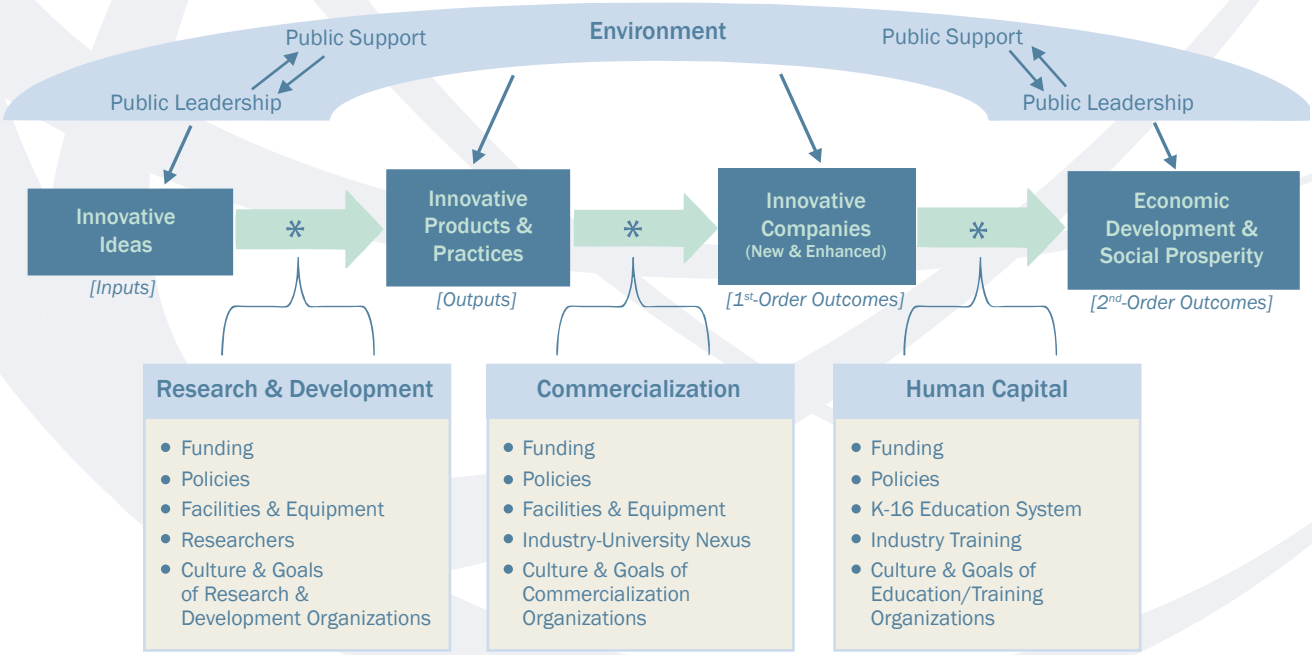
Challenges

1. Relatively low investment in industrial R&D
2. Heavy dependency on a few geographic clusters for innovation
3. Weakness in converting innovation inputs into innovation outputs
4. Large variances in performance across regions within the state
5. A continuous need to educate and train human capital

North Carolina should view its innovation challenges as an opportunity to enhance and improve the alignment of its public institutions and programs to foster and accelerate the spread of innovation throughout the state. Our institutions and programs need to keep pace and anticipate the changes resulting globally from science, technology, and innovation. The key ingredients are in place; they just need to be increased, enhanced, utilized, and combined in ways that maximize their effectiveness.

Innovative ideas are translated into economic development and prosperity through complex and dynamic interdependencies among a variety of collective efforts. Innovation, therefore, occurs within an "ecosystem" (Figure ES.1). Through a well-designed institutional and policy framework, government can strengthen structures and links within that ecosystem, enhancing its ability to deliver the economic and social fruits of research and development through innovative products, services, and business models.

Figure ES.1 The Innovation Ecosystem



**Under appropriate conditions: leadership, support, infrastructure, resources, goals and culture.*
Human capital is a key condition at all stages of the ecosystem. However, for the purposes of this figure, its most critical role is in fostering economic development and social prosperity by providing an educated workforce for innovative companies.

Framework Foundation — Ten Principles

The guiding principles for this framework should be the following:

1. **Existing organizations with demonstrated competence and statewide jurisdiction should have primary authority for implementing the framework's programs.** In light of scarce resources and the benefits of economies of scale, vesting increased authority in existing organizations is preferable to creating new organizations with new authority.

2. **The implementing organizations should receive guidance and oversight from officials who are publicly accountable.** Such a relationship guards against self-interested actions by the organizations and protects them from undue influence from private interests.

3. **The implementing organizations should maintain channels of communication with the private sector.** Ongoing contacts and communication with the private sector provides public officials with good information on economic realities, which provides the basis for sound decision making.

4. **The framework should use a diverse and supportive tool kit, including information and education, inducements and assistance, and coordination and facilitation.** Rather than being top-down and prescriptive, the framework should help create the conditions in which bottom-up, regionally based market actors—private and public—can collaborate in new, innovative, productive ways and make more informed decisions.

5. **Programs should target "new" activities.** "New" refers to products that are new to the local economy, to new technologies for producing existing products, and to new processes for accomplishing existing activities. Targeting these activities would diversify the economy, promote innovation, and generate new areas of competitive advantage.

6. **New programs should be sufficiently long-term and well-funded to make a difference, but decisions about and their continuation and/or modifications should be guided by clear benchmarks and performance criteria.** Absent these criteria, imperfections are more likely to go unrecognized and be perpetuated, and successes may not be continued or replicated.

7. **Programs should have the flexibility to respond to continually changing circumstances and to support different needs across regions.** The ability to modify and vary public programs is necessary to keep pace with the innovative, region-based economy.

8. **Programs should focus primarily on cross-cutting activities, not narrowly defined sectors.** Focusing on activities targets attention on the core factors impeding the innovation process, which in turn generates cross-cutting, capacity-building programs that benefit multiple sectors.

9. **Publicly supported activities should have clear potential to provide informational spillovers or demonstration effects.** Public support, by definition, is "public," not private. It should promote the public good.

10. **There should be a realization that risk and change are integral parts of innovation.** Because new activities inherently entail some risk, an optimal strategy for promoting innovation will necessarily yield some failures. The goal, therefore, should not be to minimize all chances of failure; rather, it should be to minimize the costs of failures when they occur and to apply constructively the knowledge learned from those failures.

Framework Operationalization — Five Roles

To fulfill the above principles, North Carolina's public leaders should enhance five roles that are uniquely in their hands:

1. **Champion and Communicator.** Public leaders can champion the importance of innovation, as well as coordinate promotion and communication of the state's successes to its citizens and other audiences.

2. **Convener and Facilitator.** Public leaders can convene cross-functional groups of policy, academic, and business leaders to elicit information and strategic policy initiatives that accelerate the progression from innovative ideas to economic development and social prosperity.

3. **Funder and Policymaker.** Public leaders can make strategic investments and policies to build world-class research and development enterprises, aid the development of scalable collaborative communications infrastructure, encourage collaboration among academia and industry, commercialize innovative products and practices, and cultivate human capital in the state.

4. **Recruiter and Retainer.** Public leaders can assist in identifying, promoting, and recruiting potential enterprises to bring to North Carolina to augment innovation clusters and economic growth, as well as assist in retaining innovative enterprises in the state for the ongoing and future benefits they provide.

5. **Evaluator and Advisor.** Public leaders can measure performance relative to strategic goals, serve as an expert resource on innovation, and, where the State has invested heavily in innovation policies, improve coordination of those policies to receive the most benefit from State investments.

Framework Leadership and Coordination — Three Institutions

To provide the leadership and coordination needed for a well-functioning innovation framework, three of North Carolina's public institutions should be enhanced, optimized, and realigned:

1. **The Board of Science and Technology should be charged and equipped with additional resources to implement an innovation framework that optimally fosters and stimulates innovation throughout all facets and regions of North Carolina's economy, government, and society.**

2. **Consistent with enhanced resources for the Board of Science and Technology and its staff, the State Science Advisor position should be reestablished and it should be optimized to carry out the position's functions.**

3. **To provide appropriate guidance and oversight of the framework, the General Assembly should strengthen the alignment of its committee and staff structure with the needs of the 21st century innovation economy.**

These three institutional recommendations are low-cost options that can be implemented immediately.

Framework Implementation — Four Drivers

To implement and coordinate the framework, the three institutions above should work to expand and enhance four core drivers that will accelerate the progression of innovative ideas into economic development and prosperity throughout the state. Two specific recommendations within each of these drivers provide an initial "front-burner" agenda for critical evaluation and future development by policy makers, state agencies, and organizations:

RESEARCH AND DEVELOPMENT

1. **Provide State-funded R&D competitive grants to public universities:** To increase the commercial relevance of North Carolina's considerable academic R&D investments and capabilities, the State should provide competitive matching grants to UNC faculty to conduct research in collaboration with industry consortia. The grant awards would provide matching support for research that facilitates job creation in targeted and strategically important industry sectors. The research would support sustainability and innovation within the industry sector. Industry Sector Development Partnerships, organized by the North Carolina Department of Commerce, would construct cluster development plans. UNC would convene the Sector Partnerships annually to develop a strategy to guide allocation of the competitive funds. Regional diversity and development across the state would be sought.

   Cost: *At least $5 million annually for the UNC system; UNC General Administration would determine how the funding is allocated among its constituent institutions. Funded through State appropriations, to be matched, at least 1-for-1, by industry partners.*

2. **Design and support programs to market the state's R&D assets:** To increase the number of companies, federal agencies, entrepreneurs, and researchers conducting R&D, locating, or expanding operations, in North Carolina, the State should convene a public/private partnership to market North Carolina's R&D assets. Specifically, a strategic, coordinated, and integrated public relations, marketing, and communications campaign should promote North Carolina as a high-tech state that values, encourages, and invests in science, technology, and innovation. The public/private partnership would be comprised of appropriate representatives from government, industry, education, regional economic development commissions, local governments, non-profit organizations, and professional associations throughout North Carolina.

   Cost: *At least $2 million annually. Funded through a combination of support from the State, private industry, universities, and nonprofit organizations.*

COMMERCIALIZATION

3. **Support the repurposing and funding of technology transfer platforms in the UNC system:** To optimize the transfer of university-generated technologies into the private sector, as well as to increase university-industry collaborative activity, the UNC technology transfer offices should be encouraged to focus more on company and industry engagement, job creation, and enhanced quality of life for all North Carolinians. To achieve this, the technology transfer offices would need recurring State appropriations, which would reduce their dependence on licensing revenue as a source of income. Moreover, the metrics used to evaluate the offices would need to be broadened, consistent with their broadened purpose.

   Cost: *At least $3 million annually for the UNC system; UNC General Administration would determine how the funding is allocated among the constituent institutions. Funded through State appropriations.*

4. **Advocate and provide funds for the continuing development of the UNC Millennial Campuses:** To facilitate industry-university collaborations that broaden the spread of innovative clusters throughout the state, all UNC institutions should be supported in their efforts to derive the benefits of the Millennial Campus Act. By allowing the institutions to build research facilities and occupy them with private-sector partners, the Act encourages the development of a synergistic research, development, innovation, and commercialization environment at each institution. The Act effectively enables the state to build on its existing strengths and distribute research and innovation activities, focusing on the unique potential of the region supported by the campus. Funds for developing Millennial Campuses could support, among other activities, feasibility study and planning grants, start-up activities, and enhancing well-defined existing collaborative activities.

   Cost: *UNC institutions should be encouraged to expedite plans for, and build out of, their Millennial campuses; cost will vary by institution. Funded through State appropriations.*

HIGH-TECH ECONOMIC ACTIVITY

5. **Continue to support programs focused on increasing the number and benefits of SBIR/STTR grants:** To foster the development and growth of high-tech and innovative businesses, the State should continue to support its programs focused on leveraging the benefits of the federal Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) grant programs. As the single largest source of early-stage funding to assist small businesses in commercializing their innovative business ideas, these federal programs serve as a valuable resource for the state's innovation-focused efforts to leverage. In particular, the Small Business and Technology Development Center (SBTDC) provides a wide range of programs designed to help small businesses learn about and apply for SBIR and STTR grants. Moreover, the One North Carolina Small Business Program, administered by the North Carolina Board of Science and Technology, assists businesses with a portion of their application expenses to the SBIR/STTR programs and matches federal SBIR/STTR grants awarded to businesses. Support for both of these state programs should be continued and expanded.

   Cost: *At least $1 million annually above current funding levels for the SBTDC's SBIR/STTR-related programs; at least $5 million annually for the One North Carolina Small Business Program. Funded through State appropriations, which leverage federal funds.*

6. **Enhance the technology adoption programs of the North Carolina Industrial Extension Service (IES) and the Small Business Technology Development Center (SBTDC).** To promote technology adoption and diffusion throughout the state, the successful programs of these two organizations should be enhanced or expanded, and new ones should be developed. Because these state organizations operate programs that leverage federal programs, such as those offered by the Manufacturing Extension Partnership and the Small Business Administration, the impact of State support is multiplied. Thus, additional support for IES and SBTDC programs targeted toward rural regions with traditionally lower levels of innovation would increase the number of companies benefiting from the organizations' services statewide.

   Cost: *At least $1 million annually above current funding levels for the IES; at least $1 million annually above current funding levels for the SBTDC. Funded through State appropriations, which leverage federal funds.*

HUMAN CAPITAL RESOURCES

7. **Increase the funding for technology- and innovation-focused workforce training programs.** To enhance existing workforce innovation-oriented training programs and fast-track the development of critically needed pools of technology-trained workers, North Carolina's educators, industries, and government should work to develop an explicit North Carolina innovation-focused technology workforce agenda and strategy. Specifically, the agenda should arrange education and workforce programs around clusters, particularly those the State has determined to be in the strategic interests of the state. Such a focus should learn from and build on the successes of the state's existing programs in clusters such as entertainment, hosiery technology, and biotechnology. State support could increase funding to expand the infrastructure of existing programs, particularly in the Community College System, to include activities such as discovering cluster needs, faculty training, curriculum development, and program assessment.

   Cost: *At least $5 million annually above current funding levels. Funded through State appropriations, which leverage existing funds from the State and other sources, such as industry and the federal government.*

8. **Provide additional support for the North Carolina New Schools Project.** To accelerate systemic, sustainable innovation in secondary schools across the North Carolina, the State should work to ensure that every student graduates ready for college, careers, and life in the society and economy of the 21st century. The North Carolina New Schools Project (NCNSP), an independent 501(c)(3) non-profit organization created in 2003 by the Office of the Governor and the Education Cabinet with support from the Bill & Melinda Gates Foundation, has pursued that goal successfully since 2003. NCNSP partners with colleges and universities, state and local government, and supporters in the private and philanthropic sectors. To date, NCNSP and school districts and educators have started more than 100 innovative high schools. The State should provide support to further these efforts and spread them throughout North Carolina, particularly rural regions.

   Cost: *At least $1 million annually above current funding levels. Funded through State appropriations, which leverage funds from multiple other sources, both public and private.*

Expanding and enhancing these drivers would be a critical set of steps to enable a broader, more robust network of effective research programs, commercialization efforts, entrepreneurial support, cluster initiatives, and education curricula around the state. The result would move us closer to an optimized North Carolina ecosystem for delivering the economic and social fruits of research and development through innovative products and practices.

In light of increasing global competition and the large-scale investments that other countries and states are making in their innovation frameworks, however, North Carolina will need to continue to increase its innovation-focused investments significantly as resources permit. The framework outlined in this report puts in place the institutions and processes capable of discovering the underlying impediments to innovation, the opportunities to engage in strategic coordination to overcome those impediments, and the resources needed to do so.

Leading competitive countries are investing in innovation at the rate of two percent to five percent of GDP. This is a benchmark to keep in mind as we move forward with equipping North Carolina to be a global leader in innovation-based economic development and prosperity.

Change, Competition, and Challenges

Key Points

- In the 21st Century, global competition is increasing rapidly and challenging the existing economic order and determinants of economic value.
- In the 21st Century, science and technology and the innovations they yield are evolving faster than ever and are the key drivers ensuring sustainable economic development and social prosperity.
- To maximize North Carolina's ability to succeed in the evolving and interconnected global economy, its government structures and policies must nimbly adapt and harness the opportunities that innovation presents at the pace they are presented.
- Over the past 50 years, North Carolina has successfully transformed itself several times in response to new scientific discoveries, technologies, and innovations.
- This report outlines a statewide, regionally-focused framework for ensuring that North Carolina can compete and prosper in the 21st century.

The Growing Competitive Challenge

On the morning of Wednesday, July 30, 2003, Pillowtex Corporation, one of the world's largest textile manufacturers, suddenly and permanently closed its doors, its owners announcing a total liquidation. Of the more than 7,600 jobs eliminated nationwide, nearly 4,400 were in and around the North Carolina city of Kannapolis, the site of the company's largest plant. This represented the largest plant closing in the history of the state and one of the largest in U.S. history. For Pillowtex workers, most with only modest education and little experience other than employment at Pillowtex, life as they knew it disappeared overnight.

The Pillowtex plant closing underscored the end of an era of traditional manufacturing in North Carolina. Just years earlier few, if any, of the plant's workers would have imagined such a scenario. At the peak of its success in the middle part of the 20th century, the plant—then known as Cannon Mills—had employed almost 25,000 people. It was the world's largest maker of sheets and towels, producing nearly 300,000 towels each day, and its sales and profits were strong and steady. Its prominence in the textile sector continued until the 1980s, when sales began to slide and profits began slipping away. Ownership changed hands several times and moved out of state. After multiple restructurings, the company eventually filed for permanent bankruptcy.

While the causes of the company's demise were many, foremost was lower-priced imports from China and other countries. The words of Pillowtex's CEO sum up the situation: "Cheap imports are flooding the U.S. market and driving down prices, while global sourcing has created a new business model for textile companies that we are unable to replicate without substantial investments."[1]

Table 1.1 Innovative Products and Services (at time of introduction)

Issue	Product	Service
Radically New	Airplane, telephone, computer, Internet	Overnight package delivery, national television networks, Internet-based retailing
Improved	New-to-market cell phone, car, software release	On-line package tracking, on-line travel reservations
More Efficient	More efficient production machinery, more efficient use of existing equipment, better worker training	Load-based call distribution, better worker training

Source: Montana et al. 2001.

Although the scale of Pillowtex's rise and fall may be rare, the basic storyline is all too common. In almost every manufacturing industry in which America has been a been a leader during the 20th century—textiles and apparel, furniture, automobiles, steel, computers, electronic equipment, pharmaceuticals, and others—we have lost, or are beginning to lose, our competitive advantage to other nations. This "offshoring" is due primarily to a dramatically changing 21st century global economy and America's role within it. As new, improved, and more efficient production techniques, communication technologies, and transportation modes have spread worldwide (Table 1.1), the world has become "flat"[2]— markets have shifted from being national to global in scope, and competition has become dramatically more intense and dynamic. The playing field has been leveled.

Political changes have paralleled and accentuated these technological changes. For nearly half a century following World War II, most of the world's population lived and worked outside the free-market system. Countries such as the Soviet Union, China, and India, as well as many others in Africa and South America, had socialist policies that minimized competition and rejected global integration. As the Cold War came to an end at the close of the 20th century, however, the world order changed dramatically. The legitimacy of command-and-control economies everywhere came into question, and countries that were once economically stagnant adopted free-market systems in pursuit of economic prosperity, wealth creation, and social development.[3]

Together, these technological, economic, and political changes worldwide are challenging the existing economic order and sources of value and competitive advantage. While in the previous century U.S. businesses could compete in world markets on the basis of cost, that luxury no longer exists in the 21st century; the cost of labor is far cheaper in most other countries. Low-wage nations can easily perform manufacturing work that is labor intensive and difficult to automate. The same is increasingly true for services such as call centers, software programming, and data storage and management.

Table 1.2 The Changing U.S. Economy: 20th Century vs. 21st Century[4]

Indicator	1960	21st Century
Composition of workforce		
College graduates*	7.7%	27%
Managerial, professional, technical workers	22.1%	34.8%
Production workers, handlers, laborers	44.4%	27.1%
Women	32.3%	46.3%
Technology development and application		
Manufacturing productivity (1992 = 100)	34.1	173.8
R&D expenditures (2000, $millions)	$51,382	$298,862
Industry contribution	33.0%	71%
Scientists and engineers in industry (thousands)	300.0	997.9
Patents issued	47,169	183,187
Economic and social well-being		
Per capita income	$10,386	$36,714
Average annual earnings per FTE worker	$18,124	$40,690
Infant mortality (per 1,000 live births)	26.0	6.3
New single-family home, median square footage**	1,385	2,237

Source: Adapted and updated from Montana et al. 2001.
** Percentage of adults 25 years and older. ** Initial figure is for 1970.*

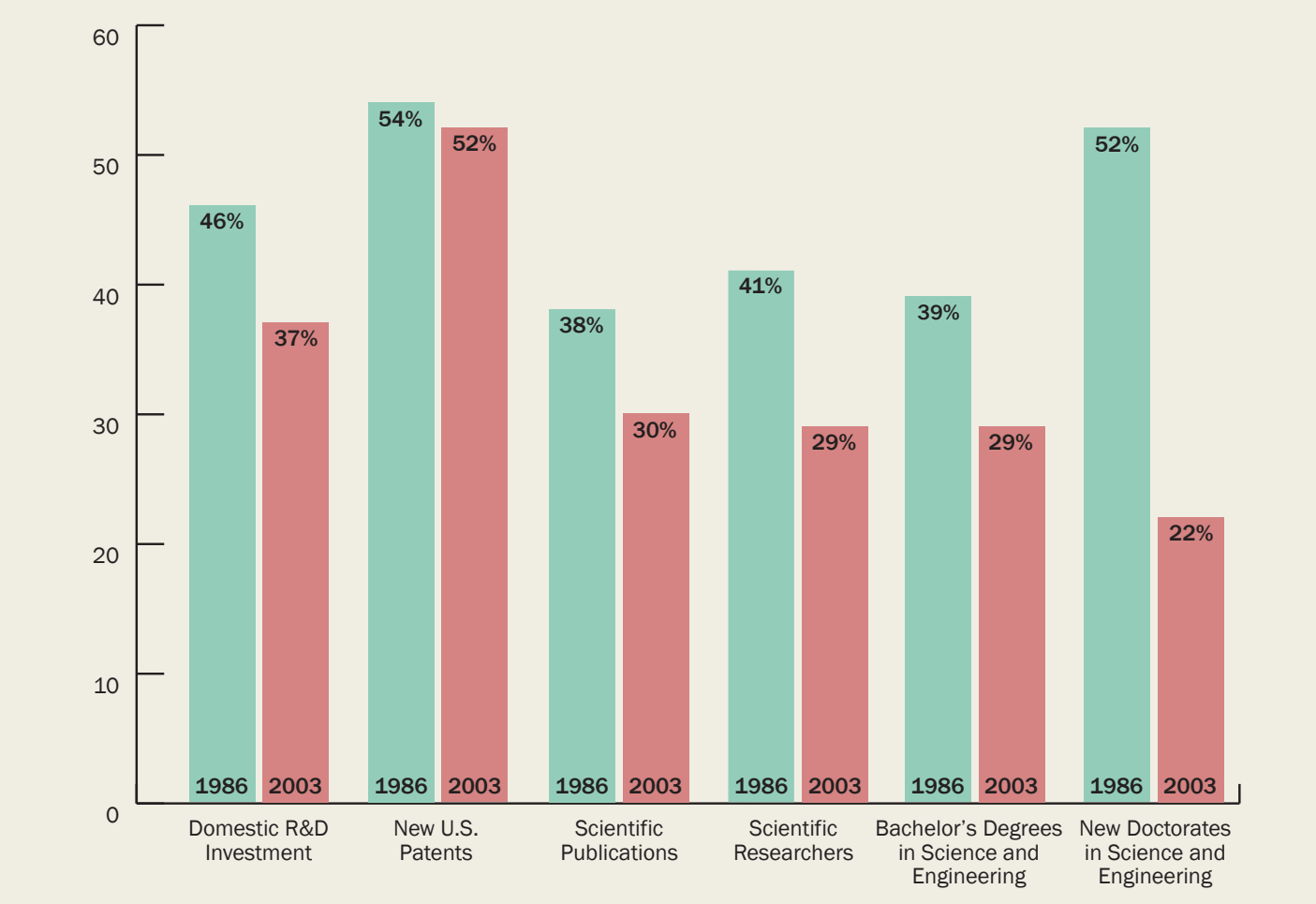
Cost, however, is not the only basis on which to compete. U.S. businesses now compete primarily on the basis of value (Table 1.2). For decades, America has invested in its knowledge-based economy by funding research, technology development, and scientific education. These strategic investments have created an unparalleled knowledge and innovation infrastructure that allows us to discover new ideas and turn them into products and services. These ideas increasingly are taking the form of packaged intelligence that is less cost sensitive because, in the 21st century economy, quality and timeliness often matter more than quantity.

The value of knowledge-based products and services resides in their uniqueness or novelty, in their ability to provide new or improved high-quality functions or uses, and in their convenience for the end-user.

Yet, the United States cannot not grow complacent with the current advantage it has in science, technology and innovation. Is innovation infrastructure—its underlying science and technology assets—still leads the world across a wide range of measures. But its successes have encouraged other countries to follow its example and boost their innovation infrastructures, just as they have with economic and governmental reforms.[5] Increasingly, the quality, coordination, and timing of a government's innovation-based investment strategies are becoming the primary determinants of its economic success and prosperity.[6]

Notably, the United States' shares of worldwide domestic R&D spending, new patents, scientific publications and researchers, and bachelors and new doctorate degrees in science and engineering all decreased between 1986 and the beginning of the 21st century (Figure 1.1). In addition, the U.S. ranks 14th among countries for which the National Science Foundation tracks the number of science and engineering articles per million inhabitants, 7th among OECD[7] countries in the percentage of GDP devoted to R&D expenditures, 33rd in the percentage of 24-year-olds with a math or science degree out of 91 countries for which data are available, and 15th in broadband penetration and speed and 18th in broadband price among OECD nations.[8] When ranked against all countries on broadband penetration (percentage of homes connected), the United States came in 24th.[9]

Figure 1.1 U.S. Share of Global Output across a Range of Science and Technology Measures is Falling.



Source: Council on Competitiveness 2007.

"[I]n each decade the relationship between individuals, markets, and communities will evolve as technology and rising expectations challenge each generation's vision of what is possible and best."

Gordon Brown, Great Britain's Chancellor of the Exchequer (now Prime Minister), February 2003

The United States can no longer take for granted its leadership in science, technology, and innovation.

Science and Technology: Key Drivers of Innovation, the Economy, and Governance

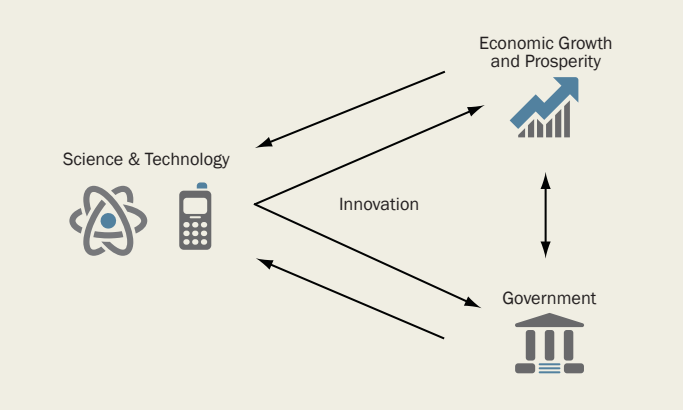
The importance of science and technology is not new. Throughout history, science and technology have been the foundation of society and civilization. New ways of shaping, arranging, and combining matter have brought about the development of tools, products, processes, and services such as the wheel, sailing ships, the plow, agricultural irrigation systems, municipal water and sewer systems, the internal combustion engine, the telegraph, audio and video, accounting processes, and medicines and medical technologies. Each generation of civilization has built on the technological achievements of prior generations and used them to create new possibilities and wealth and security.[10] As such, science and technology are dominant and determinant drivers in:

- Generating socially beneficial knowledge;
- Spurring the innovation and entrepreneurship indispensable to a dynamic global economy;
- Leading high value-added industries and businesses formation;
- Enabling high-wage, high-skill economies to compete with lower-wage economies;
- Promoting regional and community development;
- Ensuring public safety and health;
- Enabling enriched cultural and leisure life;
- Ensuring broad civic participation in the policy making process.

Fundamentally, societies use science and technology to facilitate the efficient production and allocation of the things they value. Those things include both scarce resources (food, clothing, shelter, energy, water) and intangible ideals (security, safety, equality, liberty, justice). A society's economy is the primary allocator of scarce resources,[11] and its government plays a key role in helping to allocate both tangible resources and intangible ideals.[12] It follows, then, that because allocation is central to both the economic and the governmental arenas, and because science and technology are the key means with which people produce and secure their resources and ideals, at any given time a society, its government, its economy, and its science and technology are part of a larger self-reinforcing ecosystem of production and allocation (Figure 1.2).

Innovation—the creation and adoption of new products, services, and business models—is what makes this system dynamic.[13]

Figure 1.2 The Dynamic, Self-Reinforcing System of Production and Allocation in a Society

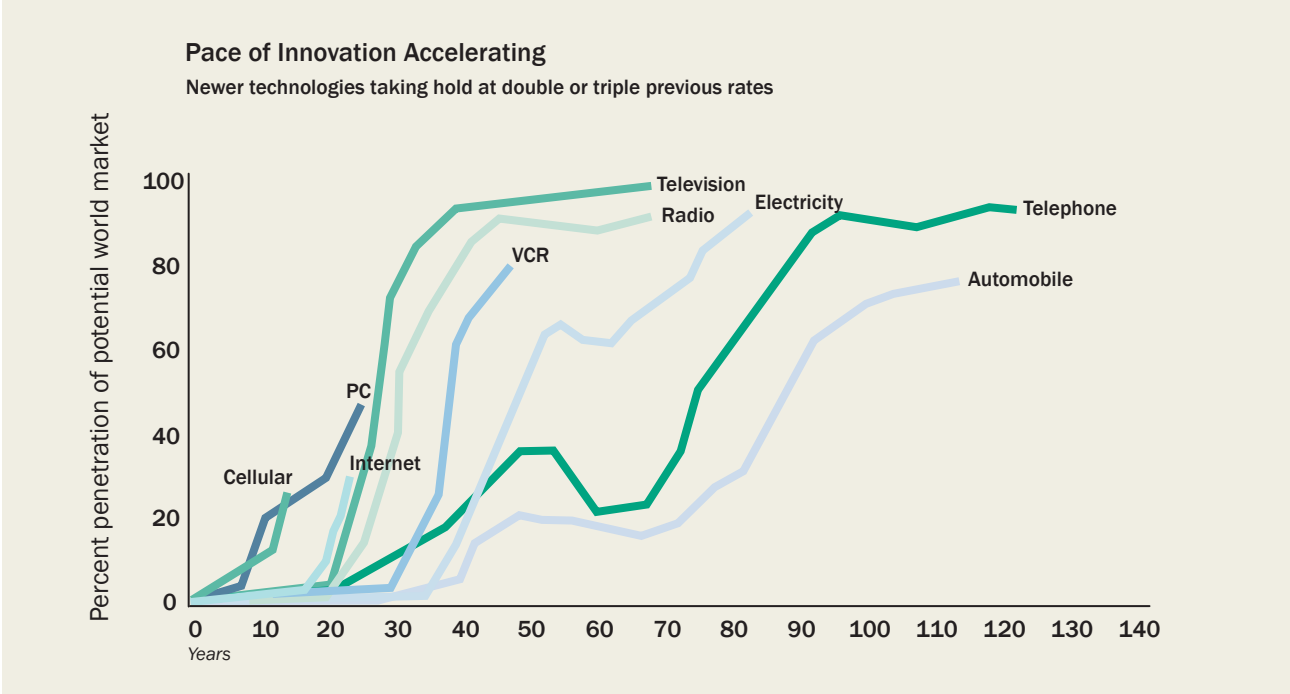


Thus, while technology-led development has been around for thousands of years, its importance has never been greater. At the dawn of the 21st century, this self-reinforcing system has become more tightly linked and dynamic than ever (Figure 1.3).

Science and technology are evolving globally at an unprecedented pace—generating increased innovation and radical changes in economies and governments worldwide—which ultimately fuels the further development and urgency in the evolution of science, technology, and innovation. This is the new reality we face.

North Carolina cannot escape this dynamic global system; in fact, it should embrace and maximize the benefits it yields.

Figure 1.3
Technology advances are diffusing at an ever-increasing rate. For example, it took 80 years for the automobile to spread to more than a quarter of the potential world market, 40 years for the telephone, 25 years for the radio, just under 20 years for the PC and the Internet, and only 13 years for the cell phone.
Source: Global Innovation Outlook, 2004, IBM



Science, Technology, and the 21st Century Economy

As the first decade of the 21st century draws to a close, we have learned much about the new economy in its formative stages. During the "dot.com" boom of the late 1990s and early 2000s, for example, multiple self-appointed prophets preached that the emergence of a new economy would wipe away the old economic order and replace it with a new order in which the economic cycle disappeared and we had only ever-increasing economic expansion. Skeptics, however, pointed to the dot.com bust during the early part of this century as evidence that the new economy never existed and that the old economic realities simply would continue unchanged.

The truth probably lies somewhere between the transformational claims of the new economy prophets and the cynical assertions from those who believe nothing has changed. Information technology has remarkably revolutionized and increased productivity; science and technology have sparked ever-new products and services; and the Internet has revolutionized the transfer of information. Despite these transformational technological changes, however, we cannot ignore the human element of the economic equation. The economy still relies on basic infrastructure, good corporate management, a strong talented and educated workforce, and governmental support and regulation.

The new economy, in actuality, is a blend of the old and the new. Moreover, it is not static; it is a constantly evolving mosaic of qualitative and quantitative factors that transform the rules of the game for how people and businesses interact (Table 1.3). The new economy is just now entering its adolescence, and as it continues to evolve and change over time, its impacts will reverberate across the globe, wash across the United States, and test the very foundations of each of the 50 states. The degree to which nations and states prosper in the face of these impacts will depend on how quickly and effectively they respond to the challenges they are presented. Those who anticipate, understand and nimbly adapt to the new rules of the game will be well positioned to compete in the new economy; those who do not will face a very uncertain future.

> *"No amount of savings and investment, no policy of macroeconomic fine-tuning, no set of tax and spending can generate sustained economic growth unless it is accompanied by the countless large and small discoveries that are required to create more value from a fixed set of natural resources."*
>
> *Paul Romer, Economist*
> *1993*

Table 1.3 Characteristics of The Old and New Economies

Issue	Old Economy	21st Century Economy
Markets	Stable	Dynamic
Scope of competition	National	Global
Organizational form	Hierarchical	Flat/networked
Production system	Mass production	Flexible production
Key factor of production	Capital/labor	Innovation/ideas
Competitive edge	Economies of scale	Innovation/quality
Prevailing value	Efficiency	Diversity/creativity/networking
Relations between orgs	Go it alone	Collaborative/strategic partnerships
Skill	Job-specific (trained)	Broad/changing (adaptive/versatile)
Workforce	Organization man	"Intrapreneur"

Source: Modified from Atkinson and Correa 2007.

Today's 21st century economy is:

- **Knowledge Dependent:** Between 1979 and 2003, U.S. managerial and professional jobs increased as a share of total employment from 22 percent to 35 percent. Moreover, only 14 percent of U.S. workers are currently employed as production workers in manufacturing, and even there, knowledge and continual life enhancement are becoming increasingly important.[14]

- **Global:** Since 1980, global trade has grown 2.5 times faster than gross domestic product. The combined total of U.S. exports and imports increased from just 11 percent of GDP in 1970 to 25 percent in 2004. Service exports have grown even faster than goods exports, increasing from 18 percent of total exports in 1980 to 30 percent in 2005.[15]

- **Entrepreneurial:** From 1980 to 2001, all of the net U.S. job growth came from firms less than five years old; older firms lost jobs. From 1996-2004, about 550,000 new businesses started each month in the United States. Seven out of 10 new jobs are created by entrepreneurial businesses, and since World War II, "smaller entrepreneurial firms have been responsible for 67% of all inventions and innovations and 95 percent of all radical innovation in the United States."[16]

- **Rooted in Information Technology:** In 2003, business-to-business e-commerce amounted to $1.8 trillion worldwide, and business-to-consumer e-commerce amounted to $143 billion. In 2005, there were more than 20,000 computer networks and close to a billion users around the world. By 2006, almost three-quarters of U.S. adults were online, and more than 52 million U.S. households, or 47 percent, had broadband access.[17]

- **Driven by Innovation:** Between 1980 and 2002, business-funded research & development has nearly doubled, from 1.19 percent to 2.02 percent of U.S. GDP. Moreover, since 1984 the number of patents issues has almost doubled, with more than 166,650 issued in 2002.[18]

> *"The choice is straightforward: in the 21st century, a developed nation can either innovate or evaporate. It can invest in the future, or it can enjoy the present until the present becomes the past."*
>
> *Norman R. Augustine, Retired Chairman and Chief Executive Officer, Lockheed Martin, Corporation, Co-Chair, National Innovation Initiative Advisory Committee, 2008*

Science, Technology, and 21st Century Government

Just as science and technology have transformed the economy, so too have they transformed government. To succeed in this new environment, governments are adopting integrated strategies and responding to the need to adapt their governance structures and tools to work with, not against, the changes driven by science, technology, and the economy.

In this setting, the most important roles for government are to maximize the strengths and minimize the weaknesses of the market-based economy—to ensure macroeconomic stability and promote open and competitive markets—as well as to take proactive steps to stimulate and support innovation. In other words, governments increasingly recognize that they play two roles in the innovation economy: creating a general landscape on which economic activity can flourish, and targeting the specific conditions that encourage innovation to take place and diffuse throughout the economy.

Science, technology, and innovation are not just about economic vitality, however. They also serve as a common thread linking government's many functions. For example, when reviewing the list of executive-branch agencies for the U.S. government or any of its 50 states, it is clear that science and technology play a crucial role in all of them. Results from scientific research inform and guide administrative policy on a wide range of issues, technology and engineering change how the departments perform their operations, and information technology affects the flow of information both inside the unit and with other departments (Figure1.4).

This role is not limited to the executive branch; it also impacts the legislative branch. As society and the economy become more technical, our legislative apparatus will be called upon increasingly to absorb new scientific results and understanding into the policy-making process and to adapt to a more flexible policy process for supporting and regulating new technologies and innovations. Most notably, the legislative committee system needs to reflect current needs. The committee system is a legislature's manner of gathering and analyzing information, just as agencies do for the executive branch.

Most governmental institutions, such as executive branch agencies and legislative committee systems, evolve incrementally and do so with a considerable lag time behind changes occurring in the broader society. To the degree that these institutions do not reflect the realities of the society they serve, they will fail to allocate that society's ideals into legitimate and effective public policies. The same changes that drive the need for government change also enable change in government (Table 1.4).

Figure 1.4 Examples of how science and technology play a role in executive branch agencies.

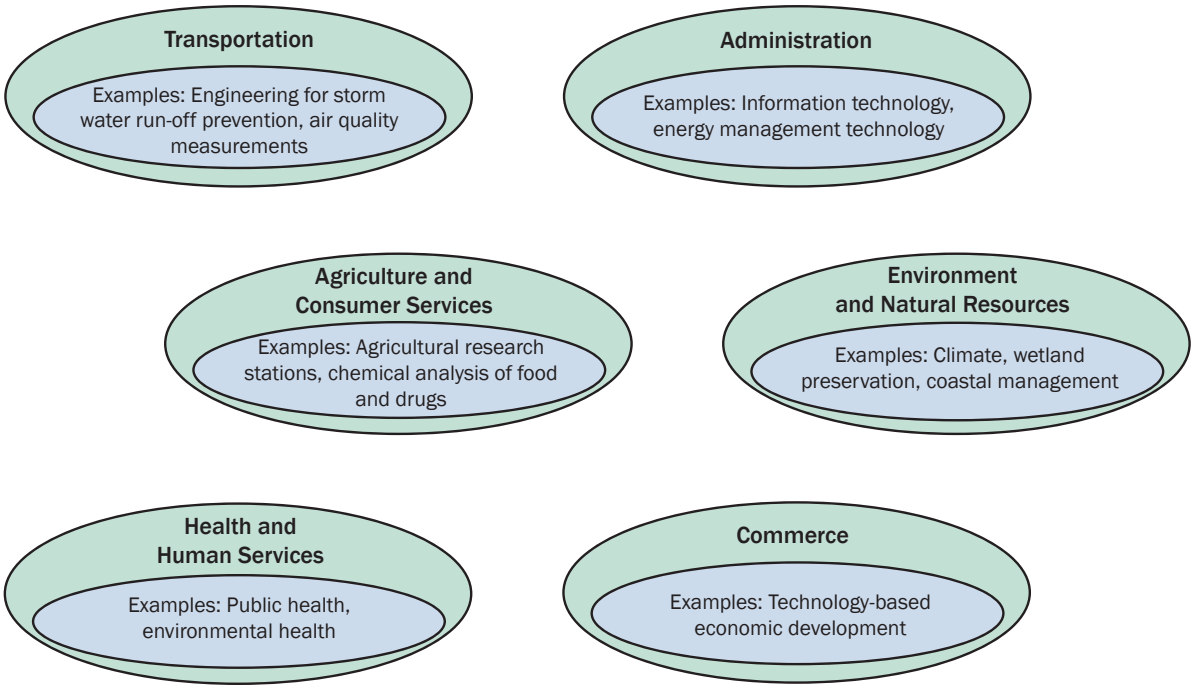


Table 1.4 The Old and New Government Approaches

Issue	Old Government	21st Century Government
Organizational form	Top-down control	Bottom-up complex systems
Nature of decision making	Hierarchical/rule-driven	Flexible/entrepreneurial
Locus of authority	Bureaucratic programs	Political entrepreneurs
Nature of information	Bureaucratically controlled	Freely available
Source of policy solutions	Bureaucracy	Markets
Determinant of behavior	Compliance with rules	Accountability for results

Source: Adapted from Goldsmith and Eggers 2004.

As with the economy, the degree to which nations and states prosper in the face of these impacts will depend on how accurately they anticipate and how quickly and effectively they respond to the challenges they are presented. Those governments that understand and try to accommodate needed changes will be well positioned to foster and encourage competition in the new economy; those that do not will face uncertain futures. Today's 21st century government must be:

- **Knowledge Dependent:** The problems governments are expected to address are increasingly complex and technical. As little as two decades ago, issues such as Internet privacy and safety, nanotechnology, stem cell research, and cyber/bioterrorism did not exist. Now they are front and center on governments' agendas, as is the need for information about how best to address them. Even long-standing issues, such as agriculture, the environment, and warfare, call for increasingly technical, innovative policy solutions.

- **Fast-Moving and Efficient:** Complex, technology-driven issues have increasingly short "half-lives."[19] By accelerating change and making the economy and society more complex, science and technology place a premium on government policies that can easily adapt to changing circumstances over time and across several interrelated spheres.

- **Entrepreneurial and Flexible:** Adaptable solutions require entrepreneurial, flexible government. Without the flexibility to respond on an as-needed basis, government runs the risk of lagging behind technological changes, causing it to act as either a rate-limiting factor for positive change or an ineffective regulator of potentially harmful activities.

- **Enabling and Facilitating:** Flexible solutions are more likely when people have access to information and can learn from and implement innovative solutions being applied across the nation and other states. With ever-evolving information technologies serving as the "central nervous system" of government communication, government has the opportunity to create dynamic systems and policies that suit the changing economic and societal realities.

- **Accountable and Accounting:** Information technologies can also help governments create systems of accountability and enable them to measure their progress toward a variety of goals. The key is getting quality data, analyzing them, disseminating them, and then using the findings to drive needed changes.

> *"We won't experience 100 years of technological advance in the 21st century; we will witness on the order of 20,000 years of progress, or about 1,000 times greater than what was achieved in the 20th century."*
>
> *Ray Kurzweil, Inventor and Futurist, 2001*

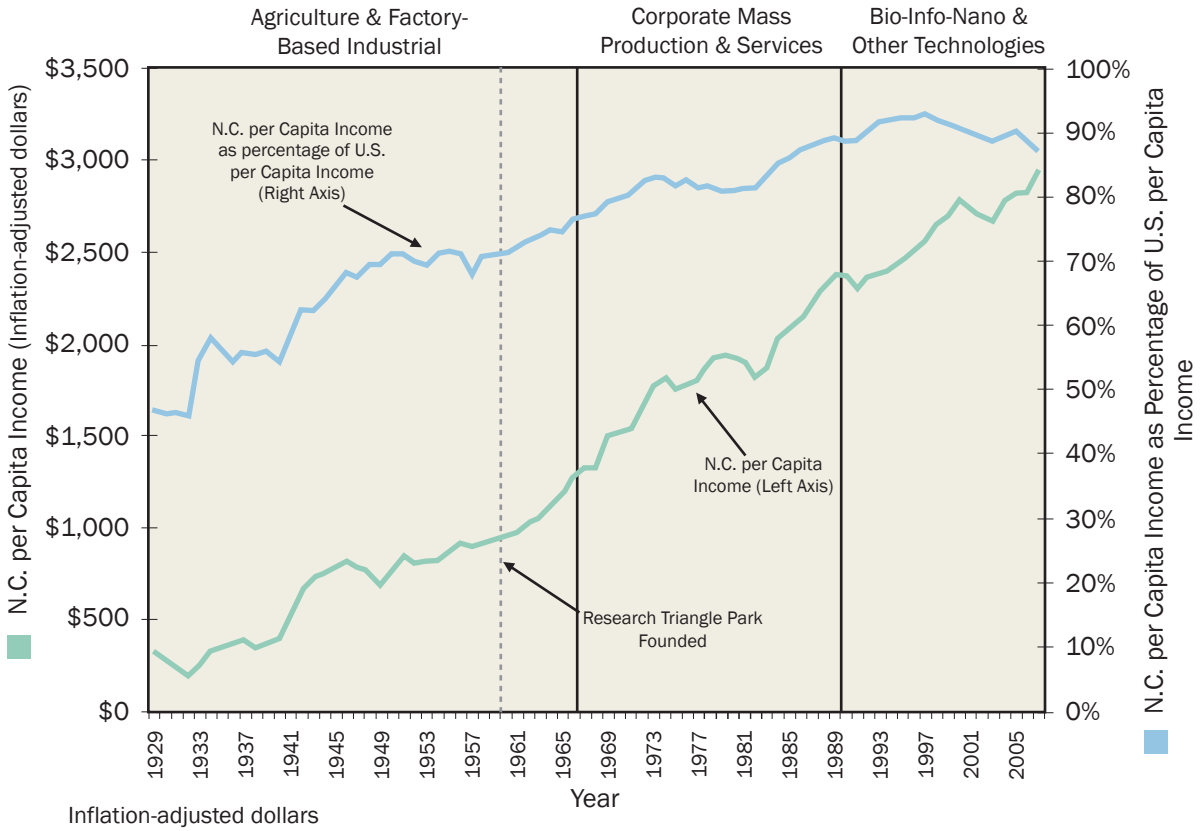
North Carolina's Response

Taken together, the 21st-century transformations of our economy and society are unprecedented in their degree and speed. However, their underlying nature—change—is not new, nor is our willingness and ability to meet the challenges and opportunities change presents. North Carolina has successfully transformed itself several times in response to new technologies and scientific discoveries in past decades (Figure 1.5). In the late 1800s, for example, changes in agricultural technology rapidly increased agricultural productivity. Federal and state governments sought to accelerate this trend by establishing land-grant institutions (e.g., NC State University; NC A&T State University) to train citizens in new agricultural and mechanical knowledge, and later started the Cooperative Extension Services to disseminate this knowledge further.

The next major changes occurred in the decades following World War II, when farm employment began to fall rapidly and employment in manufacturing and services rose rapidly.[20] State economic policy responded to this shift by focusing on recruiting manufacturers to the state to improve the economic livelihood of its citizens. Other aspects of state government—such as the Department of Commerce and the Industrial Extension Service—were similarly modified or created to handle the new realities.

Perhaps the most notable response happened in the late 1950s, when a group of the state's education, industry, and government leaders began to advance the idea that the state's three research universities—located in Raleigh, Durham, and Chapel Hill—could act as magnets to attract companies, particularly those focusing on research and development. This vision led to the formation of the Research Triangle Park, now the largest and arguably best-known research park in the world. Its economic impacts are felt throughout North Carolina, and it is in large part responsible for North Carolina's reputation as a leader in science and technology. Yet, the Park's success was far from certain when it was envisioned nearly 50 years ago. In fact, at the time of its founding, few people anticipated the impressive level and scope of activity it has achieved to date.

Figure 1.5 Waves of economic change in North Carolina driven by new technologies, 1929-2007



Source: State Annual Personal Income, Bureau of Economic Analysis, U.S. Department of Commerce.
Per capita income data are inflation-adjusted, with 1929 as the base year; this shows the real increase in North Carolina's per capita income.
Using non-inflation-adjusted data, North Carolina's per capita income is $33,636 in 2007.

Given this historical context, the economic transformation of the past 15 years can be seen as a new chapter in our history, one that is rooted in technological change.[21] Past changes, while challenging in the short run, ultimately led to increased per capita income for North Carolinians.[22] Those gains appear to be slipping, however, as North Carolina's per capita income as a percentage of U.S. per capita income has decreased in recent years (Figure 1.5). To continue our gains from the past, we must continue to embrace the challenges and opportunities that science and technology present to ensure North Carolina's competitive edge and prosperity in the 21st century.

As outlined in the appendix and discussed in Chapter 3, since 2000 North Carolina has undertaken a large number of initiatives to advance innovation throughout the state. But we cannot stop with those initiatives. In fact, more than ever before, we must affirm and advance innovation as a fundamental value of the state. We must advocate for investments and support for innovation as a companion to education as our strategic building blocks in economic development. We must infuse an emphasis on innovation into every aspect of life in North Carolina, building on our current positioning as "The State of Minds."

Moving Forward

What does all of this suggest for the future, and how can and should North Carolina respond and adapt? This report addresses those questions.

The next chapter reviews the history of North Carolina's science and technology-based innovation economy, paying particular attention to the way we compete in the new economy and to our strengths and weaknesses. It compares North Carolina to other U.S. states, ultimately showing that North Carolina has enjoyed a long period of success in the realm of basic science, due primarily to its early, sustained, and significant investments in higher education. While these investments have served the state well on many fronts, they are insufficient for creating continued high levels of economic growth and prosperity in the modern innovation economy. Moreover, the state's innovation assets and activities are heavily concentrated in metropolitan areas, causing disparities in economic development and prosperity across the state. North Carolina can and must continue to do more to strengthen other aspects and regions of its innovation economy. A careful reading of the empirical evidence shows the areas most in need of attention.

The third and concluding chapter recommends a new framework, specifically tailored to North Carolina, to equip it to increase and maintain its leadership position in the science- and technology-based innovation economy. Building on the state's existing institutions, programs, and policies, the framework would enable government to be a facilitator that encourages companies and other organizations to innovate in ways that optimally serve the public interest. The relationship among government, businesses, and other organizations would be an interactive and ongoing process of strategic cooperation between the public and private sectors which, on the one hand, serves to elicit information on business opportunities and constraints and, on the other hand, generates policy initiatives in response.

The new framework, founded on ten guiding principles, is operationalized through enhancing five roles that are uniquely in the hands of public leaders and implemented by three institutional leaders: an enhanced North Carolina Board of Science and Technology, an optimized Science and Technology Advisor, and a General Assembly committee structure that is more closely aligned with the needs of the 21st century innovation economy. Implementing the framework entails engaging in and supporting four core innovation drivers that recognize, respect, and build upon the state's regional differences to both increase the overall level of innovation and distribute it more evenly throughout the state through flexible and adaptive programs.

While these economic and governmental changes are novel and transforming, North Carolina will confront them and adapt, just as it learned and adapted during previous periods of change.

> *"It is not the strongest of the species that survive, nor the most intelligent, but the ones most responsive to change."*
>
> *Charles Darwin, Naturalist, 1859*

North Carolina's Innovation Performance

Key Points

- North Carolina has enjoyed a long-standing leadership position in university-led basic research.
- North Carolina has had less success in translating basic research into innovation-based economic and societal rewards.
- North Carolina's performance across a range of indicators showing its innovation performance is mixed, ranking at or below the U.S. average on a majority of factors.
- Understanding North Carolina's performance on relevant indicators requires examining not only the state as a whole and its history, but also differences across regions within the state.
- North Carolina's innovation assets and activities are geographically concentrated in metropolitan areas that are distributed broadly across the state.
- Though the degree of North Carolina's concentration is not uncommon among U.S. states, it presents a set of challenges and opportunities on which to focus an enhanced innovation framework that recognizes, respects, and builds upon regional differences.

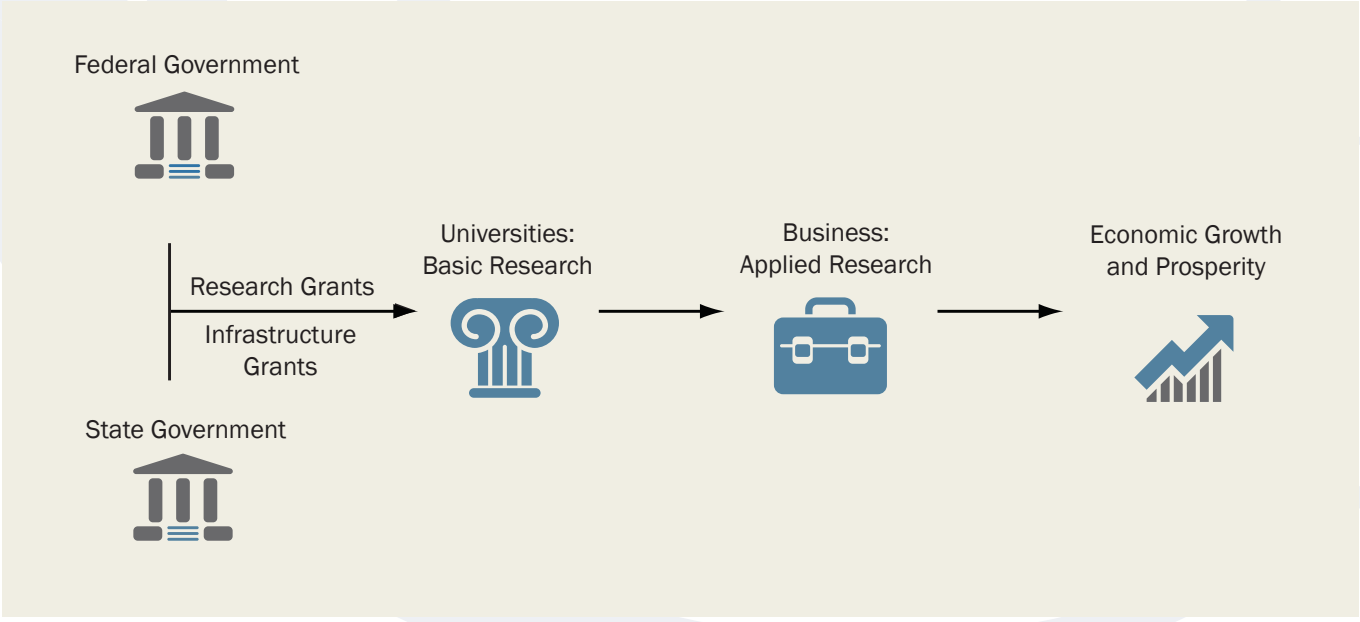
Traditional Innovation-Based Economic Development

The traditional view of innovation-based economic development assumes that building "basic" (or "fundamental" or "pure") research capacity automatically, and almost magically, leads to economic growth and prosperity. [23] This view was popularized by the first presidential science advisor, Vannevar Bush, appointed in 1939 by President Roosevelt and largely credited as the architect of the federal government's role in scientific research after World War II. He advanced the idea that "as long as scientists are free to pursue the truth wherever it may lead, there will be a flow of new scientific knowledge to those who can apply it to practical problems."[24]

The federal government has largely followed this linear model for the past 60 years in distributing science and technology funding toward basic research (Figure 2.1).

Conventional wisdom has said that increased basic research capacity will lead automatically to economic growth.

Figure 2.1 Traditional View of Government's Role in the Innovation Economy



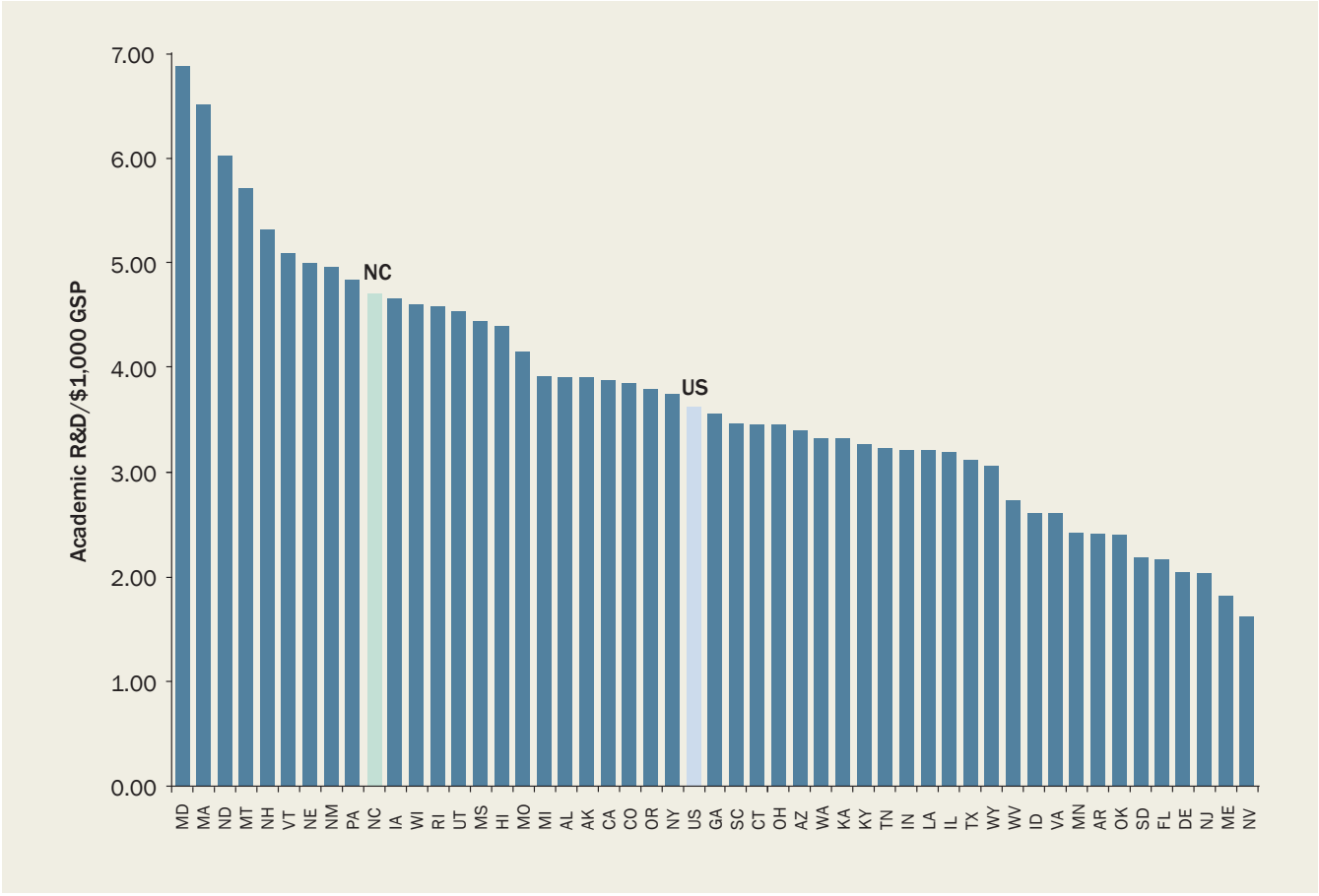
Many states, including North Carolina, have crafted their science and technology-based economic development strategies to focus on expanding their academic research capacity.[25,26] The idea that basic science alone will promote economic development and prosperity was given credence in the 1980s by studies that found university basic research was adopted by local companies and that a university's presence induced commercial innovation.[27]

In advancing basic science through its higher education system, North Carolina has done remarkably well. It has a strong, well-regarded higher education system, with 16 public universities in the University of North Carolina system, 58 public community colleges in the North Carolina Community College System, and 36 independent private colleges and universities. These universities and colleges are distributed widely across the entire state. Of these institutions, six universities boast high or very high research activity as defined by the Carnegie Classifications.[28] Because of the large number of research universities, North Carolina ranks high in academic research. In terms of academic research intensity, measured as academic R&D as a share of gross state product (GSP), North Carolina ranks very high (10th) among U.S. states and well above the U.S. average (Figure 2.2).

Modern Innovation-Based Economic Development

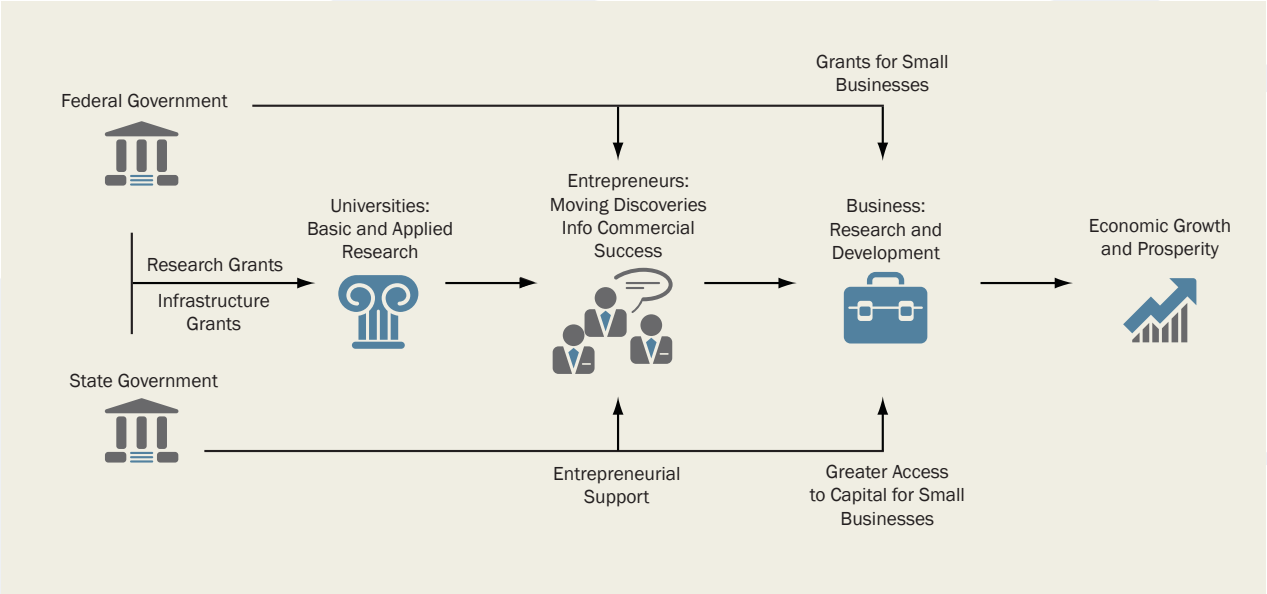
Basic research prowess, while clearly important, does not, however, automatically or easily translate into local economic gain or prosperity. In fact, a growing body of studies indicates that while research universities do generate substantial numbers of research discoveries, those discoveries often go unused by local organizations or instead flow out of state. *Simply stated, valuable research does not directly translate into valuable innovation.* Those studies have also found that while successful regions have a source of basic science, such as a university or national lab, they also have mechanisms in place that allow the region to transform and absorb the gains from research.[29] This important finding suggests new areas for government participation in the innovation economy, in particular through entrepreneurial and commercialization support (Figure 2.3).

Figure 2.2 State Rankings in Academic R&D per $1,000 of Gross State Product, Dollars, 2005
North Carolina ranks 10th in the nation and well above the U.S average in academic R&D.



Source: National Science Board, Science and Engineering Indicators 2008.

Figure 2.3 New View of Governmental Role in the Innovation Economy



Studies have found that basic, university-based research does not automatically translate into local economic gain.

North Carolina's Ranking in the Modern Innovation Economy

Where does North Carolina as a state stand in this modern innovation economy? Figure 2.4 shows a recent ranking of the 50 U.S. states in terms of the new science and technology-based innovation economy. Overall, North Carolina ranks in the middle (24th). This finding, while surprising to many, has remained roughly the same for more than a decade and is supported by several other similar rankings.[30] The basis for the ranking becomes clearer when examined in more detail.

Figure 2.4 State Rankings in Science, Technology, and Innovation.
North Carolina overall ranks 24th in the nation in terms of its science and technology-based innovation economy, according to a recent ranking of states.
(Reproduced from the Information Technology and Innovation Foundation's 2008 New State Economy Index)

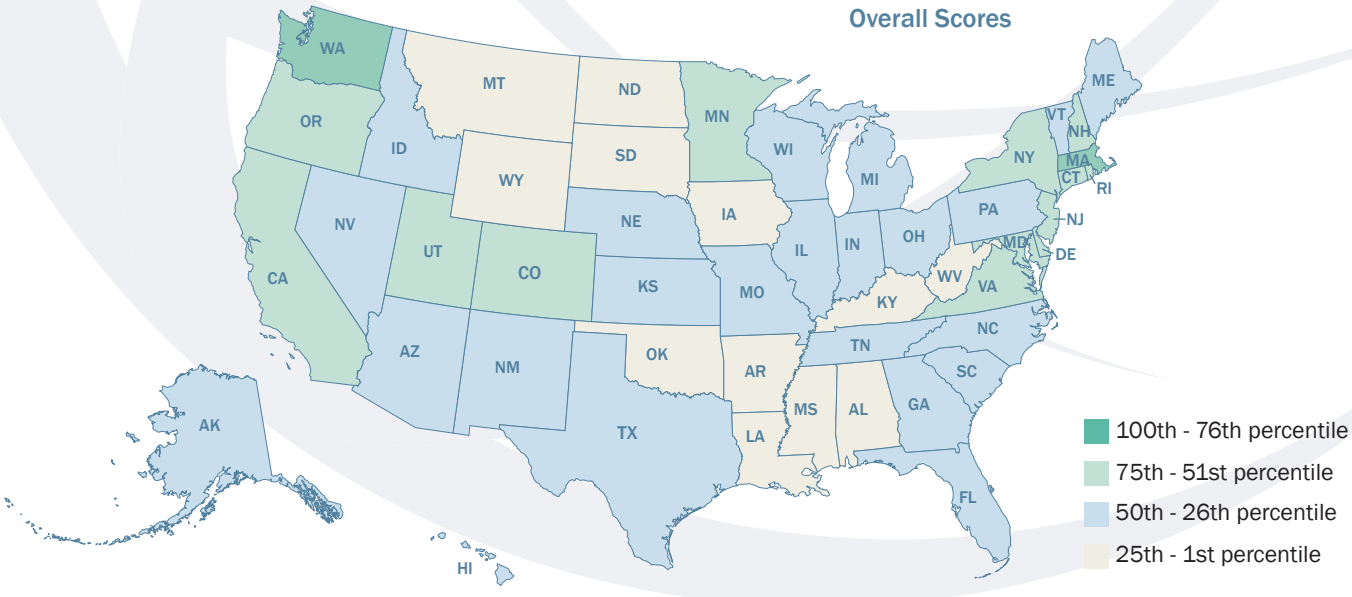
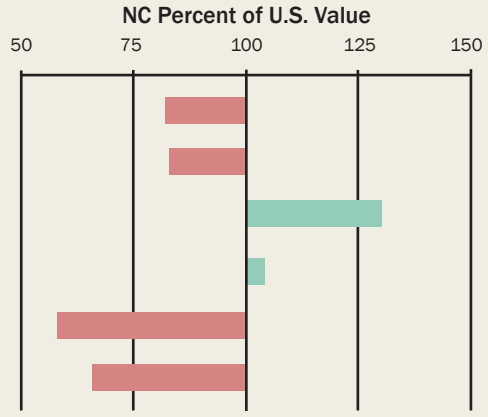


Figure 2.5 North Carolina's Performance on R&D Activity Indicators.

R&D Activity	NC Rank
Total R&D as Share of Gross State Product (2004)	23
Industry-Performed R&D as Share of Private-Industry Output (2005)	19
Academic R&D per $1,000 of Gross State Product (2005)	10
Academic Articles per 1,000 S&E Doctorate Holders in Academia (2006)	15
Federal R&D Obligations per Civilian Worker (2005)	24
Federal R&D Obligations per Individual in S&E Occupation (2005)	27



North Carolina ranks at or below the U.S average on several indicators related to a state's performance in the innovation economy.

To that end, the modern view of a science and technology-based innovation economy suggests that four areas are important to examine further to understand North Carolina's performance:

1. **Research and Development Activity**
2. **Commercialization Activity**
3. **High-Tech Economic Activity**
4. **Human Capital Resources**[31]

The sections below examine North Carolina's performance in these four key areas.[32] Two patterns clearly stand out and serve as the basis for understanding how to equip North Carolina to build and maintain a leadership position in the innovation economy[33]:

- **North Carolina ranks at or below the U.S. average on several indicators of its innovation-related assets and activities.**
- **North Carolina's innovation assets and activities are geographically concentrated in metropolitan areas that are distributed broadly across the state.**

Research and Development (R&D) Activity

R&D is critical to the innovation economy; it is the driving force behind innovation and sustained economic growth and prosperity. Companies, universities, and research institutions performing R&D create numerous product innovations, thus potentially expanding markets and sales, stimulating investment, and ultimately creating jobs and prosperity. The level of a state's R&D spending gauges the extent to which R&D plays a role in a state's economy and is an input to innovation and economic growth.

North Carolina's R&D Performance Compared to Other States

North Carolina's performance varies considerably across the mix of indicators of its R&D activity (Figure 2.5).

Most generally, in terms of total R&D (academic + industry + all other) as a share of gross state product, North Carolina ranks 23rd in the nation, with an activity level that is 82 percent of the U.S. value. In other words, the total amount of R&D in North Carolina is only 82 percent of what we would expect based on national levels of R&D. Moreover, the level of its total R&D is only one-fourth the level of the top-ranking state (New Mexico).[34]

This modest ranking reflects the relative distribution of academic R&D to industry R&D, as well as the levels, within North Carolina and nationally. In particular, North Carolina's academic R&D level is more than 125 percent of the U.S. level, while its industry R&D level is only 83 percent of the U.S. level and one-third of the leading state's (Michigan). Nationwide, industry R&D accounts for more than 70 percent of total R&D, meaning that North Carolina's low level of industry R&D puts it at a competitive disadvantage in total R&D. While the core strength of North Carolina's R&D activity is in its universities and colleges, in general academic R&D accounts for only a small portion of total R&D (12 percent nationally and 20 percent in North Carolina). *Thus, industry R&D, not academic R&D, is the primary driver of total R&D. Moreover, industry performs the large majority of applied R&D and obtains the majority of patents issued in the U.S. Together, these facts mean that the level of academic R&D is not strongly related to levels of technology commercialization.*[35]

The R&D pattern in North Carolina reflects the distinctive character and history of the state's research environment. North Carolina has a comparatively large number of colleges and universities for its population, and several are national leaders in the sciences and engineering, as evidenced by its higher-than-average performance on academic articles per 1,000 science and engineering doctorate holders in academia. However, reflecting the state's industrial and branch-plant roots, comparatively few companies within the state have significant research operations, which typically locate at or near company headquarters, which are often located outside of North Carolina. Moreover, North Carolina has a small number of federally funded research and development centers, which makes its ranking in federal R&D obligations relatively low.[36]

This blend of high levels of university research and low levels of industry and federal government R&D underscores the fact that, despite strong applied efforts at several universities, a large proportion of research conducted in North Carolina is basic in nature and therefore not heavily focused on industry requirements or direct economic outcomes. This fact underlies North Carolina's lower-than-expected performance on many of the other indicators discussed below. In addition, North Carolina ranks well below average in federal R&D obligations, which reflects the fact that the state has relatively few federal laboratories or large defense or other federal contractors.

North Carolina must go beyond academic research to remain competitive in the new economy.

While North Carolina's academic research is important for producing new knowledge and scientific stature, private industry R&D is more often the engine that translates the basic research discoveries into commercial products. This suggests that attention should be given to continuing to strengthen academic research, to improving industrial research performance, to recruiting and retaining the

Measuring North Carolina's Innovation Performance

Computing the Measures

Measuring North Carolina's innovation performance relative to the nation and other states entails a three-step process.

First, a reliable, valid, and up-to-date set of indicators is obtained. In this case, the *Science and Engineering Indicators 2008*, produced by the National Science Board, serve as those indicators.

Second, North Carolina's value for each indicator is expressed as a quotient reflecting the intensity of that indicator relative to the relevant base measure, such as gross state product, private industry output, civilian workers, etc. This standardizes the indicators by removing differences resulting from variations in state size. North Carolina's national rank on each indicator is then computed and presented.

Third, for each indicator, North Carolina's quotient value is divided by the United State's quotient value and multiplied by 100 to produce a percentage. The national average is 100, and so North Carolina's percent value for each indicator shows its performance relative to national patterns of activity.

Interpreting the Measures

Both the rankings and the percentages used here (in Figures 2.5, 2.9, 2.13, and 2.16) are valuable, but for different reasons.

Rankings show North Carolina's performance, in a purely rank-order sense, relative to other states. Higher ranks are clearly better than lower ranks. However, on some measures there is very little statistically significant difference between states and a simple ranking cannot account for this. Hence, rankings must be used appropriately and not be over-interpreted.

This is where percentages help. They show North Carolina's performance, in an interval sense, relative to the U.S. average. In contrast to rankings, the difference between two values can be accounted for and is meaningful, as it can be thought of as a measure of intensity for that indicator.

Thus, when measuring North Carolina's performance, it is better to know both its national rank and its percent of U.S. value. Each tells us something unique and helps us make sense of the other. Together, they provide more information than they would by themselves.

The two numbers typically track together (e.g., when one is high, so is the other). When they don't, it typically is when a small number of states dominate U.S. activity (e.g., see Venture Capital in Figure 2.9 below) or when there is little statistically significant difference between states (as with many of the Human Resources indicators in Figure 2.13 below).

types of companies that build headquarters and perform their R&D in the state, and especially to academic-industry collaborative research.

R&D within North Carolina

An examination of the distribution of R&D within North Carolina highlights one of the most salient characteristics of the state's innovation economy: It depends heavily on a few leading geographic technology clusters for its R&D.

In particular, academic research, a crucial innovation input and one of the state's strongest areas overall, is highly concentrated in the Research Triangle Park (RTP) region. In 2005, the three largest universities located in the RTP region—UNC-Chapel Hill, Duke University, and North Carolina State University—accounted for 83 percent of all academic R&D expenditures within the state (Figures 2.6 and 2.7; Table 2.1).[37] Sizable activity also exists at other universities throughout the state, however.

The state's R&D activities are heavily concentrated in a small number of geographic regions.

Figure 2.6 Total North Carolina Academic Research Expenditures by University.

Three universities in the Research Triangle—Duke, UNC-CH, and NCSU—region perform more than 80 percent of the state's academic research.

(Source: National Science Foundation. 2007. Academic Research and Development Expenditures: Fiscal Year 2005)

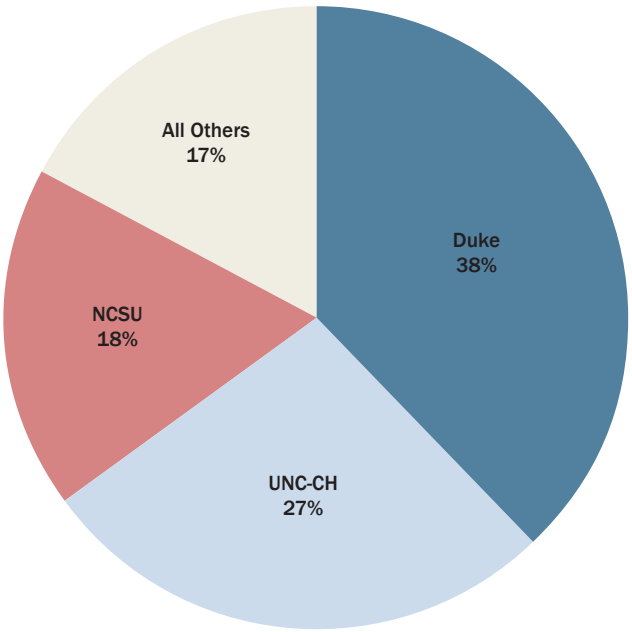


Figure 2.7 Geographic Distribution of University R&D Expenditures in North Carolina, Average Annual Expenditures, 2003-2005.

University R&D expenditures are most concentrated in the Research Triangle region, but sizable activity also exists at other universities throughout the state.

(Source: National Science Board, Science and Engineering Indicators 2008)

Table 2.1 Proportion of Statewide Academic Research Performed at Three Universities: Duke University, University of North Carolina-Chapel Hill and North Carolina State University, Fiscal Year 2005.

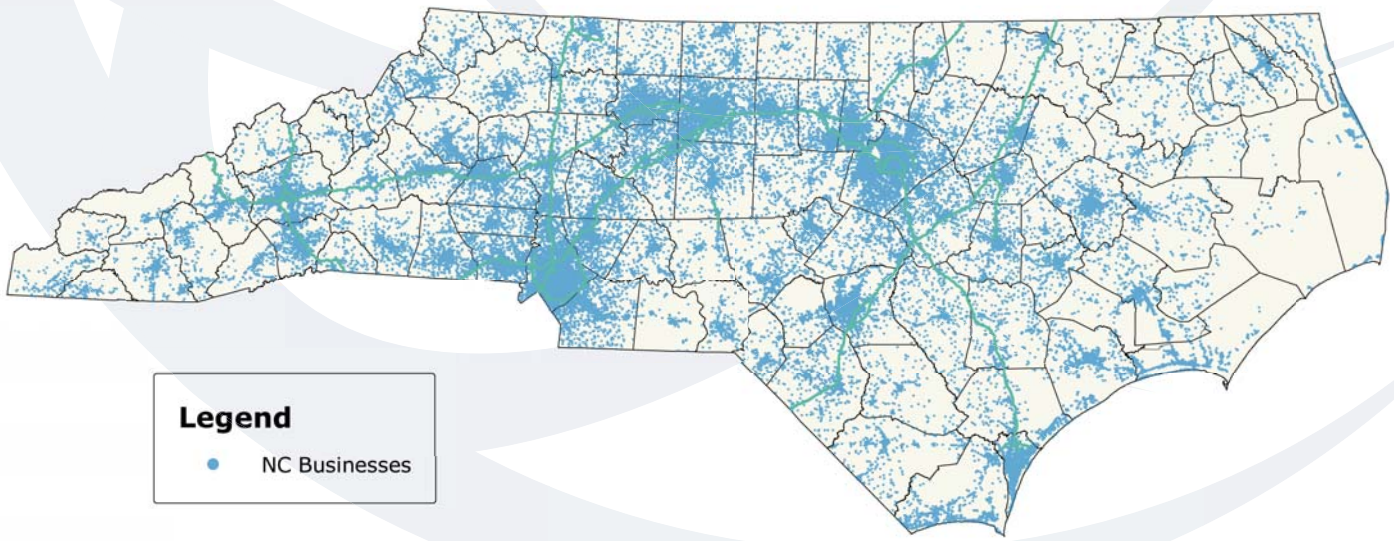
	Funding Source				
	All Sources	Federal Government	State/local Government	Industry	Others
All North Carolina Universities	$1,652,049	$1,011,116	$147,629	$199,728	$293,576
Duke University	$630,752	$376,568	$19,716	$134,608	$99,860
UNC-Chapel Hill	$441,033	$320,294	$20,846	$6,678	$93,215
NC State University	$303,596	$109,128	$92,125	$38,710	$63,633
Ratio of the Three Universities to All Universities	**83.3%**	**79.7%**	**89.9%**	**90.1%**	**87.4%**

Industry R&D across the state is also concentrated, largely in a pattern that reflects the location of the state's population and metropolitan regions. Statistics indicating the location and level of industry R&D within North Carolina are not available,[38] but it is possible to estimate the location by mapping the location of all businesses in North Carolina (Figure 2.8). Assuming equal rates of R&D across industries,[39] the distribution of businesses across the state gives an approximation of the distribution of industry R&D across the state. In general, the pattern suggests that industry R&D is most concentrated in metropolitan regions. It is also concentrated near universities and other academic centers, which are spread more broadly throughout the state.

Overall, this heavy concentration of R&D, the primary input to the innovation process, inevitably causes regional disparity in innovation capacity throughout North Carolina.

Figure 2.8 Geographic Distribution of Industry in North Carolina, 2007.
Industry is most concentrated in metropolitan regions. Assuming equal rates of R&D across industries, the distribution of industry across the state gives an approximation of the distribution of industry R&D across the state.

(Source: Harris Selectory Online, accessed August 2008)



Commercialization Activity

An infrastructure that supports the conversion of inventions to commercial innovations is central to advancing a dynamic technology-driven economy. Although many factors contribute to the process of converting science and technology research into innovative products or services, three of the most important are strong entrepreneurial teams, entrepreneurial funding (early-stage and venture), and the generation and protection of intellectual property. Absent champions, funding, and legal protection, the benefits of inventions typically go unrealized.

North Carolina's Commercialization Efforts Compared to Other States

As with R&D performance, North Carolina's performance across a range of commercialization activity indicators varies considerably (Figure 2.9)

The single largest source of early-stage funding for small businesses in the U.S. is the federally funded Small Business Innovation Research (SBIR) Program, which provides competitive grants to entrepreneurs to help finance R&D and to start-up and commercialize their innovative business ideas. The amount of SBIR funding in a state strongly correlates with successful technology-based economic development.

In terms of SBIR funding awarded per gross state product, North Carolina ranks 31st in the nation, with an activity level that is 54 percent of the U.S. value. Moreover, its per-GSP level of SBIR funding is only 10 percent of the leading state's (Massachusetts) and 20 percent of the second-ranking state's (Maryland). This relatively low level of early-stage funding suggests that North Carolina is potentially missing out on opportunities to fund and commercialize its innovative discoveries.

It is important to note, however, that a large percentage of the small tech-based firms in North Carolina focus on pharmaceuticals and medical technology sectors, which are among of the state's strengths. Those firms, in fact, have a high success rate in receiving SBIR grants from the National Institutes of Health. However, the interests of other large SBIR-granting agencies—such as the Department of Defense, the National Aeronautics and Space Administration, and the Department of Energy—do not align as well with the majority of North Carolina firms' commercialization interests. This misalignment, in part, accounts for North Carolina's lower-than-expected award rate for SBIR grants

In additon to early-stage funding, intellectual property protecton via patents is an important foundation for many entrepreneurial ventures in the innovation economy. A patent for an invention is the grant of a property right to the inventor, issued by the U.S. Patent and Trademark Office. By allowing inventors to have exclusive rights over inventions for a period of time, patents provide those inventors with incentives for economically efficient research and development. The number of patents generated by North Carolina universities, companies, and research institutions reflects the magnitude of initial discovery and protection of innovative ideas. These new ideas are a potential catalyst for future products and marketable commodities, resulting in commercially relevant research and development.

Because strong patent activity measures attempts by inventors to fully and exclusively appropriate returns from their innovations, it is a broad indicator of innovative activity. While several types of patents exist, academic patents are the best indicator of the degree to which the academic workforce generates results with perceived economic value. With regard to this indicator, North Carolina ranks 8th in the nation, with an activity level that is 112 percent of the U.S. average. This reflects, as detailed above, the state's strong academic research enterprise.

North Carolina performs considerably less well, however, when looking at total patent activity (academic and nonacademic) relative to the size of its science and engineering workforce.[40] On this indicator, North Carolina

Figure 2.9 North Carolina's Performance on Commercialization Activity Indicators.

Source: National Science Board, Science and Engineering Indicators 2008.

ranks 23rd in the nation, with an activity level that is 86 percent of the U.S. average. This reflects its lower level of industry R&D as well as its relatively low number of high-tech business establishments (Figure 2.13 below). Thus, as a broad indicator of non-academic innovative activity within a state, this indicator suggests that North Carolina's non-academic private sector is not as strong as its academic sector at initial discovery and protection of innovative ideas. As with industry R&D above, this blend of high levels of academic patents and lower levels of non-academic patents underscores the fact that a large proportion of research conducted in North Carolina is basic in nature and therefore less heavily focused on commercialization or industry outcomes.

North Carolina's performance is similar with respect to venture capital, which comes at a later stage and provides significantly higher amounts of funding than does SBIR funding. While it ranks 10th nationally in in the amount of venture capital disbursed per gross state product, North Carolina's venture capital activity level is only 69 percent of the U.S. average.

This somewhat paradoxical finding results from the fact that, nationwide, venture capital is highly concentrated in a few regions in the U.S., primarily around Boston in Massachusetts and around Silicon Valley, Los Angeles, and San Diego in California. Massachussetts and California alone account for more nearly 60 percent of all the venture caputal deals in the U.S.[41] Thus, entrepreneurs with venture capital needs often have little choice but to locate in those areas. This also explains North Carolina's performance on venture capital deals as a share of high-tech business establishments, which measures the extent to which high-technology companies in a state receive venture capital investments. While North Carolina's 12th-place ranking on this indicator is notable, its level of activity is only 74 percent of the U.S. average.

Overall, these findings with respect to the state's commercialization activity raise the prospect that North Carolina businesses, universities, and research institutions will spin-off technology companies that may leave the state in order to obtain the financing they require to grow. To the extent that this occurs, the state will not fully capture the gains—in terms of downstream jobs, income, and prosperity—of research and innovation that it fosters in the early stages of commercialization.

Entrepreneurial and Commercialization Activity within North Carolina

Looking one level deeper at the distribution of commercialization activity within North Carolina reveals important patterns. Similar to R&D activity, commercialization activity is highly concentrated in a small number of geographic regions.

For example, SBIR and STTR awards go primarily to three counties in the Research Triangle region—Durham, Wake, and Orange. Those counties receive more than 80 percent of the state's SBIR and STTR awards, with the remainder going primarily to the Piedmont Triad and Charlotte regions (Figure 2.10). Similarly, three counties—Wake, Mecklenburg,

Figure 2.10 Geographic Distribution of SBIR and STTR Awards Received in North Carolina, 2003-2005.
SBIR and STTR awards are most concentrated in the Research Triangle, Piedmont Triad, and Charlotte regions.

(Source: U.S. Small Business Administration, Tech-Net Database, accessed May 2007)

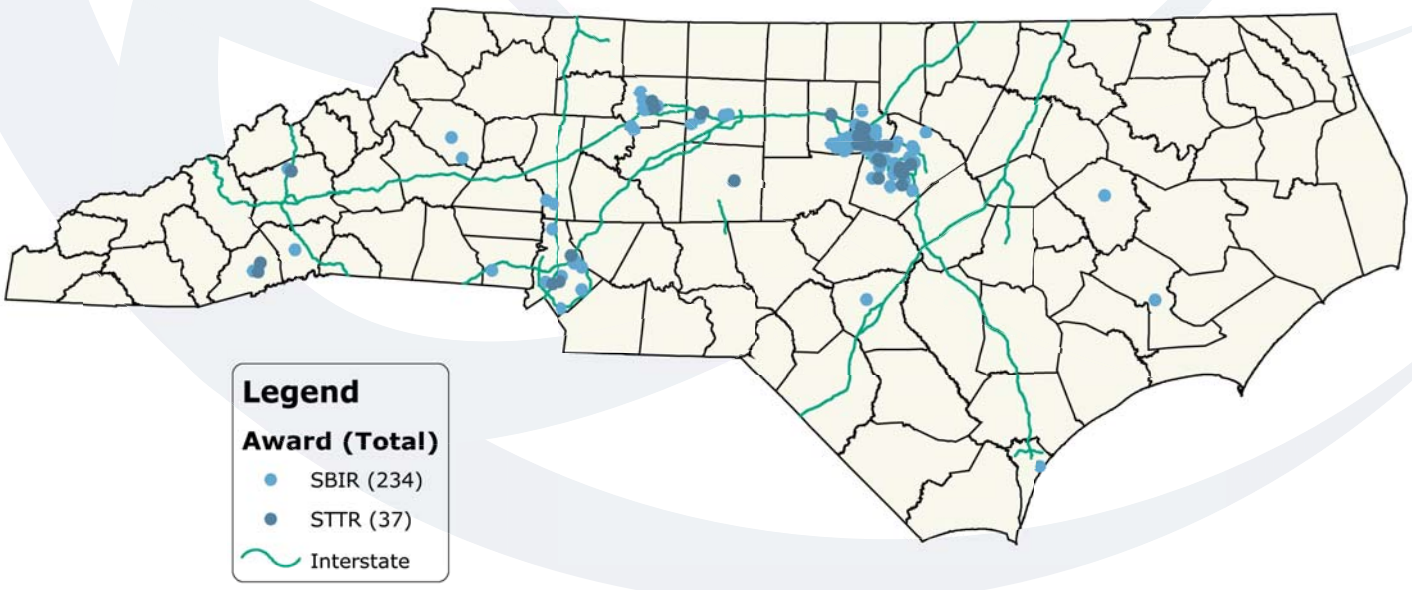


Figure 2.11 Geographic Distribution of Patents Received in North Carolina, Average Annual Awards, 2004-2006.
Patents are most concentrated in the higher-population counties, particularly those near interstate highways.

(Source: Decision Data Resources, Accessed August 2008)

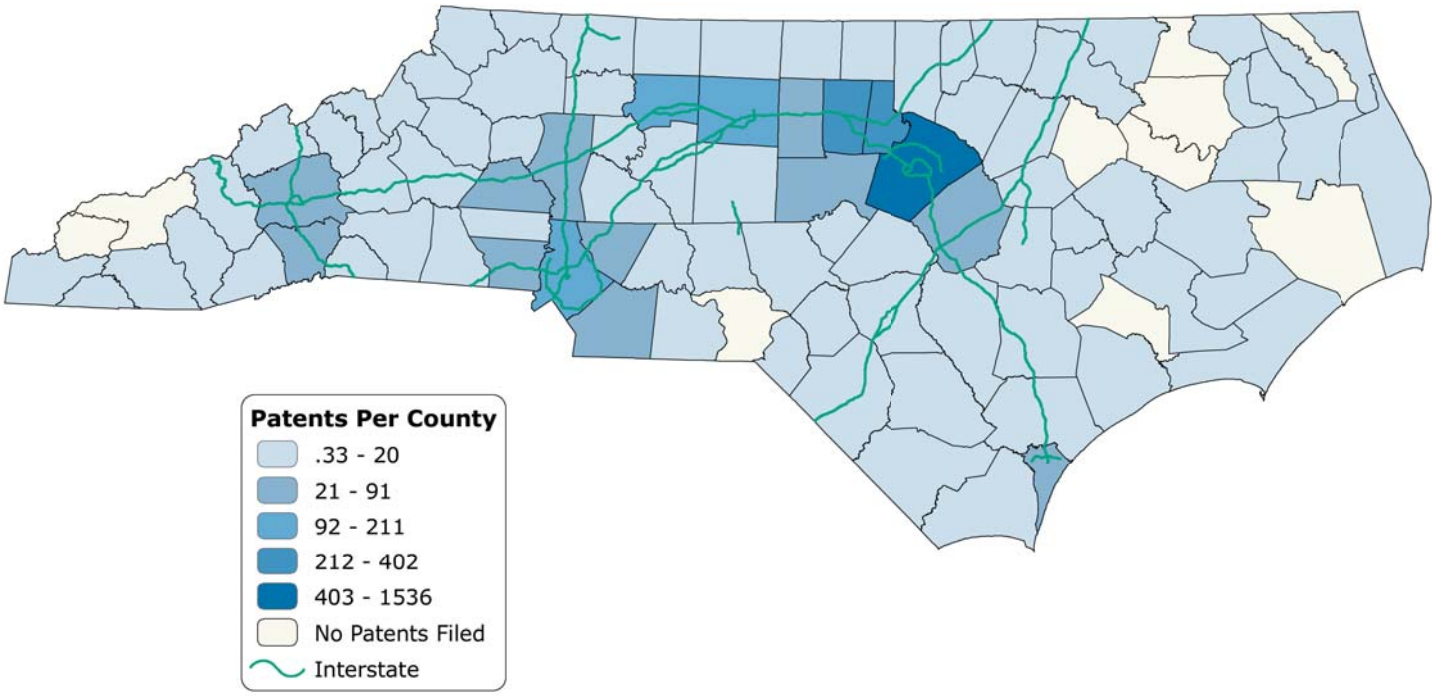
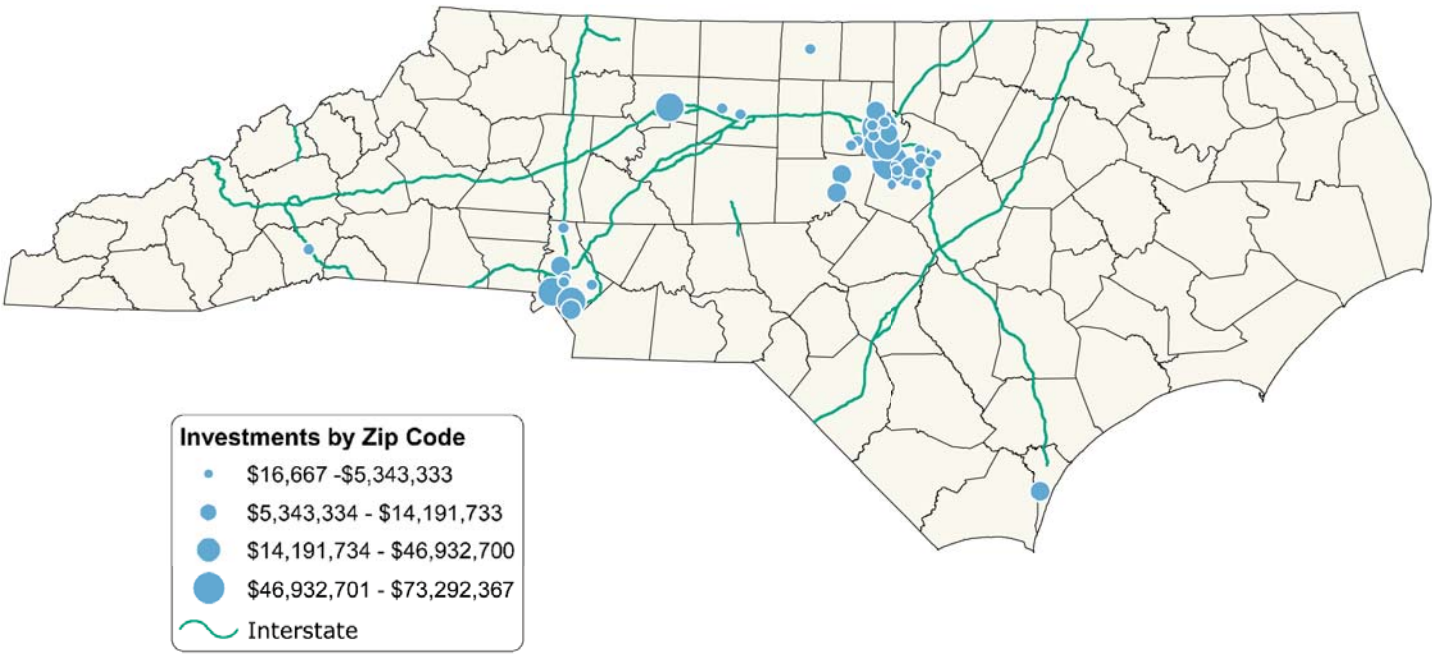


Figure 2.12 Geographic Distribution of Venture Capital Award Dollars Received in North Carolina, 2004-2006.
Venture capital dollars are most concentrated in the Research Triangle, Piedmont Triad, and Charlotte regions.

(Source: PriceWaterhouseCoopers MoneyTree Report, accessed August 2007)



and Orange—account for slightly more than half of the patent activity. Five other counties—Durham, Guilford, Forsyth, Buncombe, and New Hanover—receive eight percent, six percent, five percent, three percent, and two percent, respectively. The remaining 27 percent of patent activity is spread across 83 other counties (Figure 2.11).[42] As for venture capital dollars, Durham and Wake counties receive nearly 70 percent of the state's funding. Two other counties—Mecklenburg and Forsyth—together receive 22 percent, with the remaining eight percent of venture capital spread across six other counties (Figure 2.12). Overall, this highly concentrated commercialization activity reflects the level of concentration in the North Carolina's R&D activity and its population.

High-Tech Economic Performance

In the innovation economy, the presence of high-tech, fast-growing businesses indicates the degree to which a state's economy is dynamic, innovative, and a positive environment for economic growth and job creation. In addition, states with a large number of high-tech workers are well positioned to take advantage of new technological developments because they have a relatively larger pool of experienced high-technology workers.

North Carolina's High-Tech Economic Activity Compared to Other States

In terms of high-tech economic activity, North Carolina's performance is mixed (Figure 2.13).

Looking at the share of its businesses accounted for by high-tech businesses, for example, North Carolina ranks 25th, with its value on this indicator at 89 percent of the U.S. value.[43] A similar pattern holds for employment in high-tech businesses. On this indicator, North Carolina ranks 29th in the nation and has a value that is 88 percent of the U.S. value. Combined, these indicators reflect the dual facts that a large proportion of North Carolina remains rural in nature and that North Carolina maintains a higher-than-average share of companies in lower-tech manufacturing industries and agriculture.

The state's industry mix is changing over time, however. A key indicator of this is that North Carolina ranks 10th among the states and has a value that is more than 150 percent of the U.S. value in terms of net high-technology business formations. This high rate of growth in technology-intensive businesses indicates that North Carolina is gaining relative to other states, has an innovative and adaptive state economy, and is gaining momentum.

Most of the newly emerging or existing and growing industry clusters in North Carolina have high levels of employment, high rates of growth, and high average salaries (Table 2.2).[44] While many of these clusters are significantly high-tech and are typically more concentrated in metropolitan areas (e.g., scientific and research development services; environmental and other technical services; Internet publishing and broadcasting), many others are less high-tech and are distributed more evenly throughout the state (e.g., transportation equipment manufacturing; health care services; boat building). Industry clusters, therefore, are dispersed throughout the state. *Regardless of their level of technology intensity, if these clusters want to remain competitive in the interconnected global economy, they will need to innovate—create and adopt new products, services, and business models.*

Figure 2.13 North Carolina's Performance on High-Tech Economic Performance Indicators.

Source: National Science Board, Science and Engineering Indicators 2008.

Table 2.2 Emerging and Existing Industry Clusters in North Carolina.

Industry Cluster (Grouped by stage of development)	NC Employment 1Q 2007	NC Employment Growth 1992-2007	NC Location Quotient 2006*	NC Weighted Avg. Wages 2006
Emerging				
Banks	63,826	64.8%	1.14	$83,198
Architectural, engineering, & related services	38,543	116.7%	0.88	$43,563
Business, scientific, & technical consulting services	26,030	333.3%	1.17	$46,680
Scientific research & development services	17,597	127.4%	8.60	$58,438
Data processing, hosting, & related services	10,131	46.9%	1.23	$79,373
Advertising	7,548	29.4%	0.53	$36,135
Software publishers	6,591	187.7%	0.86	$83,153
Environmental and other technical consulting services	5,800	488.8%	0.92	$46,671
Internet publishing & broadcasting, ISPs & search portals, & related services	3,433	33.4%	2.13	$69,014
Specialized design services	3,123	73.3%	0.72	$30,830
Magnetic & optical media manufacturing & reproduction	2,708	21.2%	2.57	$107,765
Aircraft engines & parts	2,319	68.2%	0.90	$103,767
Miscellaneous transportation equipment manufacturing	574	567.4%	1.20	$67,796

Source: Goldstein, et al. 2008
** The location quotient is the ratio of the cluster's share of employment in North Carolina to its share of employment in the U.S. as a whole. A location quotient equal to 1.0 indicates that the cluster's share in North Carolina matches the comparable share for the U.S. as a whole. A location quotient significantly above 1.0 signifies state specialization, i.e., the state has a larger share of activity in the cluster than we would expect based on national trends. A location quotient significantly below 1.0 signifies the state has a smaller share of activity in the cluster than we would expect based on national trends.*

Figure 2.14 Geographic Distribution of High-Tech Companies in North Carolina with More than 20 Employees, 2007. High-tech companies are spread throughout North Carolina, but they are concentrated in larger metropolitan areas or near higher-education institutions.

(Source: Harris Selectory 2007; NC State Demographics 2005)

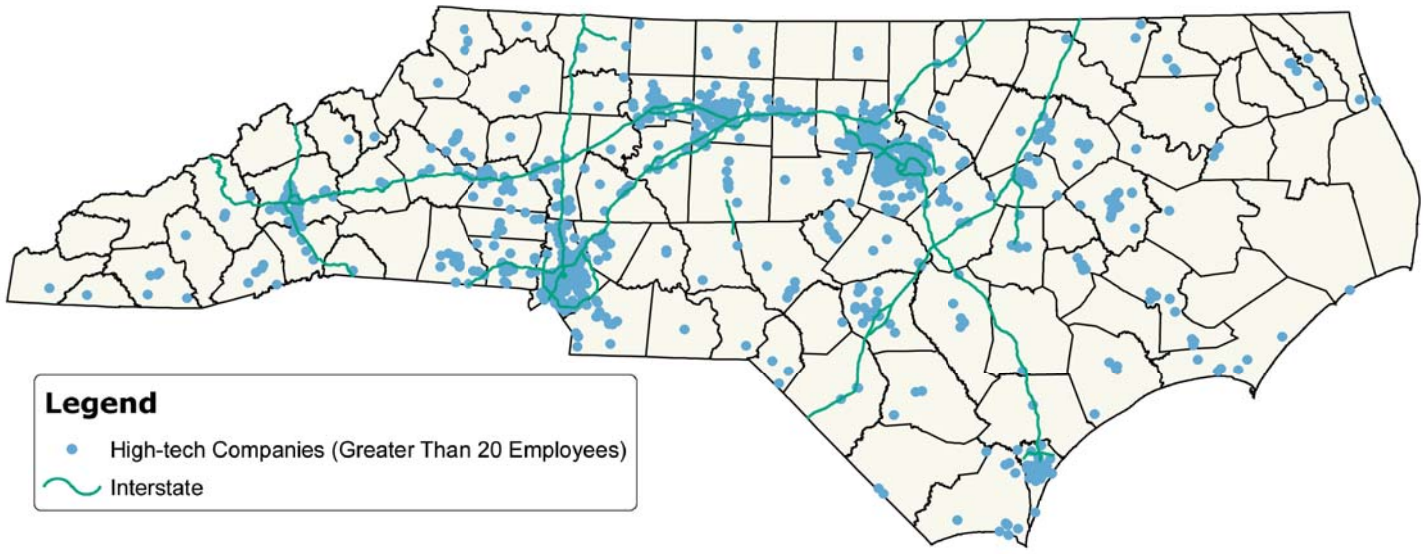


Table 2.2 Emerging and Existing Industry Clusters in North Carolina. (cont.)

Industry Cluster (Grouped by stage of development)	NC Employment 1Q 2007	NC Employment Growth 1992-2007	NC Location Quotient 2006*	NC Weighted Avg. Wages 2006
Existing				
Growing				
Health care services	508,974	75.7%	1.62	$42,401
Computer programming, systems design & computer-related services	33,296	93.8%	0.97	$53,893
Heavy duty trucks	6,399	297.7%	6.66	$83,904
Agricultural, construction, & mining machinery manufacturing	5,751	137.0%	1.71	$64,087
Boat building	4,361	142.7%	2.39	$43,309
Surgical & medical instruments	2,813	110.7%	0.83	$63,359
Stable				
Animal production & processing	43,797	43.5%	3.74	$18,880
Wood product manufacturing	25,296	1.3%	2.83	$38,653
Pharmaceutical & medicine manufacturing	19,027	51.2%	2.12	$111,565
Electronic instrument manufacturing	9,700	44.5%	1.99	$107,707
Crop production	8,724	33.6%	9.43	$16,460
Declining				
Textile mills & textile mill product manufacturing	54,817	-69.4%	18.78	$40,327
Furniture & related product manufacturing	49,896	-36.5%	10.42	$43,486
Apparel manufacturing	18,107	-80.3%	13.17	$42,437
Forestry & logging	3,290	-17.6%	1.68	$22,127
Household appliance manufacturing	2,092	-50.1%	5.08	$52,674

High-Tech Economic Activity within North Carolina

Although high-tech companies are located throughout North Carolina, approximately half of those companies are located in just three counties—Mecklenburg, Wake, and Guilford (Figure 2.14). Four other counties—Durham, Forsyth, New Hanover, and Buncombe—contain eight percent, four percent, three percent, and three percent, respectively. The remaining 33 percent is spread across the remaining 93 North Carolina counties.

However, as noted earlier, although North Carolina has high rate of growth in technology-intensive businesses, most of the gains between 1989 and 2002 took place in the Research Triangle region (Figure 2.15). While the absolute number of technology-intensive jobs increased in every region over the period, the Research Triangle is the only region whose statewide share of technology-intensive jobs increased. The Charlotte and Piedmont Triad regions gained 23 percent and 11 percent, respectively. This means that these three regions together account for 83 percent of the technology-intensive job growth during that period. The remaining 13 percent of new high-tech job is shared among the four other regions in North Carolina.

Human Capital Resources

In the innovation economy, knowledge-based jobs permeate all sectors and drive prosperity. Such jobs are typically managerial, professional, and technical positions held by individuals with at least two years of college. These skilled and well-educated workers serve as the backbone of any state's most important industries, from high value-added manufacturing to high-wage traded services. To succeed in the innovation economy, North Carolina needs a high-tech, well-educated workforce. When it comes to the creation of new products and ideas, states that have a robust science and engineering workforce have a competitive advantage over states that do not.

North Carolina's Human Capital Resources Compared to Other States

Consistent with its performance on indicators related to R&D, commercialization, and the high-tech economy, North Carolina's performance across a mix of human capital resource indicators varies considerably (Figure 2.16).

Workforce

A key indicator of the relative size of the overall scientific and technical expertise in a state is the number of science and engineering (S&E) workers as a share of the workforce.[45] With respect to this indicator, North Carolina ranks 29th nationally and has a value that is 88 percent of U.S. value. A similar but slightly better pattern holds for North Carolina's employment of computer specialists. Specifically, in terms

Figure 2.15 Distribution of Growth in Technology Intensive Jobs in North Carolina, by Economic Development Region, 1989-2002

The Research Triangle region gained nearly half of all new technology-intensive jobs created in North Carolina between 1989 and 2002.

(Source: Employment Security Commission, 2003)

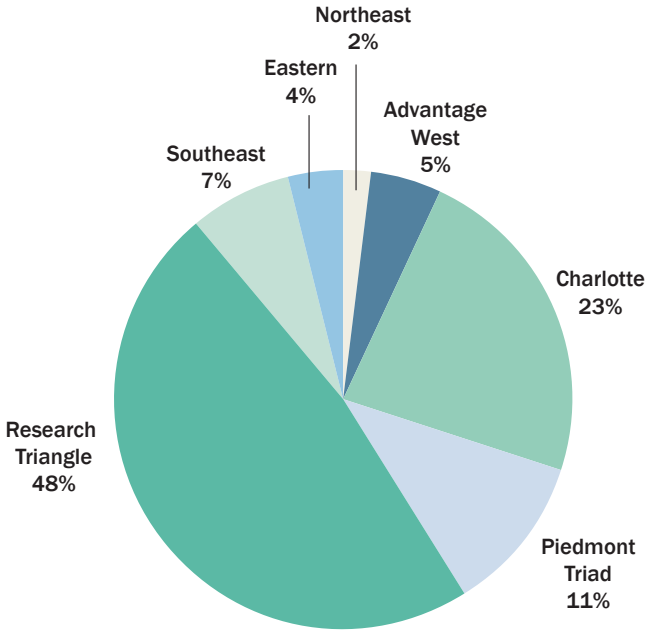
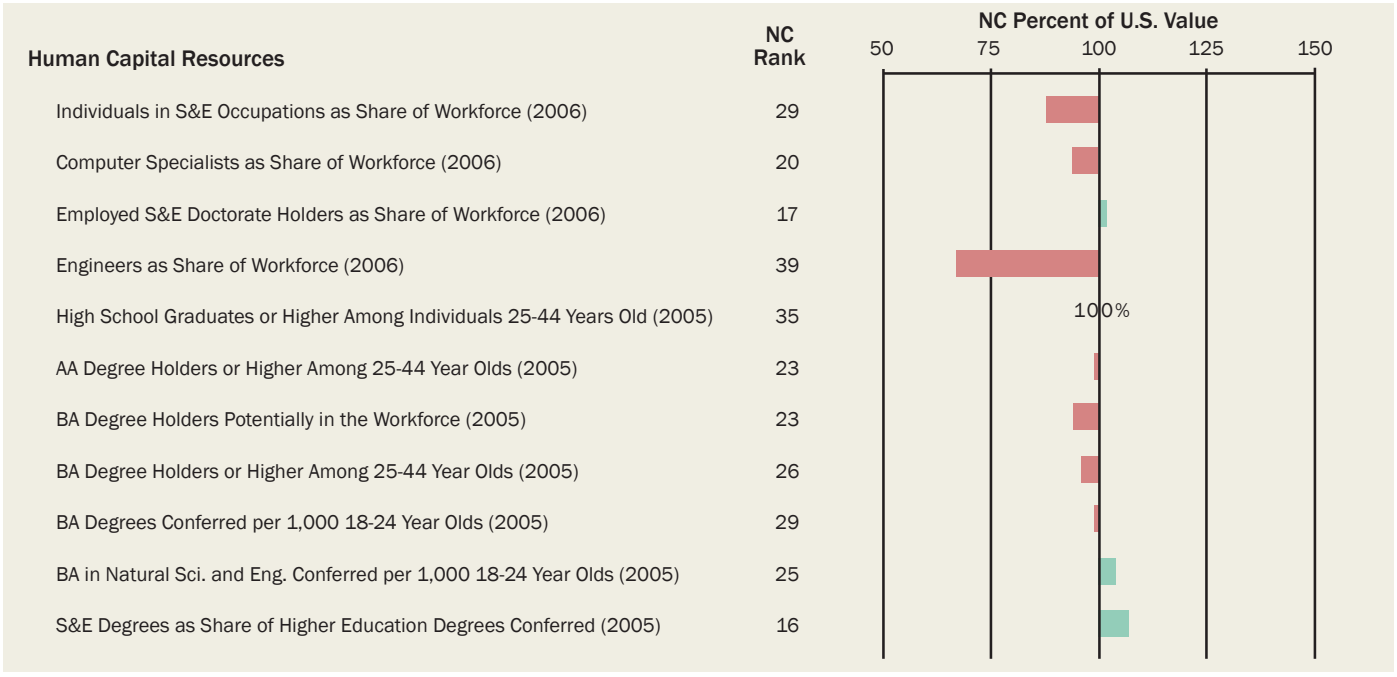


Figure 2.16 North Carolina's Performance on Human Capital Resource Indicators.



Source: National Science Board, Science and Engineering Indicators 2008.

of computer specialists as a share of workforce, North Carolina ranks 20th nationally and has a value that is 93 percent of the U.S. value. On each of these indicators, North Carolina's share is less than half the share of the leading state (Virginia).

As in the case of employment in high-tech establishments, North Carolina's relatively low performance on these two workforce indicators reflects the dual facts that a large proportion of North Carolina remains rural in nature and that North Carolina maintains a higher-than-average share of its companies in lower-tech manufacturing industries and agriculture. States with the highest rankings on these indicators tend to be those with significant corporate R&D laboratory facilities or states with significant federal laboratory facilities.

North Carolina fares better in terms of employed S&E doctorate holders as a share of the workforce.[46] This indicator shows a state's ability to attract and retain highly trained scientists and engineers. These individuals often conduct R&D, manage R&D activities, or are otherwise engaged in knowledge-intensive activities. On this indicator, North Carolina ranks 17th among states and has a value that is 102 percent of U.S. value. This ranking reflects North Carolina's higher education strengths as well as the much higher--than-average number of doctorate holders in the state's Research Triangle region. It ranks low, however, in terms of engineers as a share of the workforce, with a national ranking of 39 and a value that is only two-thirds the U.S. value.

Education

Regardless of industry or occupation, a well-educated, skilled workforce is a prerequisite for success in the innovation economy. The educational attainment of the workforce is a fundamental indicator of how well a state can generate and support economic growth centered on innovation. Moreover, the greater the share of well-educated workers within a state, the less the state has to rely on outside areas to sustain its pool of workers.

In terms of individuals between the ages of 25-44 who have graduated from high school, North Carolina ranks 35th nationally, with a value that ties it with the value for the nation as a whole. The same pattern hold true for the percentage of the early- to mid-career population that has earned at least a college degree in North Carolina. Specifically, in terms of the number of associate's degree holders among individuals 25-44 years old, North Carolina ranks 23rd among the states and has a value that is 99 percent of the U.S. value.

In terms of the number of bachelor's degree holders potentially in the workforce population, North Carolina again ranks 23, with a value that is 94 percent of the U.S. value. It ranks roughly the same in terms of the number of bachelor's holders or higher among the 25–44 year old population. Here it ranks 26th among the states, with a value that is 96 percent of the U.S. value. In terms of bachelor's degrees conferred per 1,000 individuals in the 18–24 year old population, North Carolina ranks 29th, with a value that is 99 percent of the U.S. value.

North Carolina ranks higher, however, in bachelor's degrees in natural sciences and engineering for the 18-24-year-old population. On this indicator, North Carolina ranks 25th nationally, with a value that is 104 percent of the national value. In general, the ratio of new S&E bachelor's degrees to the 18–24-year-old population indicates the extent to which a state prepares young people to enter the types of technology-intensive occupations that are fundamental to a knowledge-based, technology-driven economy. Thus, North Carolina's higher ranking for this indicator suggests its relative success in providing a technical undergraduate education.

North Carolina ranks even higher in terms of the proportion of its higher education degrees accounted for by S&E degrees. On this measure, it is 16th nationally and has a value that is 107 percent of the U.S. average. This indicator measures the extent to which a state's higher education programs are concentrated in S&E fields, and high values for this indicator reflects North Carolina's emphasis on S&E fields in its higher education institutions. In general, the more technical the degree, the better North Carolina fares.

Human Capital Resources within North Carolina

As with R&D activity, commercialization activity, and the high-tech economy in North Carolina, educational attainment is relatively concentrated in larger metropolitan areas. While a similar pattern also exists in other states, the pattern is stronger than average for North Carolina because it is a relatively rural state. Only 15 of its 100 counties are classified as urban, and those 15 counties account for more than 50 percent of the state's population. Moreover, North Carolina's top three metropolitan statistical areas contain 70 percent of the state's population.[47]

Because more highly educated workers tend to work in urban centers, the pattern of educational attainment across North Carolina roughly mirrors that of the population density. Specifically, associate's degree holders are the most dispersed throughout the state, bachelor's and master's degree holders are more concentrated in urban areas, and doctoral degree holders are the most concentrated in urban areas (Figures 2.17-2.20).[48] These patterns both reflect and shape the nature of North Carolina's innovation economy. They also are strongly positively correlated with per capita income, a key measure of economic vibrancy and prosperity (Figure 2.21).

Figure 2.17 Geographic Distribution of Associate's Degree Holders in North Carolina, 2008.
Associate's degree holders are spread throughout North Carolina, but they are heavily concentrated in larger metropolitan areas.

(Source: NC Economic Security Commission, 2008)

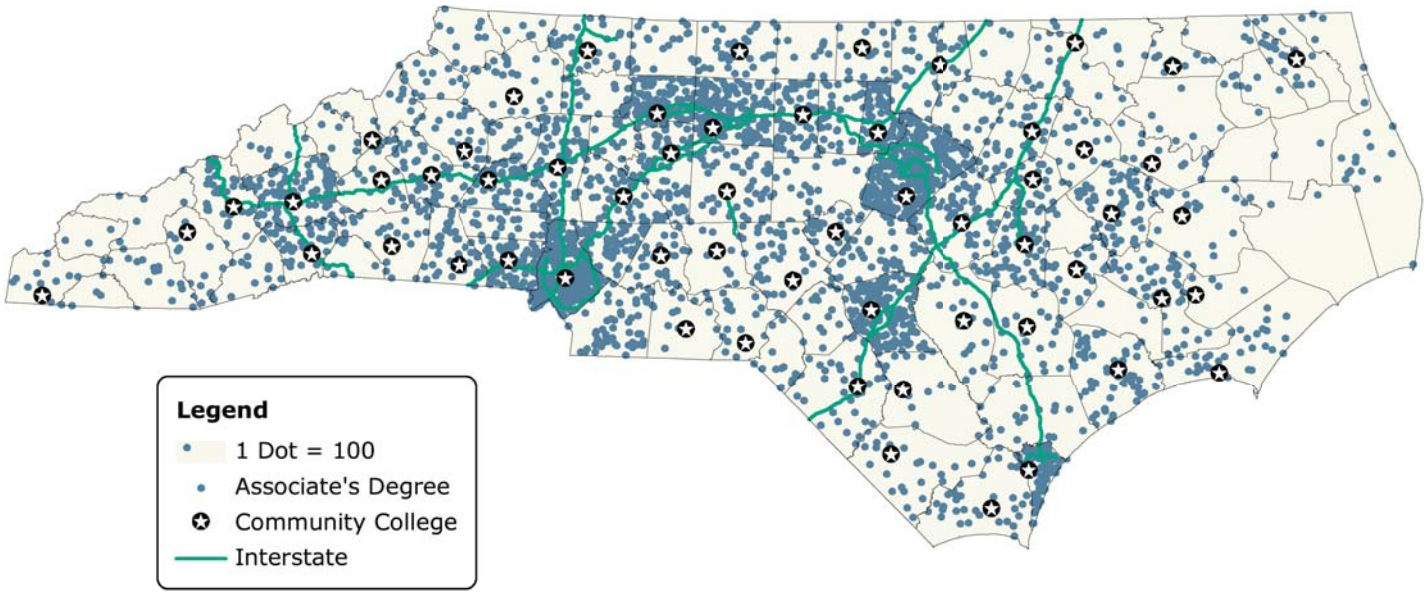


Figure 2.18 Geographic Distribution of Bachelor's Degree Holders in North Carolina, 2008.
Bachelor's degree holders are spread throughout North Carolina, but they are heavily concentrated in larger metropolitan areas.

(Source: NC Economic Security Commission, 2008)

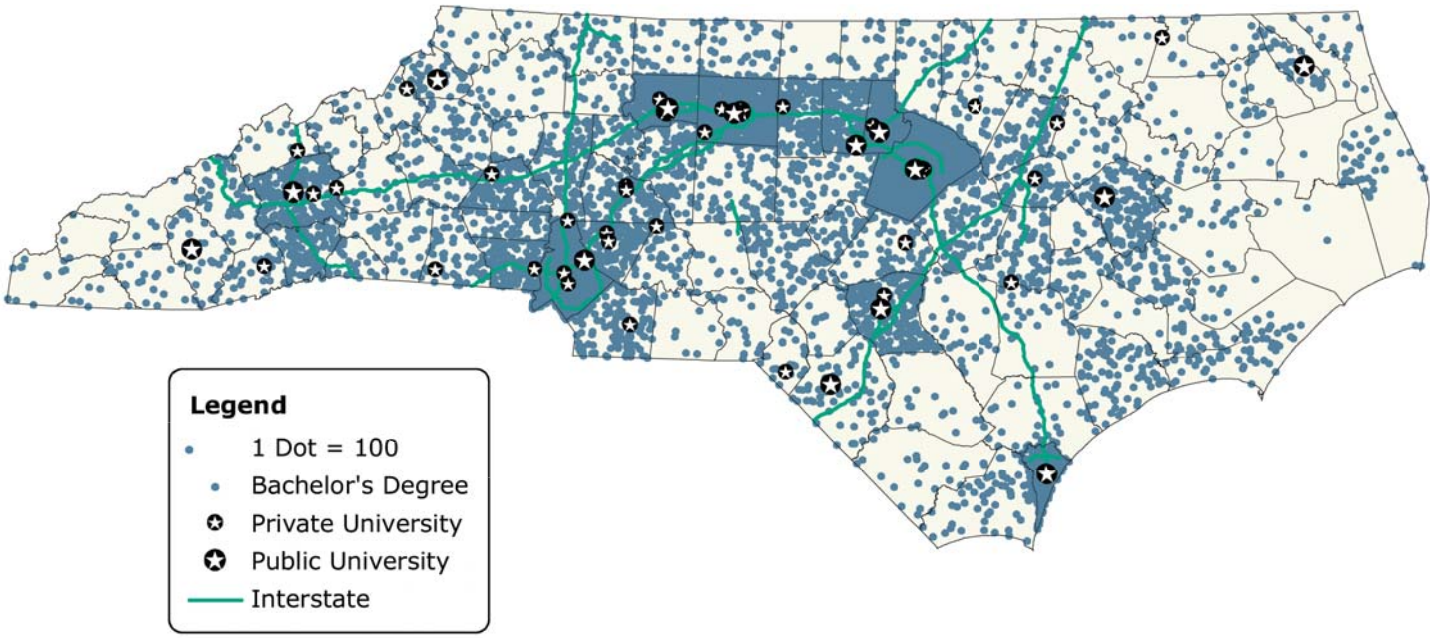


Figure 2.19 Geographic Distribution of Master's Degree Holders in North Carolina, 2008.
Master's degree holders are spread throughout North Carolina, but they are heavily concentrated in larger metropolitan areas.

(Source: NC Economic Security Commission, 2008)

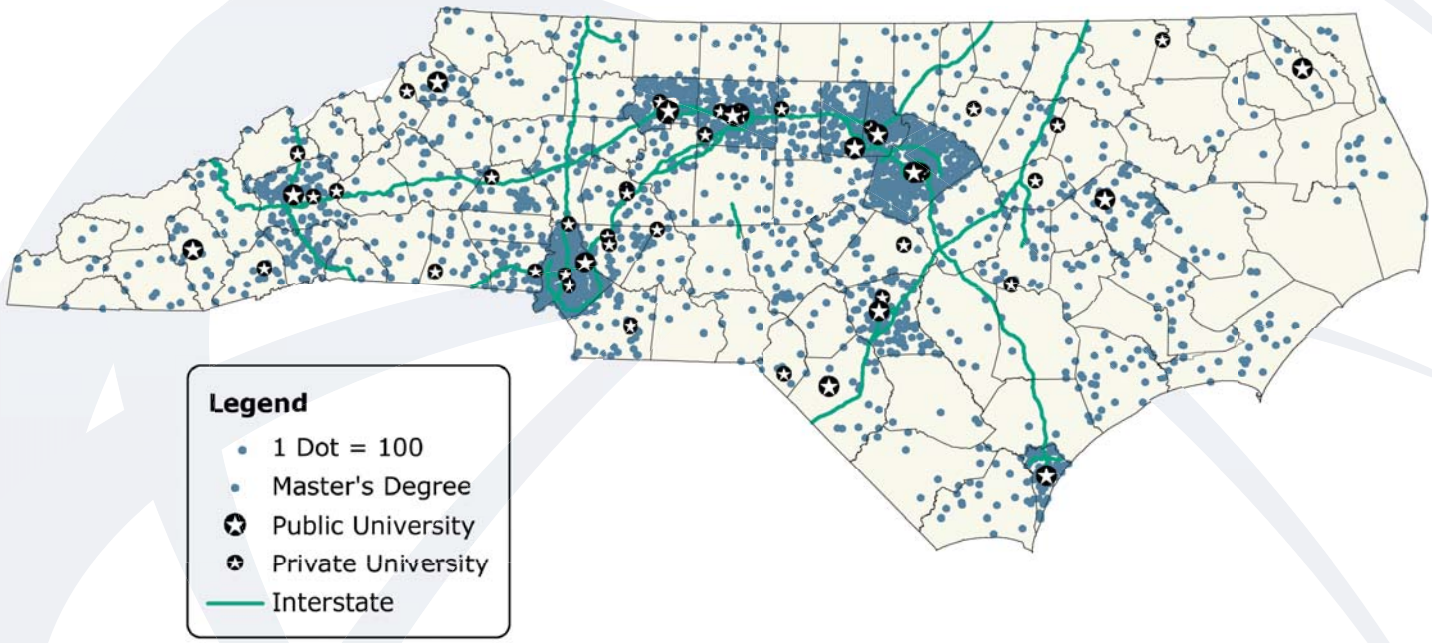


Figure 2.20 Geographic Distribution of Doctoral Degree Holders in North Carolina, 2008.
Doctoral degree holders are spread throughout North Carolina, but they are heavily concentrated in larger metropolitan areas, particularly the Research Triangle Region.

(Source: NC Economic Security Commission, 2008)

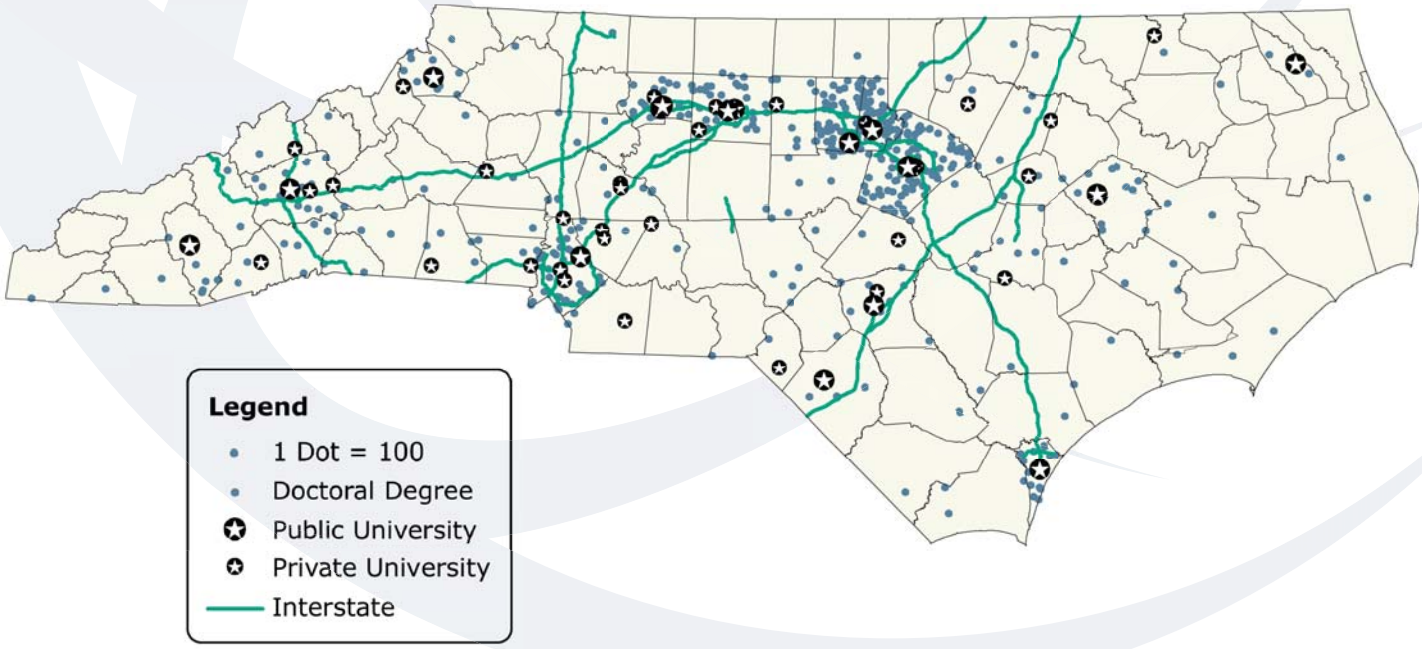


Figure 2.21 Per Capita Income in North Carolina, by County, 2007.
Per capita income varies widely in North Carolina and typically is higher in urban areas.

(Source: Division of Policy, Research, and Strategic Planning, NC Department of Commerce)

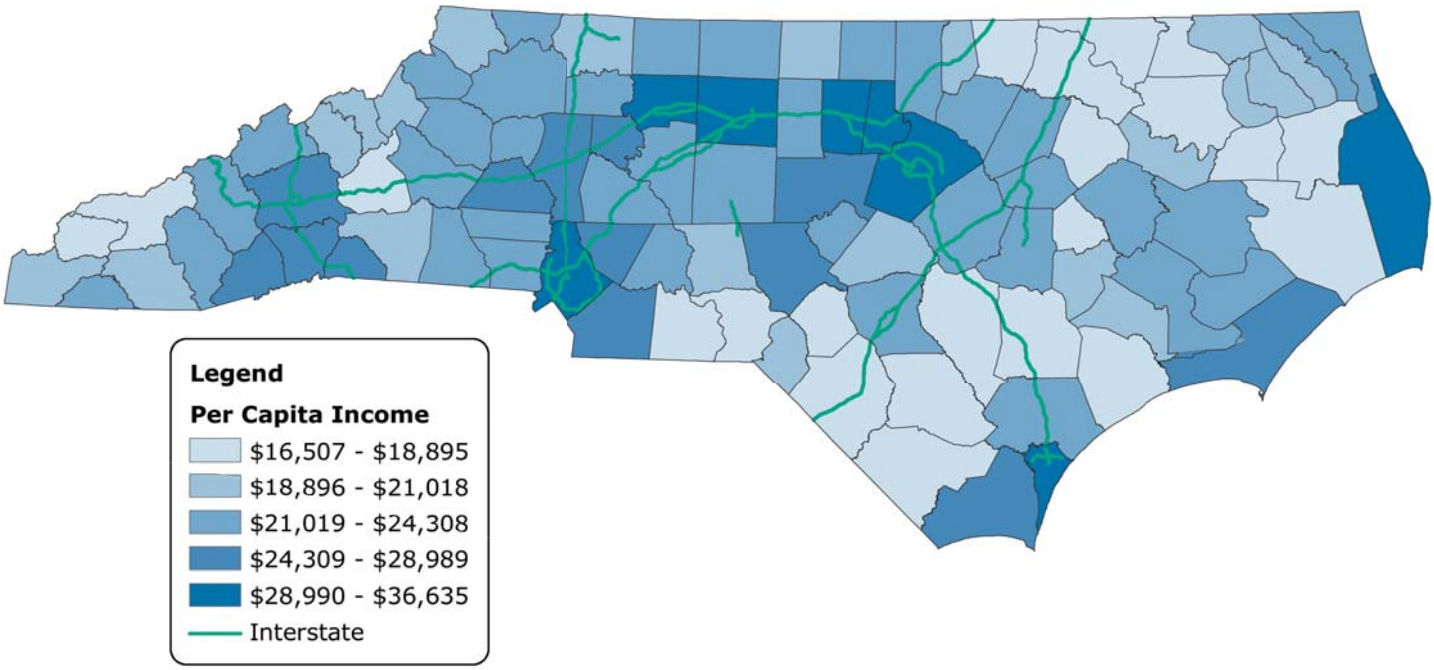
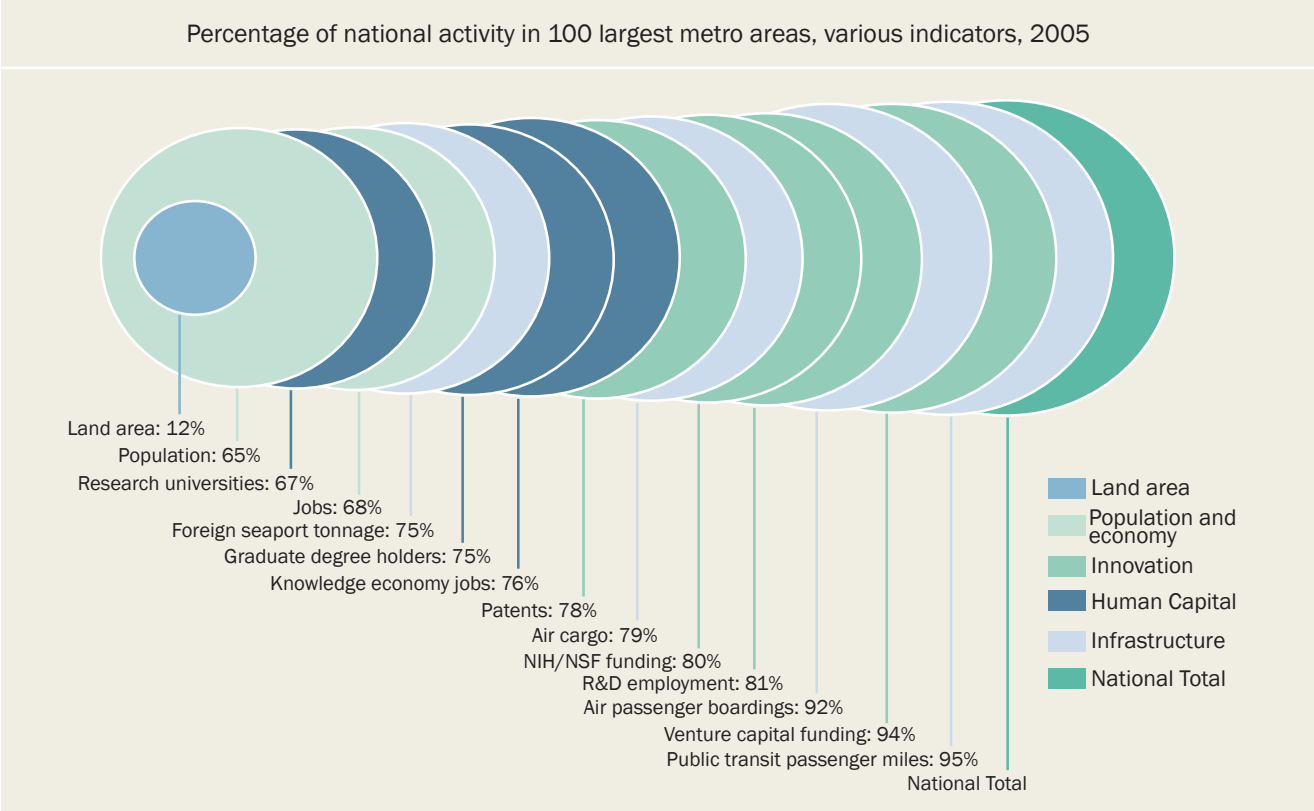


Figure 2.22 The Importance of Metropolitan Areas for Prosperity
Major metropolitan areas aggregate fundamental drivers of prosperity and generate 75 percent of U.S. GDP.

(Reproduced from Metro Nation: How U.S. Metropolitan Areas Fuel Prosperity, 2007, Brookings Institution)



Conclusions

North Carolina has enjoyed a long period of success in the realm of basic research, due in large part to its early, sustained, and significant investments in higher education. While these investments have served the state well on many fronts, in the modern innovation economy they are insufficient for creating continued high levels of economic growth and social prosperity. North Carolina can and must do more to strengthen the other aspects of its innovation economy and to use its higher education assets to spread innovative activities throughout the state.

As shown by several indicators important for understanding a state's performance in the innovation economy, North Carolina is performing at or below the U.S. average, particularly on those indicators not closely associated with the state's higher education strengths. This pattern has been stable for more than a decade. In many cases, North Carolina's below-average performance results from the historic legacy of North Carolina's economy, which was largely rural in nature and concentrated heavily on traditional manufacturing and agriculture, or from the nature of its relatively concentrated R&D and industry strengths.

An equally important factor explaining North Carolina's performance is the degree of regional concentration in metropolitan areas within the state in terms of key innovation assets. Though the degree of North Carolina's concentration is not unique among U.S. states (Figure 2.22), it does present a set of challenges and opportunities worthy of further attention.

The next chapter offers recommendations for a framework and policies that will address the challenges and opportunities of North Carolina's innovation economy. If North Carolina develops a framework that has strong leadership, recognizes and respects its regional differences, and optimizes its innovation assets through establishing strategic, ongoing collaborative relationships between the private sector and government, it can both increase its overall level of innovation and distribute it more evenly throughout the state.

An Innovation Framework for Competing and Prospering

Key Points

- **Many states are actively optimizing their innovation-based frameworks and programs.**
- **North Carolina's existing innovation framework has several strengths but could be made even stronger with an enhanced and better-aligned framework that respects and builds on regional differences.**
- **To differentiate and position itself optimally to compete and prosper in the interconnected global economy, North Carolina must strive to develop an economically sound innovation framework that leverages the state's unique strengths while addressing its specific challenges.**
- **The new framework should be:**
  - **Founded on 10 guiding principles that would strengthen and align the links and relationships within North Carolina's innovation ecosystem, optimizing that system's ability to transform the economic and social fruits of research and development into innovative products and practices.**
  - **Operationalized by enhancing five roles that are uniquely in the hands of public leaders:**
    - **Champion and Communicator**
    - **Convener and Facilitator**
    - **Funder and Policymaker**
    - **Recruiter and Retainer**
    - **Evaluator and Advisor**
  - **Led and coordinated by three public institutions:**
    - **An enhanced North Carolina Board of Science and Technology**
    - **An optimized North Carolina Science and Technology Advisor**
    - **A realigned Carolina General Assembly committee structure**
  - **Implemented through programs that expand and enhance four core drivers of innovation:**
    - **Research & Development**
      - Provide state-funded R&D competitive grants to public universities
      - Design and support programs to market the state's R&D assets
    - **Commercialization**
      - Support the repurposing and funding of technology transfer platforms in the UNC system
      - Advocate for and fund the continuing development of the UNC Millennial Campuses
    - **High-Tech Economic Activity**
      - Support programs focused on increasing the number and benefits of SBIR/STTR grants
      - Enhance the technology adoption programs of the North Carolina IES and SBTDC
    - **Human Capital Resources**
      - Increase the funding for technology- and innovation-focused workforce training programs
      - Provide additional support for the North Carolina New Schools Project

The Innovation Race is in High Gear

As science and technology continue to change at a rapid pace—generating increased innovation and changes in economies and governments worldwide—the way in which governments and businesses interact is changing throughout the United States. To ensure its continued economic growth and prosperity, North Carolina must optimize its innovation framework—*its government institutions, policies, and relationships with other organizations*—to harness and maximize the benefits of innovation.

Other states are already making significant competitive changes on many fronts. For example, in the first three months of 2007, 39 governors announced new initiatives focused on science, technology and innovation, covering priorities ranging from secondary and higher education reform, to investment strategies, to stem cell research, to funding for research and development, to digital infrastructure (Figure 3.1).[49] The amount of money invested in these proposed programs is substantial. Arizona's "One Arizona" plan included $75 million for new science and technology initiatives; Pennsylvania proposed an $850 million "Energy Independence Fund;" Texas proposed spending $300 million to recapitalize its "Emerging Technology Fund;" and California proposed $95 million for the "California Research and Innovation Initiative" for projects in clean energy, biotechnology, and nanotechnology.[50] These investments indicate other states are placing a priority on gaining leadership positions in the ever-changing innovation economy.

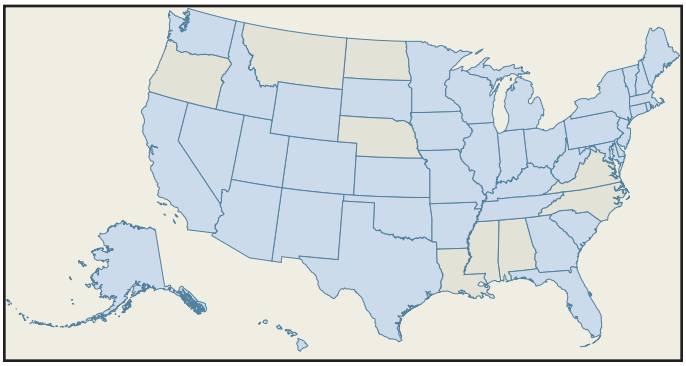


Figure 3.1
Thirty-nine states, highlighted in blue, introduced new innovation-based economic development initiatives in just the first three months of 2007.

An obvious trend is emerging around some of the initiatives noted above: states are increasingly copying or adapting initiatives from other states. Of the 39 science initiatives referenced above, 25 governors proposed to be leaders in their clean energy or alternative energy initiatives, and eight proposed a new or expanded stem cell research program.[51] Although alternative energy is clearly an important field of research, there cannot be 25 leaders.

The spread of ideas and common approaches is furthered by "best practice" documents in technology-based economic development. Several organizations publish "best practices" documents, but these documents often reflect only the common practices in state technology-based economic development policies rather than an objective "best."[52] The "best practices" are often formulaic and rated on their activity—the number of grants given, the number of businesses assisted, or the amount of money distributed—but are rarely based on quantifiable outcomes or unique and differentiating resources that can be leveraged as well as provide constraints on options. Therefore, states often adopt, with little or no variation, policies drawn from these "best practice" documents, thus increasing the number of states with very similar technology-based economic development portfolios.

Ideas from one state are quickly implemented in others…

…but few conclusive findings exist to show whether these practices actually work.

Limited work has been done to date, either in the policy realm or academic community, focusing on measuring the true outcomes of technology-based economic development, that is, whether a given program actually *improves the well-being of the citizenry*.[53] Many programs do not include measurement of outcomes because of its difficulty. There are a number of confounding variables, and it is difficult to determine whether any one program has made a difference in the overall economy of the state or to quantify what that difference may be. However, lacking this very crucial piece of information, it is hard to know how to balance the state's innovation policy framework. Given limited resources, should more money be placed in workforce development or in early business seed capital? Or should the state put its resources in an entirely different area?

This combination of common practices unsupported by conclusive findings confirming efficacy and effectiveness of outcomes should suggest three things to North Carolina policy makers:

- First, there is no strong reason to think that adopting another state's initiatives will necessarily improve the economic well-being or prosperity of the citizens of North Carolina.
- Second, adopting "best practices" will likely not give us a competitive advantage, as multiple states will implement these same common practices quickly.
- Third, a shotgun approach toward policy—in effect shooting at several targets with little understanding of how they relate, whether they are the right targets, or whether we have the right policy—is, at best, an inefficient use of resources and, at worst, unlikely to be successful.

Thus, to differentiate itself, North Carolina must strive to develop smart, unique, targeted approaches that build on our strategic strengths, accommodate our unique constraints, and integrate them in various economic contexts to maintain and grow our leadership. North Carolina was one of the early leaders in this policy race—benefiting early from its first-mover advantage—yet now finds itself running as fast as ever but in the middle of the pack on a number of indicators and lacking a clear framework for future prowess. Now is the time to run not only faster but smarter.

We must, therefore, anticipate future trends and continue to be proactive, innovative, and smart in our approach. As with similar creative efforts in the past—such as the Research Triangle Park, the Board of Science and Technology, the Biotechnology Center, the School of Mathematics and Science, MCNC, and the North Carolina Information Highway—changes of this type and magnitude won't be easy, painless, or without investment costs. Nonetheless, our future successes will be determined by what we do today—the quality of our vision, how we invest, how we prioritize, and how we respond to the challenges of the accelerating innovation economy.

North Carolina's future competitive advantage does not lie in following others' practices, but in crafting solutions specific to its own unique context.

North Carolina's Innovation Challenges

When determining the best framework to ensure North Carolina's economic growth and prosperity in the innovation economy, the place to start is with the principles underlying our market-based economy.[54] At their core, the fundamental principles underlying a market-based economy—such as the importance of prices as an indicator of scarcity and as a method of allocation, the importance of property rights as an incentive for accumulation and innovation, and the importance of regulatory institutions for maximizing the successes and minimizing the imperfections of market competition—are universal. These economic principles remain constant regardless of setting and have proved their resilience over time.

What is not constant, however, are the numerous and varied contexts in which these principles are applied. Each context, with its own particular set of conditions and constraints, requires a different set of policies in which to operationalize economic principles.[55] Thus, an innovation-focused framework that works well in Virginia or Georgia might not work well, or even the same way, in North Carolina. For example, North Carolina has three to five large "hubs" of economic activity that are geographically quite distributed (as demonstrated in Chapter 2), while Georgia has one primary hub where the economic activity is very concentrated.

As a result, an understanding of the "conditions on the ground" with respect to innovation in North Carolina is the central factor in determining what role public institutions and policies should play. Moreover, rather than respond with a laundry list of possible reforms, government should focus its resources on a small number of opportunities for, and key impediments to innovation, economic growth, and social prosperity. It should focus on those investments and reforms likely to yield the greatest return.

In terms of our existing market-based innovation economy, North Carolina's strengths and challenges, as outlined in the previous chapter, include the following:

Strengths

1. Substantial investment in academic R&D, from inside and outside the state
2. A higher-education system with substantial potential to support statewide innovation
3. Strong potential for commercialization and increased high-tech economic activity

Challenges

1. Relatively low investment in industrial R&D
2. Heavy dependency on a few geographic clusters for innovation
3. Weakness in converting innovation inputs into innovation outputs
4. Large variances in performance across regions within the state
5. A continuous need to educate and train human capital

The strengths did not happen by chance. They are the product of deliberate choices by the state's long-standing visionary leadership, which recognized early the importance of institutions of higher education and a well-educated citizenry. For example, only six years after the close of the Revolutionary War, North Carolina policy makers chartered the first public university in the United States. In 1971, state policy makers placed the state's 16 public senior institutions under one governing board to foster the development of a well-planned and coordinated system of higher education—to improve the quality of education, to extend its benefits, and to encourage an economical use of the state's resources. And in recent decades, as the economy has become more global and demanded job skills that relied less on brawn and more on brains, our policies have targeted high-tech growth industries and developed community college and university training and education programs to fuel them.

North Carolina's strengths are the product of deliberate choices by the state's long-standing visionary leadership. Its challenges result primarily from circumstance.

The challenges North Carolina faces, however, result less from deliberate choices and more from circumstance. First, North Carolina's economic history is rooted in agricultural and labor-intensive manufacturing. As a result, the state has had to work hard to diversify its economy in light of the broader changes occurring worldwide. Second, the geography and historical development of the state have generated a small number of major metropolitan areas surrounded by large rural areas. Hence, the levels of innovative activity and prosperity vary greatly throughout the state. And third, classic economic market imperfections related to innovation create impediments that cause the market to generate less innovation than is socially desirable.[56]

In terms of these impediments, it is well established that economic free markets, while the most efficient means to allocate goods and services, fail to allocate sufficient resources for innovation. In particular, at least six classic market imperfections, all currently in play in North Carolina, limit the innovation process.[57]

1. **Organizations produce less innovative activity than society needs:** Studies have consistently shown that the societal rates of return from corporate R&D are at least twice the estimated returns that accrue to the companies performing the R&D.[58] This is the case because the knowledge needed to create new products and services is a "public good;" it cannot easily be contained within or captured by an individual organization. Thus, left on their own, organizations will produce less innovation than society needs because the knowledge they create can be used by other organizations that have not paid the costs of creating it.

2. **The private financing of R&D is shifting away from riskier early-stage activities to lower-risk later stage activities:** As the venture capital market has matured, companies have found it more profitable to invest in larger deals and less-risky later-stage deals.[59] The result is a funding gap between the completion of basic research and applied R&D.

3. **R&D increasingly depends on collaboration between industry and universities, but the interests of the collaborators are not well aligned:** Since the end of World War II, the amount of research that industry conducts in-house has decreased. As a result, companies are increasingly outsourcing R&D to universities and engaging in industry-university collaborations. Yet, industry and universities have different cultures and needs, which hinders coordination and impedes the flow of knowledge that can contribute to innovation.

4. **Many organizations lag in adopting proven technologies:** Many organizations, particularly those that aren't science-based or that are small or mid-sized, lack information about new technologies as well as the resources to adopt them once aware of them. Moreover, change of any type is rarely easy, meaning beneficial technologies are often under- or slowly utilized.

5. **The innovation-producing benefits of clusters are under-realized:** Geographic clustering facilitates innovation by enabling and encouraging organizations to share knowledge, take advantage of common resources, and adapt in response to both the increased competition and cooperation within clusters. Yet, these benefits are a public good: they spill over beyond the boundaries of an individual organization, which means that market forces produce less geographic clustering than society needs. Failure to meet these common needs inhibits the growth and productivity of clusters.

6. **The interests of geographically mobile organizations in locating innovative activity may diverge from those of their area residents:** Organization's decisions about where to locate innovative activity are based on their own interests, which may or may not coincide with the interests of an area's residents. With the rise of the globally integrated enterprise, states need robust economic innovation policies to compete globally.

Left to itself, the market will produce less innovation than our society needs. In an interconnected globally competitive world, this is a limitation we can no longer afford.

Together, this mix of geography, historical development, and classic market imperfections adds up to a less-than-optimal innovation ecosystem in North Carolina.

Although the private sector and consumers, not government, are the heart of the engine for the innovation process, public leaders can strengthen it through a framework that optimizes the roles that are uniquely in their hands. Before proposing an enhanced innovation framework, it is useful to review the state's existing framework.

North Carolina's Existing Innovation Framework

North Carolina has several public organizations and programs that focus on activities related to innovation, but there is no agency or organization that focuses solely or primarily on innovation. Moreover, these organizations are largely disconnected from one another and would benefit from additional support, coordination, and alignment. The primary public organizations and programs include the following:

North Carolina Board of Science and Technology[60]
In 1963, the North Carolina General Assembly established the Board to encourage, promote, and support scientific, engineering, and industrial research applications in North Carolina. As the first such organization in the United States, the Board meets its goals by investigating new areas of emerging science and technology and conducting studies on the competitiveness of state industry and research institutions in these fields. The Board also works with the General Assembly and the Governor to put into place the infrastructure that keeps North Carolina on the cutting edge of science and technology.

Of the Board's 19 members, 15 are appointed by the Governor, and two are appointed by the General Assembly; the remaining two positions are ex-officio. The members broadly represent the business, academic, and public sectors from across the state. Throughout most of its history the Board was housed within the Governor's office; in 2001 it was moved to the North Carolina Department of Commerce to align it more closely with the state's economic development efforts.

The Board's primary role has been advisory—recommending, for example, the creation of a number of internationally recognized initiatives to catalyze the transformation of the North Carolina economy by leveraging university research, science, entrepreneurship, and technology-based economic development. Among these are organizations such as:

- The North Carolina Biotechnology Center, the first such center in the United States (see description below in this section);
- The North Carolina School of Science and Mathematics, the country's first residential high school at which students study a specialized curriculum emphasizing science and mathematics;
- The North Carolina Technological Development Center, now called First Flight Venture Center, a technology incubator designed to increase the number of technology companies originating or relocating to North Carolina; and
- MCNC, which provides technical infrastructure to educate, innovate and enhance economic development throughout North Carolina.

In recent years the Board's staff has also recommended and implemented several well-known strategic initiatives and benchmarking efforts, such as:

- Vision 2030, a statewide science and technology-focused strategic planning effort;
- The Governor's Task Force on Nanotechnology and North Carolina's Economy, which produced roadmap for successful nanotechnology-based economic development and high-wage employment across North Carolina;

and grant programs, such as:

- The One North Carolina Small Business Program, which awards matching grants to North Carolina Small Businesses that have received federal grants designed to help them commercialize their innovative technologies; and
- The North Carolina Green Business Fund, which awards competitive grants to North Carolina organizations having innovative projects focused on developing and commercializing promising and innovative "green" technologies.

These efforts, particularly the grant programs, have encouraged innovations in a wide variety of activities throughout the state, such as biotechnology, health care, advanced materials, computer software, defense technologies, biofuels, green building technologies, and alternative and renewable energy.

North Carolina Department of Commerce: Office of Science and Technology
In 2001, the staff of the Board was transferred from the Department of Administration to the Department of Commerce to more closely align the Board's work and science and technology initiatives with economic development. Additionally, the transfer enabled the leveraging of the capabilities of the science and technology staff by providing the support of the Department of Commerce's policy and research, public affairs, marketing, legal, and administrative functions. Utilizing these synergies mitigated the impact of recession-induced budget cuts at the time.

The Office serves as staff to the Board of Science and Technology, supports the Department's economic development initiatives, administers the One North Carolina Small Business and Green Business Funds, and leads initiatives such as coordinating the development of North Carolina's nanotechnology roadmap, and planning and organizing a statewide nanotechnology commercialization conference. Additionally, working with the Department's Legislative Liaison, the Office advocates for programs focused on science, technology, and innovation.

University of North Carolina (UNC)[61]
Chartered by the North Carolina General Assembly in 1789, UNC was the first public university in the United States. Today, UNC is a multi-campus university composed of all 16 of North Carolina's public institutions. Its mission is to discover, create, transmit, and apply knowledge to address the needs of individuals and society. The university promotes innovation in several ways, the most important being through its core missions of teaching, research, and outreach and engagement. Through its member campuses, the University performs more than $1 billion in research annually. Additionally, it has several programs, offices, and initiatives focused on or related to promoting innovation:

- At least six UNC institutions (ECU, NC A&T, NCSU, UNCC, UNC-CH, UNCG) have offices focusing on technology commercialization and transfer. These offices are dedicated to identifying research that has potential commercial interest and developing strategies and carrying out activities to achieve that interest.

- UNC has eight "Millennial Campuses" existing or in the planning stages at its constituent institutions (ECU, FSU, NC A&T-UNCG [joint], NCSU, UNCC, UNC-CH, UNCW, WCU) throughout the state. Such campuses enhance an institution's research, teaching, and service mission and the economic development of the region served by the institution. By allowing the institutions to build research facilities and occupy them with private-sector partners that derive benefits from a close working relationship with university faculty and students, the Millennial Campus Act,[62] approved by the North Carolina General Assembly in 1999, extends the educational and economic benefits of these partnerships to regions throughout the state.

- North Carolina State University operates the Industrial Extension Service (IES), whose mission is to help companies throughout the state innovate by helping them adopt the latest technologies and best practices in both engineering and business management. IES provides education and technical assistance to business and industries across the state, and it works directly with small- and medium-sized manufacturers to help them with improvements, the use of modern practices, and new technology.[63]

- UNC's Small Business and Technology Development Center (SBTDC) serves as the university's business and technology extension service, providing knowledge, education and other supportive resources that enable existing small and mid-sized businesses, emerging entrepreneurs, and local/state leaders to innovate and succeed. Its services include business counseling, export financing services, government procurement, management education, marketing & research services, and technology development and commercialization.[64]

- In 2006, the UNC Board of Governors (BOG) endorsed a new strategic direction: *Respond to and monitor the economic needs and directions of the state, paying particular attention to the differing needs of the state's economic development regions.* To help meet the economic development needs of the state, UNC is pursuing five goals:
  - Deliver learning that meets the needs of the 21st century economy;
  - Enhance the capacity of public institutions to implement successful and sustainable economic development policies;
  - Enhance opportunities for research and innovation;
  - Provide support to build competitive businesses;
  - Grow high-quality, healthy and attractive communities.

Efforts to achieve these goals are ongoing.

- In 2007, UNC formed the UNC Tomorrow Commission to determine how the University can respond more directly and proactively to the 21st century challenges facing North Carolina, now and in the future, through the efficient and effective fulfillment of its three-pronged mission of teaching, research and scholarship, and public service.[65]

  With its partners and oversight by the UNC Board of Governors, UNC is undertaking this initiative through a four-part process:

  1. ***Preparation*** - February – July 2007
     Work with campuses to analyze what they are currently doing to meet present and future challenges facing our state and their region and how they identify those challenges; conduct internal review of existing resources; and synthesize and update existing reports and studies.

  2. ***Assessment*** - August 2007 – January 2008
     Meet with business, nonprofit, community, policy, and governmental leaders in each of the state's regions and in statewide sectors to hear from them what they need from UNC over the next twenty years; Commission issues report and recommendations to UNC BOG.

  3. ***Response*** - February 2008 – May 2008
     Develop a response to identified needs by UNC and each campus consistent with UNC's mission as well as systemic changes to internal processes to ensure continued focus in future years. The UNC BOG will approve response plans.

4. ***Implementation*** - June 2008 – January 2012
Implement responses at the UNC and campus level by integrating responses into missions, programs, and curriculum, and assessing progress toward goals.

The outcomes of the initiative will guide and shape current and future resource allocations, existing and future programs, and strategic plans and missions of the University. The goal is to become more proactive and responsive to the needs of the state, and to remain so in the years to come, as the people of North Carolina continue to confront the challenges of the rapidly changing, knowledge-based global economy and environment of the 21st century.

North Carolina Community College System (NCCCS)[66]
Created by the North Carolina General Assembly 1963, the NCCCS has as its mission to open the door to high-quality, accessible educational opportunities that minimize barriers to post-secondary education, maximize student success, develop a globally and multi-culturally competent workforce, and improve the lives and well-being of individuals. NCCCS also has at least two major programs and initiatives related to promoting innovation:

- The Small Business Center Network includes Small Business Centers (SBCs) at each of the state's 58 community colleges, all committed to assisting North Carolinians who operate or want to start small businesses. The SBC Network supports the development of new businesses and the growth of existing businesses by being a community-based provider of training, counseling, and resource information on topics such as entrepreneurship and international business.
- NCCCS BioNetwork is a statewide initiative that connects community colleges across North Carolina, providing specialized training, curricula, and equipment to develop a world-class workforce for the biotechnology, pharmaceutical, and life sciences industries. All community colleges serving the pharmaceutical and biotechnology sector are part of BioNetwork.

North Carolina Biotechnology Center (NCBC)[67]
Established by the North Carolina General Assembly in 1984, the North Carolina Biotechnology Center was the world's first government-sponsored biotechnology center. Its mission is to provide long-term economic and societal benefits to North Carolina through support of biotechnology research, business and education. NCBC is not a site for laboratory research or company incubation. Instead, it works to strengthen the research capabilities of North Carolina's companies and universities.

NCBC has several programs and initiatives focused on or related to promoting innovation:

- The Science and Technology Development Program supports biotechnology research at North Carolina's universities and institutions through grant programs and intellectual exchange activities.
- The Business and Technology Development Program supports North Carolina bioscience companies through funding, technology assessment, strategic partnerships, business plans, networking, venture capital, site locations and professional referrals.
- The Education and Training Program promotes workforce preparedness and public understanding of biotechnology through instructor training, teaching materials, grants programs, needs assessments and other activities at all educational levels throughout North Carolina.
- NCBC operates five regional offices across the state (greater Charlotte, Eastern, Piedmont Triad, Southeastern, and Western). These offices help their regions identify needs, goals and core competencies; draw on the programs and activities of the Biotechnology Center; and coordinate advisory committees to guide biotechnology development.
- The Centers of Innovation Program is designed to establish research and commercial hubs for products and processes deemed especially well-suited to creating biotechnology-related jobs across the state. These awards are intended to catalyze the state's efforts in the research and commercialization of strategically selected sectors, such as nanobiotechnology, marine biotechnology, and advanced medical technologies.

North Carolina Rural Economic Development Center (North Carolina Rural Center – NCRC)[68]
In 1987, the Rural Center was established as the first organization in the country devoted exclusively to state rural advancement. Its mission is to develop, promote, and implement sound economic strategies to improve the quality of life of rural North Carolinians. The center provides financial support through its R&D Grants Program to other organizations to test innovative ideas.

NCRC has at least two programs and initiatives focused on or related to promoting innovation:

- The e-NC Authority is the State initiative to link all North Carolinians—especially those in rural areas—to the Internet. The e-NC Authority is responsible for the following:
  - Tracking the availability of high-speed Internet services in each county across the state;
  - Advocating for high-speed Internet access at competitive prices to all North Carolinians;

  - Significantly increasing the numbers of individuals, businesses and organizations who own computers and computer devices and who subscribe to the Internet;
  - Establishing telecenters located in the state's most economically distressed areas;
  - Establishing a Web site to provide North Carolinians with complete information on Internet and telecommunications services.
- The Institute for Rural Entrepreneurship stimulates and supports the development of micro, small and medium-size enterprises in North Carolina's 85 rural counties. The Institute provides technical assistance and training, entrepreneurship education and training, access to capital, access to networks, and leadership and policy development.

Regional Economic Development Partnerships[69]
In 1994, the North Carolina General Assembly ratified the Regional Economic Development Commission Expansion Program, which directed the North Carolina Department of Commerce to assign all 100 counties to one of seven Regional Economic Development Partnerships.[70] According to the legislation, each partnership's region was to be the appropriate size, economically integrated, and have an economic engine. The seven partnerships are as follows:

- AdvantageWest Economic Development Group (23 counties)
- Charlotte Regional Partnership (16 counties)
- North Carolina's Eastern Region (13 counties)
- North Carolina's Northeast Commission (16 counties)
- North Carolina's Southeast Commission (11 counties)
- Piedmont Triad Partnership (12 counties)
- Research Triangle Regional Partnership (13 counties)

While some of the partnerships are public commissions, others are private, non-profit corporations. Each, however, receives a portion of its funding from State appropriations. Moreover, while the range of activities across the partnerships varies, their core functions include marketing, advertising, promotion, research-related economic development activities, and economic development activities to secure jobs and new investment in the region served by the commission.

In 2002, the General Assembly required the development of a five-year vision plan for each of the seven economic development regions in the state. And in 2004, the General Assembly directed each of the seven partnerships to perform a comprehensive study of its region's resources and exiting business to determine what clusters exist and the boundaries of those clusters, to develop ways to strengthen those clusters, and to determine in what areas the region has competitive advantages that could lead to the development of future clusters. These latter efforts, which are the partnerships' most innovation-focused initiatives, are ongoing.

With a few important exceptions, therefore, none of the public organizations and programs above has advancing innovation—across sectors and the entire state—as its primary purpose. Together, however, they do provide the core resources and programs necessary for achieving this goal. A list of innovation-related initiative created by these organizations and others since 2001 is in the appendix. This list, while impressive, is not sufficient for ensuring North Carolina's leadership in the 21st century.

The key ingredients are in place; they just need to be increased, enhanced, utilized, and combined in ways that maximize their effectiveness. Currently, however, North Carolina's state government is limited in its ability to see and promote the complementarities that may exist between innovation needs in different industries and geographic regions. It also is limited in its ability to achieve synergies from its resources and programs that can serve those needs. An enhanced and optimized framework would address these limitations.

An Enhanced North Carolina Innovation Framework

Effectively addressing the innovation challenges outlined above is the key to ensuring North Carolina's innovative edge and prosperity in the 21st century. If we fail to address them, the market will continue to produce a sub-optimal level of innovation whose impacts will be targeted to the most populated regions in the state.

"It is pointless to obsess, as is common in many discussions of industrial policy, about policy instruments and modalities of interventions. What is much more important is to have a process in place that helps reveal areas of desirable interventions."

Dani Rodrik,
Economist,
2007

Innovation Frameworks in Other Countries[71]

Ireland, Finland and Singapore, countries that are similar in size to many American states, are not leaving the development of innovation to chance—they are making a concerted, consistent effort to make it happen. Here are some highlights of their stories:

IRELAND

In the 1990s, Ireland redirected its faltering economy away from farming and manufacturing toward technology and services. As a major part of that process, the country began strategically investing in research and development. Three government agencies share responsibility for growing the country's knowledge-based economy and work together to ensure great ideas are not wasted. Enterprise Ireland works to transform Irish industry; IDA Ireland secures foreign investment that in 2006 hit $635 million U.S.; and Science Foundation Ireland (SFI) links industrial and academic research.

SFI emerged from the country's 2000 to 2006 National Development Plan with more than $700 million to fund research projects. In just a few years, SFI has become a prime example of Ireland's R&D success, bankrolling more than 1,000 projects and helping to attract 2,500 research scholars. Hundreds of international companies, including Dell, Microsoft, Intel and Motorola, now have operations in Ireland and have established research partnerships with Irish universities.

Ireland is now one of the world's most dynamic economies, but it is not resting easy. Its newest six-year National Development Plan continues the country's steadily increasing investment in R&D and includes $35 billion for human capital development and another $27 billion for enterprise, science and innovation, $1.9 billion of which SFI will invest in new research opportunities.

FINLAND

Finland's 7 percent unemployment rate may still be high compared to some countries, but it's a vast improvement over the country's 1994 peak of 16.6 percent. Since then, the country has dramatically ramped up research and development spending. Finland spent $7.7 billion on R&D in 2006, an increase of 235 percent since 1990. Government and businesses alike have steadily increased their investments, with government spending comprising a third of national R&D expenditures.

As in Ireland, three Finnish organizations carry out their R&D strategy. Sitra, the Finnish national fund for research and development, can thank Nokia, the cell phone manufacturer, for providing the bulk of its $1 billion endowment, which it uses to supply venture capital to Finnish start-ups. Tekes, Finland's national technology agency, supports university- and business-based research; its budget tops $650 million, which it uses to fund more than 2,000 projects annually. Additionally, the Finnish Academy of Science and Letters funds centers of excellence with a focus on science.

Finland's strategy has paid off. Their GDP grew 3.4 percent in 2006, up from 2 percent in 1990, and the number of college graduates has nearly doubled over the past two decades. By 2005, the country climbed to the top of the World Economic Forum's Global Competitiveness Index. National leaders admit, though, that Finland's investment has not translated into as many new innovations, businesses, or jobs as it would like. In the past year, Finland has refocused its attention on broad-based innovation policy and assessing the efficiency and effectiveness of R&D investment.

SINGAPORE

With a GDP equivalent to Oklahoma's, Singapore has successfully used a targeted approach to R&D. In 1991, its first national technology plan invested $1.3 billion in the country's life sciences sector. In 2005, total R&D spending in Singapore hit $3 billion, with private-sector spending comprising two-thirds of that total. While continuing to encourage private-sector investment, the country has committed to doubling its own R&D budget between 2006 and 2011, earmarking $8.9 billion over that time for research-related initiatives.

Singapore is now the world's fifth most competitive economy, with three times as many research scientists and engineers as it had in 1990. It has lured scientists from across the world with its offer of generous funding for their research and the chance to work in the Biopolis, a self-enclosed science city. The country's Agency for Science, Technology and Research (A*STAR), which coordinates public research initiatives, tracks the work of more than 900 scientists in its national researchers database.

The country's consistent commitment to R&D starts at the top. The current five-year plan established a Research, Innovation and Enterprise Council (RIEC), chaired by Singapore's prime minister, and the National Research Foundation, which supports the RIEC and provides coherent national leadership of R&D.

Framework Foundation — Ten Principles

In keeping with North Carolina's history as a policy leader, and in response to the new rules of the game in the 21st Century innovation economy, North Carolina should view its innovation challenges as an opportunity to enhance and re-align its public institutions and programs further to foster and accelerate the spread of innovation, both within government and externally throughout the state's economy to the broader society. Such a re-alignment is needed because the importance and potential of innovation-based economic development deserve optimal visioning, planning, and coordination of initiatives and activities. Our institutions and programs need to keep pace and anticipate the changes resulting from science, technology, and innovation.

Such a re-alignment would not cause large-scale relocations of existing government operations and personnel, nor would it detract from the core missions of existing government agencies and organizations. The restructuring would simply take existing governmental and economic actors and create a network to better enable the actors to foster and spread innovation. Market forces and private entrepreneurship would still be the main actors in the economy, but government would play an enhanced strategic and coordinating role that would enable and encourage the actors to collaborate and innovate in their respective spheres.

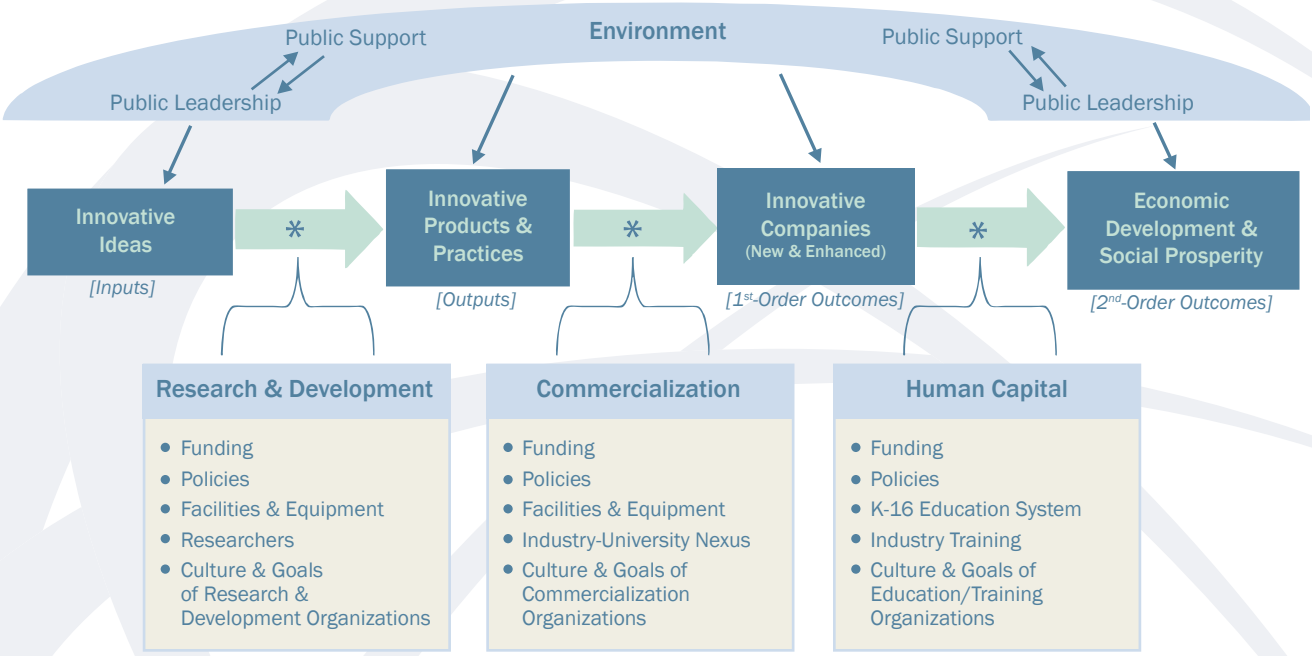
"Today, globalization is changing the geography of markets, competition, and cooperation. Yet companies continue to cluster and remain remarkably place based. [Moreover] although competition in this global economy is sometimes viewed as between nations, it really is between high-performing economic regions."

Cluster-Based Strategies for Growing State Economies, National Governors Association 2007

In effect, government would best position itself to serve as a facilitator that encourages companies and other organizations to innovate in ways that serve the public interest. The relationship among government, businesses, and other organizations would be *"an interactive process of strategic cooperation between the public and private sectors which, on the one hand, serves to elicit information on business opportunities and constraints and, on the other hand, generates policy initiatives in response."*[72] The goal would be to *focus on establishing strategic, ongoing collaborative relationships between the private sector and government for the purpose of discovering both the underlying impediments to innovation and to engage in strategic coordination to overcome those impediments and seize opportunities.* To the extent those relationships function well, good outcomes will naturally follow.

Relationships are critical because innovative ideas are translated into economic development and social prosperity through complex and dynamic interdependencies among a variety of collective efforts. Innovation, therefore, occurs within an "ecosystem;"[73] it is a "team sport." Moreover, a state's innovation ecosystem consists of a network of regional innovation ecosystems. Government can strengthen links, networks, and teamwork within these ecosystems, enhancing their ability to deliver the economic and social fruits of research and development through innovative products and practices. Government can help create a mutually advantageous conjunction of innovative assets and actors where the whole is greater than the sum of the parts.

Figure 3.2 The Innovation Ecosystem



**Under appropriate conditions: leadership, support, infrastructure, resources, goals and culture. Human capital is a key condition at all stages of the ecosystem. However, for the purposes of this figure, its most critical role is in fostering economic development and social prosperity by providing an educated workforce for innovative companies.*

Thus, while government is not the engine for the innovation process, public leaders can strengthen that process through a framework that optimizes (lubricates and tunes) the roles that are uniquely in their hands. A well-designed institutional and policy framework is the best way to help foster these types of productive, innovation-fostering relationships.[74] In keeping with the nature of 21st century economy and government (Tables 1.3 and 1.4), the guiding principles for this framework should be the following:[75]

1. **Existing organizations with demonstrated competence and statewide jurisdiction should have primary authority for implementing the framework's programs.** In light of scarce resources and the benefits of economies of scale, vesting increased authority in existing organizations is preferable to creating new organizations with new authority.

2. **The implementing organizations should receive guidance and oversight from officials who are publicly accountable.** Such a relationship guards against self-interested actions by the organizations and protects them from undue influence from private interests.

3. **The implementing organizations should maintain channels of communication with the private sector.** Ongoing contacts and communication with the private sector provides public officials with good information on economic realities, which provides the basis for sound decision making

4. **The framework should use a diverse and supportive tool kit, including information and education, inducements and assistance, and coordination and facilitation.** Rather than being top-down and prescriptive, the framework should help create the conditions in which bottom-up, regionally based market actors—private and public—can collaborate in new, innovative, productive ways and make more informed decisions.

5. **Programs should target "new" activities.** "New" refers to products that are new to the local economy, to new technologies for producing existing products, and to new processes for accomplishing existing activities.[76] Targeting these activities would diversify the economy, promote innovation, and generate new areas of competitive advantage.

6. **New programs should be sufficiently long-term and well-funded to make a difference, but decisions about and their continuation and/or modifications should be guided by clear benchmarks and performance criteria.** Absent these criteria, imperfections are more likely to go unrecognized and be perpetuated, and successes may not be continued or replicated.

7. **Programs should have the flexibility to respond to continually changing circumstances and to support different needs across regions.** The ability to modify and vary public programs is necessary to keep pace with the innovative, region-based economy.

8. **Programs should focus primarily on cross-cutting activities, not narrowly defined sectors.** Focusing on activities targets attention on the core factors impeding the innovation process, which in turn generates cross-cutting, capacity-building programs that benefit multiple sectors.

9. **Publicly supported activities should have clear potential to provide informational spillovers or demonstration effects.** Public support, by definition, is "public," not private. It should promote the public good.

10. **There should be a realization that risk and change are integral parts of innovation.** Because new activities inherently entail some risk, an optimal strategy for promoting innovation will necessarily yield some failures. The goal, therefore, should not be to minimize all chances of failure; rather, it should be to minimize the costs of failures when they occur and to apply constructively the knowledge learned from those failures.

"Government has a vital role to play as a catalyst for large-scale innovation. Government should not seek to dictate, micromanaging every aspect of an agenda, but rather to serve as a steward by convening and facilitating."

John Kao,
Harvard Business School,
2008

Framework Operationalization — Five Roles

To fulfill the above principles, North Carolina's public leaders should enhance the capacity and effectiveness of the state's existing innovation framework. They can do so by enhancing five roles that are uniquely in their hands:

1. **Champion and Communicator.** Public leaders can champion the importance of innovation, as well as coordinate promotion and communication of the state's successes to its citizens and other audiences.

2. **Convener and Facilitator.** Public leaders can convene cross-functional groups of policy, academic, and business leaders to elicit information and strategic policy initiatives that accelerate the progression from innovative ideas to economic development and social prosperity.

3. **Funder and Policymaker.** Public leaders can make strategic investments and policies to build world-class research and development enterprises, aid the development of scalable collaborative communications infrastructure, encourage collaboration among academia and industry, commercialize innovative products and practices, and cultivate human capital in the state.

4. **Recruiter and Retainer.** Public leaders can assist in identifying, promoting, and recruiting potential enterprises to bring to North Carolina to augment innovation clusters and economic growth, as well as assist in retaining innovative enterprises in the state for the ongoing and future benefits they provide.

5. **Evaluator and Advisor.** Public leaders can measure performance relative to strategic goals, serve as an expert resource on innovation, and, where the State has invested heavily in innovation policies, improve coordination of those policies to receive the most benefit from State investments.

No other institutions or organizations can fulfill these roles to the extent that public leaders can.

"Highly educated people, great universities and networks for interaction can't be found in the earth, nor do they appear through spontaneous generation. They come into being as the result of well thought out and strategic public policy."

Investing in Innovation,
National Governors Association
2007

Framework Leadership and Coordination — Three Institutions

Public leadership and support shape the overall environment in which innovative ideas are translated into economic development and social prosperity. More than ever before, we must build a supportive climate for innovation in North Carolina. We must affirm and advance innovation as a fundamental value and culture of the state. We must advocate for investments and support for innovation as a companion to education as our strategic building blocks in economic development. And we must infuse an emphasis on innovation into every aspect of life in North Carolina, building on our current positioning as "The State of Minds." Building

constituencies for innovation agendas is fundamental, as it improves the likelihood of securing the ongoing support and funding needed to survive economic downturns and creates the cumulative successes upon which innovations depend.

North Carolina currently has the public institutions in place to provide the leadership and coordination needed for a well-functioning innovation framework. Those institutions simply need to be enhanced, optimized, and realigned. Specifically, leadership and coordination for the framework should come from the following three state institutions: An enhanced Board of Science and Technology, an optimized State Science and Technology Advisor, and a realigned General Assembly committee structure. The role and recommendations for each are discussed below.

> *"Public sector institutions have the ability to articulate a public agenda and then act as a catalyst. Government's role as a convener of different interests helps to build bridges across disciplines and between upstream and downstream activities."*
>
> *New Foundations for Growth: The U.S. Innovation System Today and Tomorrow, RAND Corporation, 2002*

Board of Science and Technology

Among the organizations comprising North Carolina's existing innovation framework, the North Carolina Board of Science and Technology is best positioned to lead and coordinate an enhanced framework. It has the longest history of encouraging, promoting, and supporting new science, technology, and industrial research applications throughout North Carolina. Moreover, it has a close relationship with both the Governor and the General Assembly, who have assigned it as a steward to ensure that science and technology play an important role in promoting the economic growth and development throughout the state. It has similarly close ties with the private sector, as well as an extensive track record of benchmarking the state's performance and implementing and coordinating programs focused on promoting technology-based economic development. Accordingly:

1. **The Board of Science and Technology should be charged and equipped with additional resources to implement an innovation framework that optimally fosters and stimulates innovation throughout all facets and regions of North Carolina's economy, government, and society.**[77]

To a limited degree, the Board performs this purpose already, but the extent to which it does so has been severely constrained by limited resources, particularly in recent years. For example:

- Through its *One North Carolina Small Business Grant Program*, the Board provides matching funds to North Carolina small businesses who have been awarded federal grants designed to help them commercialize their innovative technologies. It also provides partial reimbursement funds to help the companies cover costs associated with applying for the federal grants. The program enables the businesses to generate the kinds of innovation critical for making the state a leader in the global economy. In the last two legislative sessions, however, funding for the program has decreased substantially while the funding needs of early-stage businesses have increased.

- Through its *North Carolina Green Business Fund*, the Board awards competitive grants to North Carolina organizations having innovative projects focused on developing and commercializing promising and innovative "green" technologies, such as biofuels, green building, and environmentally conscious clean technology and renewable energy products. Funded projects are cross-cutting and capacity-building, spanning all facets of the economy and society. In the last two legislative sessions, however, the program has received limited levels of funding. As a result, a large number of innovative and valuable green technologies have been unable to receive funding.

- Through its strategic initiatives such as the *Vision 2030* strategic planning effort and a *Roadmap for Nanotechnology in North Carolina's 21st Century Economy,* the Board has championed innovation. Such efforts convened cross-functional groups of policy, academic, and business leaders to elicit information and strategic policy initiatives that accelerate the progression from innovative ideas to economic development and social prosperity. However, the due to limited resources, the Board has not been able to implement many of the needed recommendations outlined in those reports.

More generally, the operating budget of the Board's staff in the Office of Science and Technology—exclusive of its programmatic budget—has been cut in five of the past six years, and now stands at 30 percent of its 2000 level. The resources needed to enable the Board to implement the new innovation framework are not large, but they can have a strong multiplier effect if used to bring together other players in the innovation ecosystem throughout the state—notably research institutions, education and training institutions, innovative and entrepreneurial leaders, and the private

sector—that already devote a great deal of money toward translating innovative ideas to economic development and prosperity.

Additional resources would better enable the Board to assess and monitor innovation, serve as an expert resource on innovation within state government, and, where the State has invested heavily in innovation policies, improve coordination of those policies to receive the most benefit from State investments. Just as a private company must measure profit and loss, states must define and apply their own performance assessment measures to make sure their innovation-focused resources and efforts are delivering increasing benefits. These assessments yield valuable information about how best to foster innovation regionally and statewide.

State Science and Technology Advisor

At least 10 states (Arkansas, Idaho, Iowa, Maine, Ohio, Oregon, New Mexico, South Carolina, Utah and Virginia) currently have individuals who serve state policy makers as science and technology advisors.[78] Having a science and technology advisor provides a competitive advantage by giving governors and other state policy makers:

- Immediate access to scientific and technical advice;
- Connections with networks in other states and globally;
- A "go to" person for identified impediments to the innovation and economic growth imperative;
- The perspective and focus to see strengths, weaknesses, and opportunities across the state; and
- A champion to unite science and technology agendas across agencies and throughout the state.

Prior to 2000, North Carolina had a Science Advisor who reported to the Governor and also served as the Executive Director of the Board of Science and Technology. In 2001, the Science Advisor and the Board were moved, by statute, from the North Carolina Department of Administration to the North Carolina Department of Commerce, the Office of Science and Technology was created in the Department of Commerce, and the title "Science Advisor to the Governor" was statutorily removed from the Executive Director's position.[79] The subsequent Executive Directors have continued to serve as the de-facto State Science Advisor, but in a less potent capacity than in previous years. Accordingly,

2. **Consistent with enhanced resources for the Board of Science and Technology and its staff, the State Science Advisor position should be reestablished and it should be optimized to carry out the position's functions.**

This position could report directly to the Governor or to the Head of the agency in which it and the Board are housed. The reporting structure for the position is less important than is having sufficient resources to carry out the duties of the position.

The position's purpose would be to facilitate the Board of Science and Technology; to advise the Governor, the General Assembly, and other state policy makers on the impacts of science, technology, and innovation on domestic and international affairs; and to champion and unite science and technology agendas across agencies and throughout the state. Rather than being new for North Carolina, this position would restore science, technology, and innovation issues to their previous stature, as well as provide strategic, integrated, and well-informed leadership and coordination to the state's innovation framework.

General Assembly

To complement, guide and, provide oversight to the Board's and the Science and Technology Advisor's coordination of the innovation framework, the North Carolina General Assembly should adapt and enhance its institutional structure to take into account the changes driven by science, technology, and the innovation economy. Accordingly:

3. **To provide appropriate guidance and oversight of the framework, the General Assembly should strengthen the alignment of its committee and staff structure with the needs of the 21st century innovation economy.**

Specifically, the General Assembly should establish one or more standing committees explicitly designed to consider issues related to science, technology, and the innovation economy. In recent years, many state legislatures have established committees focusing on the challenges posed by rapid economic change. For example, the California State Legislature created the Joint Committee to Prepare California

> *"Today, approximately two-thirds of the award-winning U.S. innovations involve some kind of inter-organizational collaboration—a situation that reflects the more collaborative nature of the innovation process and the greater role in private sector innovation by government agencies, federal laboratories, and research universities."*
>
> *Where Do Innovations Come From? Information Technology and Innovation Foundation, 2008*

for the 21st Century, and Indiana's House of Representatives recently created a Committee on Technology Research and Development, and its Senate created a Committee on Economic Development and Technology. These committees are organized to focus legislative attention on the development of a robust statewide innovation economy.

Although the North Carolina House of Representatives currently has a standing Science and Technology Committee, the Senate does not have a similar committee. Moreover, the House committee rarely considers issues of innovation policy. Thus, to enhance North Carolina's legislative focus on science, technology, and the innovation economy, the House Science and Technology Committee should increase its focus on innovation economy issues, and the Senate should create a committee whose jurisdiction corresponds to that of the House Science and Technology Committee. These changes will significantly strengthen strategic coordination between the legislative branch and the executive branch in matters related to innovation.

These three institutional recommendations are low-cost options that can be implemented immediately. They would provide the leadership and oversight needed to implement and coordinate the framework.

Framework Implementation — Four Drivers

To implement and coordinate the framework, the three institutions above should work to expand and enhance four core drivers that will accelerate the progression of innovative ideas into economic development and prosperity throughout the state: *Research & Development, Commercialization, High-Tech Economic Activity, and Human Capital Development.*[80] In the sections that follow, two specific recommendations are made within each of these drivers, providing an initial "front-burner" agenda for critical evaluation and future development by policy makers, state agencies, and organizations. Together, they serve to engage a wide variety of North Carolina individuals and organizations around the goal of competing and prospering in the interconnected global economy.

RESEARCH AND DEVELOPMENT

1. **Provide State-funded R&D competitive grants to public universities:** To increase the commercial relevance of North Carolina's considerable academic R&D investments and capabilities, the State should provide competitive matching grants to UNC faculty to conduct research in collaboration with or industry consortia. The grant awards would provide matching support for research that facilitates job creation in targeted and strategically important industry sectors. The research would support sustainability and innovation within the industry sector. Industry Sector Development Partnerships, organized by the North Carolina Department of Commerce, would construct cluster development plans. UNC would convene the Sector Partnerships annually to develop a strategy to guide allocation of the competitive funds. Regional diversity and development across the state would be sought.[81]

   Cost: At least $5 million annually for the UNC system; UNC General Administration would determine how the funding is allocated among its constituent institutions. Funded through State appropriations, to be matched, at least 1-for-1, by industry partners.

2. **Design and support programs to market the state's R&D assets:** To increase the number of companies, federal agencies, entrepreneurs, and researchers conducting R&D, locating, or expanding operations, in North Carolina, the State should convene a public/private partnership to market North Carolina's R&D assets. Specifically, a strategic, coordinated, and integrated public relations, marketing, and communications campaign should promote North Carolina as a high-tech state that values, encourages, and invests in science, technology, and innovation. The public/private partnership would be comprised of appropriate representatives from government, industry, education, regional economic development commissions, local governments, non-profit organizations, and professional associations throughout North Carolina.

   Cost: At least $2 million annually. Funded through a combination of support from the State, private industry, universities, and nonprofit organizations.

COMMERCIALIZATION

3. **Support the repurposing and funding of technology transfer platforms in the UNC system:** To optimize the transfer of university-generated technologies into the private sector, as well as to increase university-industry collaborative activity, the UNC technology transfer offices should be encouraged to focus more on company and industry engagement, job creation, and enhanced quality of life for all North Carolinians. To achieve this, the technology transfer offices would need recurring State appropriations, which would reduce their dependence on licensing revenue as a source of income. Moreover, the metrics used to evaluate the offices would need to be broadened, consistent with their broadened purpose.

   Cost: At least $3 million annually for the UNC system; UNC General Administration would determine how the funding is allocated among the constituent institutions. Funded through State appropriations.

4. **Advocate and provide funds for the continuing development of the UNC Millennial Campuses:** To facilitate industry-university collaborations that broaden the spread of innovative clusters throughout the state, all UNC institutions should be supported in their efforts to derive the benefits of the Millennial Campus Act.[82] By allowing the institutions to build research facilities and occupy them with private-sector partners, the Act encourages the development of a synergistic research, development, innovation, and commercialization environment at each institution. The Act effectively enables the state to build on its existing strengths and distribute research and innovation activities, focusing on the unique potential of the region supported by the campus. Funds for developing Millennial Campuses could support, among other activities, feasibility study and planning grants, start-up activities, and enhancing well-defined existing collaborative activities.

   Cost: UNC institutions should be encouraged to expedite plans for, and build out of, their Millennial campuses; cost will vary by institution. Funded through State appropriations.

HIGH-TECH ECONOMIC ACTIVITY

5. **Continue to support programs focused on increasing the number and benefits of SBIR/STTR grants:** To foster the development and growth of high-tech and innovative businesses, the State should continue to support its programs focused on leveraging the benefits of the federal Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) grant programs. As the single largest source of early-stage funding to assist small businesses in commercializing their innovative business ideas, these federal programs serve as a valuable resource for the state's innovation-focused efforts to leverage. In particular, the Small Business and Technology Development Center (SBTDC) provides a wide range of programs designed to help small businesses learn about and apply for SBIR and STTR grants. Moreover, the One North Carolina Small Business Program, administered by the North Carolina Board of Science and Technology, assists businesses with a portion of their application expenses to the SBIR/STTR programs and matches federal SBIR/STTR grants awarded to businesses. Support for both of these state programs should be continued and expanded.

   Cost: At least $1 million annually above current funding levels for the SBTDC's SBIR/STTR-related programs; at least $5 million annually for the One North Carolina Small Business Program. Funded through State appropriations, which leverage federal funds.

6. **Enhance the technology adoption programs of the North Carolina Industrial Extension Service (IES) and the Small Business Technology Development Center (SBTDC):** To promote technology adoption and diffusion throughout the state, the successful programs of these two organizations should be enhanced or expanded, and new ones should be developed. Because these state organizations operate programs that leverage federal programs, such as those offered by the Manufacturing Extension Partnership and the Small Business Administration, the impact of State support is multiplied. Thus, additional support for IES and SBTDC programs targeted toward rural regions with traditionally lower levels of innovation would increase the number of companies benefiting from the organizations' services statewide.

   Cost: At least $1 million annually above current funding levels for the IES; at least $1 million annually above current funding levels for the SBTDC. Funded through State appropriations, which leverage federal funds.

HUMAN CAPITAL RESOURCES

7. **Increase the funding for technology- and innovation-focused workforce training programs:** To enhance existing workforce innovation-oriented training programs and fast-track the development of critically needed pools of technology-trained workers, North Carolina's educators, industries, and government should work to develop an explicit North Carolina innovation-focused technology workforce agenda and strategy. Specifically, the agenda should arrange education and workforce programs around clusters, particularly those the State has determined to be in the strategic interests of the state Such a focus should learn from and build on the successes of the state's existing programs in clusters such as entertainment, hosiery technology, and biotechnology. State support could increase funding to expand the infrastructure of existing programs, particularly in the Community College system, to include activities such as discovering cluster needs, faculty training, curriculum development, and program assessment.

   Cost: At least $5 million annually above current funding levels. Funded through State appropriations, which leverage existing funds from the State and other sources, such as industry and the federal government.

8. **Provide additional support for the North Carolina New Schools Project:** To accelerate systemic, sustainable innovation in secondary schools across the North Carolina, the State should work to ensure that every student graduates ready for college, careers and life

in the society and economy of the 21st century. The North Carolina New Schools Project (NCNSP), an independent 501(c)(3) non-profit organization created in 2003 by the Office of the Governor and the Education Cabinet with support from the Bill & Melinda Gates Foundation, has pursued that goal successfully since 2003. NCNSP partners with colleges and universities, state and local government and supporters in the private and philanthropic sectors. To date, NCNSP and school districts and educators have started more than 100 innovative high schools. The State should provide support to further these efforts and spread them throughout North Carolina, particularly rural regions.

Cost: At least $1 million annually above current funding levels. Funded through State appropriations, which leverage funds from multiple other sources, both public and private.

Expanding and enhancing these drivers in a manner consistent with the 10 guiding principles outlined above would be a critical set of steps to enable a broader, more robust network of effective research programs, commercialization efforts, cluster initiatives, and education curricula around the state. The result would move us closer to an optimized North Carolina ecosystem for delivering the economic and social fruits of research and development through innovative products and practices.

Conclusions and Next Steps

The framework above addresses the most pressing issues that can be attended to in the short term and also have long-term impacts. At its core, the framework focuses on public institutions: founding them on innovation-enhancing principles, operationalizing those principles through roles that are uniquely in the hands of public institutions, and vesting in those institutions enhanced responsibility for leading, coordinating, and implementing core drivers of the framework.

In tight budget times, this framework is particularly imperative because, rather than entail large capital and programmatic expenditures, it would efficiently and effectively strengthen North Carolina's public institutions in ways that enable them to better align North Carolina's existing innovation assets and maximize the state's innovative potential. It would make the most of what the state already has in place; it would make the most of the state's considerable existing capacity. As such, the Governor and General Assembly should act to authorize and fund the needed changes and initiatives in the 2009 legislative session. Doing so will begin the process of putting North Carolina squarely on track to prosper in the 21st Century innovation economy.

In light of increasing global competition and the large-scale investments that other countries and states are making in their innovation frameworks, however, North Carolina will need to continue to increase its innovation-focused investments significantly as resources permit.

The framework outlined above puts in place the institutions and processes capable of discovering the underlying impediments to innovation, the opportunities to engage in strategic coordination to overcome those impediments, and the resources needed to do so. Leading competitive countries are investing in innovation at the rate of two percent to five percent of GDP. This is a benchmark to keep in mind as we move forward with equipping North Carolina to be a global leader in innovation-based economic development and prosperity.

Epilogue: The Resurgence of Kannapolis as an Innovation Hub

In December 2004, David H. Murdock, owner of Dole Foods Corporation and one-time owner of Cannon Mills, purchased the 250-acre site of the former Pillowtex Plant in Kannapolis. Less than a year later, Murdock announced plans for a $1.5-billion scientific and economic revitalization project called the North Carolina Research Campus (NCRC), envisioned to be a world-class collaborative research hub for nutrition, health, and biotechnology research. And in October 2008, just five years after Pillowtex collapsed, the 300,000 square-foot David H. Murdock Core Laboratory, which houses the world's largest Nuclear Magnetic Resonator, began operations.[83]

The City of Kannapolis estimates that the NCRC will employ over 5,500 people in the next four years—more than the employment lost when Pillowtex closed.[84] *The average salary of the new jobs is expected to exceed $58,000, an amount that is $10,000 to $15,000 higher than the current average wage in Kannapolis.*[85] *Few people could have imagined such a remarkable transformation could happen in Kannapolis in such a short time.*

The NCRC is poised to become a remarkable success story of innovation-based economic development precisely because it embodies the key principles for successfully competing and prospering in the new economy (See Chapter 3 of this report). Specifically, the NCRC is designed to "foster a culture of innovation," drawing on the existing strengths and resources of the region. This vision builds upon partnerships with institutions of higher education, state and local governments, small and large businesses, and the local and greater North Carolina community.

By creating a culture where innovation prospers and is rewarded, NCRC builds on North Carolina's strong academic R&D: To date, seven North Carolina universities plan to or have already established research facilities there.[86] *The NCRC is an ideal catalyst for industry-academia partnerships: Several biotechnology companies plan to expand to NCRC because laboratory and research space is available and the best scientific minds will be nearby.*[87] *Moreover, emerging biotechnology and life science companies seeking to transfer innovations from the laboratory to the marketplace will have access to state and federal small business funding programs, and also to NCRC's own venture fund.*

Higher education institutions and local governments are also investing in human capital and infrastructure in support of the NCRC. Rowan Cabarrus Community College, for example, has established the Refocus, Retrain, Reemploy (R3) Center at the NCRC to offer free-of-charge career assessment and planning assistance to unemployed and under-employed workers.[88] *The R3 Center is partnering with local workforce development agencies, such as BioNetwork, to ensure workers can access all available resources and educational opportunities to become competitive in landing the high-technology jobs generated by research activity at the NCRC. For their parts, the city of Kannapolis and Cabarrus County have committed over $160 million to improve roads and other infrastructural needs to support the anticipated economic growth resulting from the NCRC.*[89] *This, in turn, has led to rising real estate prices around the NCRC, and a mushrooming of new service and hospitality-related businesses in the region.*

In short, this type of vision and action—seizing an opportunity, building on North Carolina's existing strengths, catalyzing partnerships across sectors, and fostering regional industry clusters—is a prime example of the successful outcomes that result from collaboratively embracing and maximizing innovation as an engine of economic growth.

[1] Martinez 2003.

[2] Friedman 2005.

[3] Kazmierczak and James 2005.

[4] Data for the 21st century include the years 1999-2006. For two of the indicators (Production workers, handlers, laborers, and Scientists and engineers in industry), 1999 was the latest year for which data were available. Moreover, the post-1999 years differ across factors because data from the same year were not available for each factor; for a given indicator, the latest year for which data were available is what was used. Sources: College graduates, 2006: U.S. Census Bureau; Managerial, professional, and technical workers, 2003: Atkinson and Correa, 2007; Women in the workforce, 2006: U.S. Department of Labor; Manufacturing productivity, 2006: Bureau of Labor Statistics; R&D expenditures, 2006: National Science Foundation; Industry contribution, 2006: National Science Foundation; Patents Issued, 2006: U.S. Patent and Trademark Office; Per capita income, 2006: Bureau of Economic Analysis; Average annual earnings per FTE worker, 2007: Bureau of Labor Statistics; Infant mortality rates, 2008: CIA Fact Book; New single-family home, median square footage, 2006: U.S. Census Bureau.

[5] Council on Competitiveness 2007.

[6] Tassey 2008.

[7] "OECD" stands for Organisation for Economic and Co-operation and Development. Its membership consists of 30 countries committed to democracy and the market economy. Its goals are to support sustainable economic growth, boost employment, raise living standards, maintain financial stability, assist other countries' economic development, and contribute to growth in world trade.

[8] Atkinson and Wial 2008, pages 11-12.

[9] Levy 2007.

[10] Montana, et al. 2001.

[11] This draws upon the classic definition of economics, appearing in most economics text books. It defines economics as the "allocation of scarce resources." This definition is typically attributed to Paul Samuelson in *Economics: An introductory Analysis* (1948). In a given jurisdiction, the prevailing economic system allocates scarce resources. In the United States, that system is free markets with relatively limited government intervention.

[12] This draws upon the often-cited definition of politics coined by David Easton in *The Political System: An Inquiry into the State of Political Science* (1953). It defines politics as the "authoritative allocation values." In a given country or region, the prevailing governing system is the authority that "allocates" values (i.e., ideals). In the United States, that system is representative democracy, as embodied in legislative, executive, and judicial branches comprising a federal system (i.e., power is divided between a central authority and constituent political units). Allocation takes the form of public policy outputs produced by the governing system. In the context of innovation, government's primary role is to set the general landscape on which economic activity can flourish. It does so by establishing basic factors such as macroeconomic balance, public infrastructure, property rights, enforcement of contracts, an education system, sound monetary policy, social insurance etc. Secondarily, government can help build on a society's innovative strengths by helping to identify and overcome market imperfections, setting strategic priorities, providing information, connecting disparate actors, and helping to coordinate their activities, etc.

[13] Atkinson and Wial 2008, page 4.

[14] Atkinson and Correa 2007, page 3.

[15] Atkinson and Correa 2007, pages 3 and 28.

[16] Farlie 2005.

[17] Atkinson and Correa 2007, pages 4 and 38.

[18] Atkinson and Correa 2007, page 4.

[19] Half-life is a mathematical and scientific description of exponential decay. When applied to the policy realm, it refers to the time it takes for a policy to lose half of its influential power.

[20] Orr and Stuart 2000.

[21] For example, see Atkinson 2004 for a discussion of how technological changes influence economic change.

[22] Between 1929 and 1959, the year the Research Triangle Park was founded, North Carolina's inflation-adjusted per capita income increased 184 percent. Between 1959 and 2006, it increased 198 percent.

[23] Basic research, sometimes referred to as fundamental or pure research, is research carried out to increase understanding of fundamental principles. Many times the end results have no direct or immediate commercial benefits. However, in the long term it is the basis for many commercial products and 'applied' research. For a detailed discussion of research types, see Stokes 1997.

[24] As paraphrased by George H. W. Bush in remarks while presenting National Medals of Science and Technology on November 13, 1990. (http://bushlibrary.tamu.edu/research/papers/1990/90111300.html). This likely comes from Vannevar Bush's work "Science: The Endless Frontier" (1945).

[25] An example of this type of policy is an Eminent Scholars programs, such as Georgia and Kentucky have implemented, which provide funding for state universities to attract renowned faculty through endowed chairs, monies to start-up labs, and funds for research assistants. (For more information, see A Resource Guide for Technology-Based Economic Development by State Science and Technology Institute (2006) or for more information about Georgia's program see http://www.gra.org/eminentscholars.asp).

[26] National Governor's Association 2002.

[27] Jaffe 1989.

[28] The Carnegie Foundation's most recent classifications listed Duke University, North Carolina State University, and University of North Carolina-Chapel Hill as Research Universities with Very High Research Activity and listed North Carolina A&T, University of North Carolina-Greensboro, and Wake Forest University as Research Universities with High Research Activity. (http://www.carnegiefoundation.org/classifications). Accessed March 2007.

[29] For example, see. Goldstein and Luger 1997; Acs et al. 2005; Lester 2005.

[30] For example, the same index ranked North Carolina 24th in 2002 and 30th in 1999. A similar ranking by the Milken Institute ranked North Carolina 18th in 2008, 20th in 2004 and 17th in 2002. In none of these rankings did North Carolina rank higher than the 2nd quartile of states.

[31] While not explicitly depicted as such in Figure 2.3, human capital resources are key factors at all stages in the innovation process. As such, they permeate the entire process.

[32] Given increasing competition from other countries, an ideal set of benchmarks would include data for other countries. Such data are currently difficult, if not impossible, to collect on a standardized, comprehensive, and comparable basis, however. Thus, comparison data for other U.S. states are used here. It is safe to assume, though, that if U.S. shares of worldwide innovation activity are decreasing (as discussed in chapter 1), North Carolina's performance relative to worldwide shares would resemble its performance relative to the U.S. average.

[33] Data for all state-level indicators come from the *2008 Science and Engineering Indicators* report produced by the National Science Board. These data are the latest that are currently available. In some cases there is a lag time of three to four years because the data are difficult or impossible to obtain directly or immediately. However, for most indicators the data do not vary significantly over a short period, and thus the indicators presented here can be considered representative of North Carolina's current standing in the innovation economy.

[34] In 2002, North Carolina expended 1.71 percent of its GSP in research, ranking 29th, compared to New Mexico, ranking 1st, at 8.76 percent according to the National Science Foundation's Science and Engineering Indicators 2006 (Chapter 8: State Indicators; Table 8-26).

[35] Reamer, Icerman, and Youtie 2003, Chapter 3.

[36] R&D obligations are binding financial commitment in a congressional budget appropriation. Obligations include contracts, staff employment, and purchases of goods and services.

[37] National Science Foundation 2007.

[38] Statistics are not available below the industry or state levels because of potential disclosure of information about particular firms that are respondents to the Survey of Industrial Research and Development, conducted jointly by the U.S. Census Bureau and the National Science Foundation. Respondents to the survey are guaranteed anonymity by law; Title 13 of the United States Code and a pledge of confidentiality to respondents prohibit publication or release of data or statistics that may reveal information about the individual companies that respond to the survey.

[39] This assumption is sufficiently reasonable for the purposes of approximating the location of R&D within North Carolina because the definition of R&D used in the survey is sufficiently broad as to accommodate the activities of a wide range of businesses, from manufacturing to services, and from high-tech to low-tech.

[40] People in S&E occupations include mathematical, computer, life, physical, and social scientists; engineers; and postsecondary teachers in any of these fields.

[41] 2006 data. Source: *2008 Science and Engineering Indicators*, National Science Foundation.

[42] Data showing the specific location of patents within a county are not available; thus Figure 2.15 shows county shading, not dots within counties.

[43] The data pertaining to establishments were based on their classification according to the 2002 edition of the North American Industry Classification System (NAICS). A list of the 46 industries (by 4-digit NAICS code) that are defined as high-technology can be found in the Technical Note at the end of chapter 8 of the *2008 Science and Engineering Indicators*, National Science Foundation.

[44] Sectors in which North Carolina is strong, such as biotechnology and tourism, do not appear explicitly in Table 2.2 because they are not industries, per se. Instead, they are broader, consisting of several of the industry sectors appearing in Table 2.2.

[45] S&E occupations are defined by standard occupational codes that encompass mathematical, computer, life, physical, and social scientists; engineers; and postsecondary teachers in any of these S&E fields.

[46] S&E fields include physical, life, earth, ocean, atmospheric, computer, and social sciences; mathematics; engineering; and psychology.

[47] Charlotte–Gastonia—Rock Hill, NC–SC MSA (25 percent); Greensboro–Winston-Salem–High Point, NC MSA (23 percent); Raleigh–Durham–Chapel Hill, NC MSA (22 percent). Nine other MSAs account for the remaining 30 percent of the state's population.

[48] While the maps may not appear to show this pattern, it is in fact the case and was confirmed by calculating a Herfindahl Index for each of the educational attainment levels. A Herfindahl Index is a measure of market concentration commonly used in economics. Ranging from 0 to 100, higher levels indicate more concentrated markets. The Herfindahl Index was highest for doctoral degree holders and lowest for associate's degree holders in North Carolina. The Index for bachelor's and master's degree holders was in between those for associate degree and doctoral degree holders.

[49] State Science and Technology Institute. Weekly Digest. (http://www.ssti.org/Digest/2007/).

[50] Ibid.

[51] Ibid.

[52] For one such example, see the National Governor's Association 2002, *A Governor's Guide to Building State Science and Technology Capacity.*

[53] Several publications have called for greater accountability for the research and development portfolio. See the Carnegie Commission on Science, Technology, and Government, 1992, Science, Technology, and the States in America's Third Century; Chapter 3.5: Growing need for program evaluation, and RAND Corporation, 2006, "Measuring the benefits from research" (http://www.rand.org/pubs/research_briefs/RB9202/).

[54] As noted in chapter 1, the market economy, with limited government intervention, is the system used in the United States. Increasingly, other countries are adopting market-based economies, though their specific forms vary across countries. This increasing adoption of market based-economies is a key reason underlying the need for increased innovation.

[55] For a detailed discussion of this theme, as well as the importance of markets, see Rodrik 2007.

[56] Market imperfection is a term used by economists to describe the condition where the allocation of goods and services by a free market is not efficient. A market imperfection is a scenario in which individuals' pursuit of self-interest leads to bad results for society as a whole. The belief that markets can have inefficient outcomes is a common mainstream justification for government intervention in free markets. Economists, especially microeconomists, use many different models and theories to analyze the causes of market imperfection and possible means to correct such an imperfection when it occurs. Such analysis plays an important role in many types of public policy decisions and studies. The term "market imperfection" does not suggest that markets, per se, are bad. It simply is used to describe situations in which markets are imperfect. For a comprehensive review of innovation-related marked imperfections, see Link 2008.

[57] For a discussion of each of these imperfections, see Atkinson and Wial 2008, pages 12-16.

[58] Jones and Williams 1998; Mansfield 1991.

[59] According to Atkinson and Wial 2008, venture capital in the United States more than doubled from $11.3 billion in 1996 to $26.4 billion in 2006, yet the amount invested in startup- and seed- stage deals fell from $1.3 billion to $1.1 billion. The amount invested in early-stage deals rose from $2.8 billion to $4.0 billion between 1996 and 2006, but the early-stage share of total venture funding fell from about 25 percent to about 15 percent. Similarly the number of startup- and seed-stage deals fell from 504 to 342; the number of early-stage deals rose from 762 to 918, but this represented a relative decline from about 30 percent to about 25 percent of all deals.

[60] North Carolina Board of Science and Technology (http://www.ncscitech.com). Accessed November 2008.

[61] University of North Carolina (http://www.northcarolina.edu), Long-Rang Plan 2004-2009, and Supplement to Long-Range Plan 2006 (http://www.northcarolina.edu/content.php/pres/publications/publications.htm). Accessed November 2008.

[62] Chapter 116, Article 21B, N.C. General Statutes.

[63] Industrial Extension Service (http://www.ies.ncsu.edu/). Accessed November 2008.

[64] Small Business and Technology Development Center (http://www.sbtdc.org). Accessed November 2008.

[65] UNC Tomorrow (http://www.nctomorrow.org). Accessed November 2008.

[66] North Carolina Community College System (http://www.ncccs.cc.nc.us). Accessed November 2008.

[67] North Carolina Biotechnology Center (http://www.ncbiotech.com) and 2007 Annual Report (http://www.ncbiotech.org/about_us/annual_reports/index.html). Accessed November 2008.

[68] North Carolina Rural Center (http://www.ncruralcenter.org). Accessed November 2008.

[69] Lugar and Stewart 2003; North Carolina Partnership for Economic Development (http://www.ncped.com). Accessed November 2008.

[70] S.L. 1993-769.

[71] National Governors Association and Pew Center on the States 2008, pages 49-50.

[72] Rodrik 2007, page 151.

[73] Wessner 2007. This ecosystem is ongoing and dynamic. The funding and resources needed to sustain it in a vibrant fashion should be a long-term commitment yet should be contingent on meeting clear-cut goals with appropriate metrics to track, incentivize, and retain participants in the ecosystem to remain engaged to the point where the returns are realized. In addition, a significant portion of innovative ideas will not result in economic development and social prosperity, and those that do may take years to realize. Risk and change are integral parts of innovation. Because new activities inherently entail some risk, an optimal strategy for promoting innovation will necessarily yield some failures. The goal, therefore, should not be to minimize all chances of failure; rather, it should be to minimize the costs of failures when they occur and to apply constructively the knowledge learned from those failures.

[74] For a detailed discussion of this theme, see Rodrik 2007. Rodrik reviews and expands upon the literature discussing the importance of well-designed institutions for economic growth and high standard of living.

[75] These principles draw heavily on Rodrik 2007, pages 114-117, and Mills, Reynolds, and Reamer 2008, pages 27-30.

[76] Rodrik 2007, page 115.

[77] Consistent with the enhanced scope and resources associated with this charge, the General Assembly may consider changing the Board's name to the Board of Science, Technology, and Innovation.

[78] National Governors Association and Pew Center on the States 2008, page 43.

[79] Session Law 2001-486, section 2.21.

[80] These recommendations draw heavily on the recommendations Atkinson and Wial 2008, which focus on the federal government.

[81] Along these same lines, state policy makers should also consider developing an expanded North Carolina R&D tax credit requiring industry-academic collaboration and aggressively marketing the credit to companies inside and outside the state.

[82] Chapter 116, Article 21B, N.C. General Statutes.

[83] North Carolina Research Campus (http://www.ncresearchcampus.net/media-center). Accessed December 2008.

[84] City of Kannapolis (http://www.ci.kannapolis.nc.us/NCRC_0.asp). Accessed December 2008.

[85] Ibid.

[86] North Carolina Research Campus (http://www.ncresearchcampus.net/media-center). Accessed December 2008.

[87] Ibid.

[88] Moore 2008.

[89] Prunkle 2008.

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North Carolina Innovation-Focused Initiatives, 2001–2008

North Carolina has seen several major innovation-focused initiatives implemented in the past eight years. The list below—categorized into Government-led, Public-Private/Non-profit Partnerships, and Higher Education-led—summarizes the major initiatives.

Government-led Initiatives

- **Enhanced R&D Tax Credit:** In 2004, the North Carolina General Assembly enacted a new research and development tax credit as an alternative to the then-existing credit, which was set to expire on January 1, 2006. In 2007, the General Assembly increased the percentages on which the tax credit is based to provide a greater tax benefit for North Carolina businesses. In the July 2008 Legislative Session, the tax credit, scheduled to expire on January 1, 2009, was extended for five years. http://www.nccommerce.com/en/BusinessServices/LocateYourBusiness/WhyNC/Incentives/rd.htm

- **One North Carolina Small Business Program:** Created in 2006, the program assists North Carolina small businesses with a portion of their application expenses to the Phase I federal Small Business Innovative Research (SBIR) Program or Small Business Technology Transfer Research (STTR) Program; it also matches federal SBIR/STTR grants awarded to North Carolina small businesses. Together, the federal SBIR/STTR programs are the single largest source of early-stage funding to assist small businesses in commercializing their innovative business ideas. http://www.ncscitech.com/oncsbp/

- **Governor's Task Force on Nanotechnology and North Carolina's Economy:** In 2006, the task force released a roadmap for successful nanotechnology-based economic development and high-wage employment across North Carolina. Efforts to implement the roadmap's recommendations are ongoing. http://www.ncnanotechnology.com/public/root/roadmap.asp

- **Green Economy Initiatives:**
  - **North Carolina Green Business Fund:** Established in the 2007 Legislative Session, the fund provides competitive grants to encourage North Carolina small businesses to develop commercial innovations and applications in the biofuels industry and the green building industry, and to attract and leverage private sector investments and entrepreneurial growth in environmentally conscious technologies and renewable energy products and businesses. http://www.ncscitech.com/gbf/
  - **North Carolina's Renewable Energy and Energy Efficiency Portfolio Standard (REPS):** Enacted by Senate Bill 3 in August 2007, REPS requires all investor-owned utilities in the state to supply 12.5% of 2020 retail electricity sales in North Carolina from eligible energy resources by 2021. Municipal utilities and electric cooperatives must meet a target of 10% renewables by 2018 and are subject to slightly different rules. In February 2008, the North Carolina Utilities Commission (NCUC) adopted final rules implementing the REPS. http://www.ncuc.commerce.state.nc.us/reps/reps.htm

Public-Private/Non-Profit Partnerships

- **North Carolina Life Science Initiative:** This bio-workforce training partnership, formed in 2006, includes:
  - The Golden Leaf Foundation's **Biomanufacturing Training and Education Center (BTEC):** Established at North Carolina State University to provide a pilot-scale, industry-informed, clinical Good Manufacturing Practices environment aimed toward developing a workforce proficient in the skills needed in the biomanufacturing industry. http://www.engr.ncsu.edu/btec/index.php
  - **Biomanufacturing Research Institute and Technology Enterprise (BRITE):** Established at North Carolina Central University to train the next generation of biotechnology scientists and expand North Carolina's biotechnology industry. http://brite.nccu.edu/
  - **North Carolina Community College System's BioNetwork:** A statewide initiative connecting community colleges across North Carolina, providing specialized training, curricula and equipment, and creating success for the biotechnology, pharmaceutical, and life sciences industries. http://www.ncbionetwork.org/

- **Biofuels Center of North Carolina:** Created by the General Assembly in 2007 to develop a statewide biofuels industry to reduce the state's dependence on imported liquid fuels. http://www.biofuelscenter.org/

- **Defense and Security Technology Accelerator (DSTA):** Funded by North Carolina General Assembly and established in 2007 in Fayetteville, this business incubator assists entrepreneurs in generating new security and defense technology solutions to meet the military's technology needs and business demands. http://www.dstanc.org/index.php

- **North Carolina Center for Automotive Research (NCCAR):** An independent, non-profit center devised to meet the ever-evolving product research, testing, and development demands of the automotive industry (Operational in 2009). http://www.nccar.us/

- **Renaissance Computing Institute (RENCI):** Launched in 2004, the institute brings together academia, government, industry and world-class computing and technology resources to find innovative solutions to complex problems including how to better predict, plan for, and mitigate disasters and how to improve healthcare and the overall health of North Carolinians. http://www.renci.org/

- **North Carolina Research Campus (NCRC):** Launched in 2006 in Kannapolis to create a world-class collaborative hub for nutrition, health, and biotechnology research. http://www.ncresearchcampus.net/

- **North Carolina Biotechnology Center:** In 2004, the center released a strategic plan for biotechnology job growth (New Jobs Across North Carolina), which has led to expansion in several areas, including:
  - Establishing five regional offices across the state
  - A Centers of Innovation program designed to focus the state's efforts in biotechnology research, development and commercialization in targeted industrial sectors important to economic development and job creation. http://www.ncbiotech.org/biotechnology_in_nc/strategic_plan/

- **Inception Micro Angel Fund:** In 2005, the Small Business and Technology Development Center (SBTDC) launched a statewide Inception Micro Angel Fund focusing on technology-based startups. http://www.inceptionmicroangelfund.com/links/index.html

- **North Carolina Science, Math, and Technology (SMT) Center:** In 2002, the Burroughs Wellcome Fund, established the SMT Center as non-profit organization with a mission to improve performance in science, mathematics, and technology preK-12 education as a means of providing all children in North Carolina with the necessary knowledge and skills in science, mathematics, and technology to have successful careers, be good citizens, and advance the economy of the state. http://www.ncsmt.org

- **Expansion of Research Parks:** Research parks across the state have undergone major expansion in the past eight years:
  - A 10-fold expansion of the Piedmont Triad Research Park, announced in 2002. The expansion includes establishment of a new Biotechnology Research Center in 2006 and a planned Life Science Research Park. http://www.ptrp.com/park/development.asp#
  - **Research Triangle Park's Vision 2020:** Announced in 2005, a business plan aimed at reinforcing and maintaining RTP's competitiveness in the next 15 years. Includes possible expansion of satellite campuses and strengthened university-industry partnerships. http://www.rtp.org/main/index.php

- **Regional Economic Development Partnership Strategic Plans:** In 2004, the North Carolina General Assembly approved legislation mandating each of the state's seven regional partnerships to develop a five-year vision plan. The plan was to include a comprehensive study of the region's resources and existing businesses located in the region to determine what clusters exist and the boundaries of those clusters, to develop ways to strengthen those clusters, and to determine in what areas the region has competitive advantages that could lead to the development of future clusters. Each partnership contracted with consultants to undertake the vision plan process, and efforts to implement the plans are ongoing. http://www.nccommerce.com/en/AboutDOC/PartnersAllies/#Resource2

Higher Education-led Initiatives

- **Millennial Campuses:** The campuses are designed to promote economic development, entrepreneurial activity, and partnerships with the private sector using university resources. Millennial Campuses established or expanded since 2000 include:
  - Gateway University Research Park: UNC-Greensboro and North Carolina A&T State University joint campus
  - Carolina North (UNC- Chapel Hill): planned for 2009
  - Charlotte Research Institute
  - Centennial Campus at NCSU
  - The Millennial Initiative at Western Carolina University
  - Planned Fayetteville State Millennial Campus
  - Planned UNC-Wilmington Millennial Campus http://www.ncscitech.com/resources.htm

- **New Cancer Hospital:** In 2004, the N.C. General Assembly approved $180 million in funding for a new cancer hospital to be built by the University of North Carolina Health Care System. http://cancer.med.unc.edu/news/2004/cancerhospital/default.asp

- **North Carolina State University College of Engineering Expansion:** The past eight years have seen a major expansion of NCSU's College of Engineering, including the move to the Centennial Campus and a 2007 legislature-approved $34 million in debt authorization for expansion. http://www.engr.ncsu.edu/

- **Joint School of Nanoscience and Nanoengineering (UNC Greensboro and North Carolina A&T State University):** As part of the Gateway University Research Park in Greensboro (building completion expected in 2009), a program offering PhD degrees in nanoscience and nanoengineering is planned. http://www.gatewayurp.com/index.html

- **North Carolina New Schools Project (NCNSP):** An independent 501(c)(3) non-profit organization created in 2003 by the Office of the Governor and the Education Cabinet with support from the Bill & Melinda Gates Foundation, NCNSP works to accelerate systemic, sustainable innovation in secondary schools across the state so that, in time, every high school in North Carolina graduates every student ready for college, careers and life in the society and economy of the 21st century. http://newschoolsproject.org

- **Fayetteville Technical Community College Advanced Visualization and Interactive Digital Center (i3D Center) and the All American Center for Workforce Innovation:** The center is a world-class visualization center focused on learning how to create, build, and deliver real-time, photo-realistic interactive 3D. It will serve as a regional experience and discovery center and represents the establishment of North Carolina as the leader in i3D education and content development. http://i3dtrain.com/

- **Support for Entrepreneurship:** Over the past eight years, numerous public universities—including Appalachian State, East Carolina, Elizabeth City State, Fayetteville State, North Carolina State, UNC Chapel Hill, UNC Pembroke, UNC Wilmington, Western Carolina and Winston Salem State—have launched efforts to support entrepreneurial enterprises and train students in the principles of entrepreneurship.

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