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Experiments in the Laboratories of Democracy: State Scientific Capacity Building

Maryann P. Feldman[1], Lauren Lanahan[1] and Iryna Lendel[2]

Abstract

State initiatives that build innovation capacity by supporting local academic research, attracting eminent scholars, and building research excellence have become prominent among the 50 states over the past 30 years. This article focuses on three programs: University Research Grants, Eminent Scholars, and Centers of Excellence. We include examples for each of the state programs and trace the historical evolution of program attributes. Our objectives are to differentiate program attributes to improve understanding of state science initiatives and to begin to assess how programs contribute to the ultimate goal of creating economic growth. Our empirical analysis demonstrates evidence of the long-term impact of these three programs in building state innovative capacity. The article concludes by outlining how these data may be used in future analyses.

Keywords

state economic development policy, eminent scholars, university research grants, innovation capacity

Introduction

Governments worldwide view investments in scientific capacity as a critical precursor to creating economic growth in the knowledge economy. Global competitiveness is predicated on the capacity to innovate. In contrast to a resource economy, where location is predetermined, scientific capability is constructed over time through both public and private investment. The logic is that public sector investment provides programs and incentives for subsequent private sector investment that will yield economic growth (Block & Keller, 2009; Schrank & Whitford, 2009). Although the role of universities in generating economic growth is well examined (see Andersson, Quigley, & Wilhelmsson, 2009), the ways in which public policy, in general, and state policy, specifically, incentivizes university research excellence and engagement with industry are largely unexplored.

Following the logic of Brandeis's *Laboratories of Democracy*, states in the United States have taken the lead in experimenting with technology-based economic development programs (Berglund & Coburn, 1995; Eisinger, 1988, 1995; Osborne, 1988; Plosila, 2004). Starting aggressively in the 1980s, motivated by the perceived loss of U.S. competitiveness in the last major economic recession, the number of state technology-based economic development programs and initiatives has proliferated. The full range of programs include the following: (a) educational programming directed toward ensuring a stronger workforce, especially using targeted training programs at local community colleges; (b) the delivery of economically-oriented outreach services aimed at encouraging modernization at existing firms and the formation and viability of new firms; and (c) capacity building programs at state-funded and state-located universities to encourage technology-led economic development. Of these three approaches, state policies that engage state-funded and state-located universities toward economic development objectives are the least understood despite their strategic importance and the significant resources devoted to them. One problem is that at first glance these programs appear unique and highly differentiated. This is perhaps attributable to the fact that politicians have every incentive for their programs to appear new and groundbreaking. This category of programs, however, attempts to build state science capacity with the logic of increasing the amount of research and development conducted within their borders for the ultimate impact of creating jobs and economic growth.

Berglund and Coburn's (1995) compendium of state and federal cooperative technology programs provide an early attempt to describe and classify state programs. Building on that seminal effort, the State Science and Technology Institute (SSTI) provides a wealth of information accessible through a central digital repository, classified by state. To

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begin to understand, however, what program attributes and mechanisms work well and under what circumstances, requires taxonomy of salient program attributes and grouping of similar programs. Without common taxonomy, policy makers are left to evaluate each program on an individual basis, with limited systematic learning between programs. Scholars will be limited to case studies of specific programs or limited empirical analysis within a specific state. To generalize between states and increase understanding of how programs contribute to the ultimate goal of creating economic growth, and also to determine when and if certain policies and programs may be desirable in certain industries and at specific times requires examining state programs in detail and assessing common mechanisms and evolution in form over time.

The next section of this article examines the history of state efforts to building strong economies with university science and research at their core and explores the logic behind the emergence of formal state science and innovation policy. The third section discusses data and research methods. The fourth section describes the major types of state science capacity policies: University Research Grant, Eminent Scholars, and Centers of Excellence programs. Examples for each of these programs are provided along with a discussion of the evolution of program attributes over time. The fifth section provides descriptive analysis of the diffusion of these programs across the states and further considers the impact of the adoption of programs on economic outcomes, measured in terms of state-level, federal, and industry investment in university research and development (R&D). The article concludes by outlining how the data may be used in future empirical work.

State Science Capacity Building

States have a long history of engaging in building capacity in higher education with the intended objective of creating economic development. Some argue that the current wave of programs that we study are a new phenomenon and represents a break from historical smokestack chasing (Haider & Law, 1989). Bingham and Mier (1993) argue that the era of state policies aimed at reducing the production costs of relocating manufacturers began in 1937 in Mississippi with the issuance of the first industrial development bond. This served as the starting point of an era characterized by tax abatements and incentives, and is argued to be a zero-sum game that resulted in bidding wars among states and simply shifted activity from one state to another. Indeed, there seems to be an ongoing tension between the economic development strategies of investing in building capacity versus providing industrial subsidies to lower costs. In practice and with a longer view of history these two strategies may be alternative tools in the pursuit of economic development goals. Certainly states have a long history of investing in building capacity through investments in building and sustaining state universities. While others have reviewed the literature on the role of universities in economic development (Goldstein, 2010), this section will briefly consider the role of state policy in building these institutions.

Nash (1964) argues that states historically took an active role in investing in public goods and creating conditions conducive for the development of private enterprise—what in contemporary language we would call economic development. Nash notes that colonial Americans "agreed that (state) government should assume certain responsibilities to further economic growth" (Nash, 1964, p. 11). Early policies include providing direct aid to encourage the formation and growth of private enterprise, providing information about trade opportunities, and creating conditions conducive for specific industries.

Combes and Todd (1994) argue that the establishment of public universities was motivated by a desire to improve the economy by state legislatures. As an example, the University of North Carolina system originated in the North Carolina Constitution (1777), which stated, ". . . all useful Learning shall be duly encouraged and promoted in one or more Universities."[1] State support was authorized so that instruction might be available to all residents of the state. Key (1996) notes that these early efforts provided the model used in the Federal Morrill Land Grant Act (1862), which created a mandate to establish universities in every state. State leadership in building innovative capacity is further witnessed by the establishment of a system of community colleges with a decidedly economic development orientation (Brint & Karabel, 1989).

State engagement in capacity building is a long-held tradition consistent with the contemporary orientation. Even as industrial incentives were gaining popularity capacity building existed alongside. For example, the Alabama Research Institute was established in 1941 to serve a "regular function as a research organization" and to coordinate research projects between institutions of higher education, such as the University of Alabama, Alabama Polytechnic Institute, and other universities and private firms (*Science*, 1944). This institute's mission extended to coordinating the state's economic development initiatives. State capacity building programs became more prominent in the late 1970s with the witness of a marked decline in federal funding for economic development. Up until this time, the federal government was at the forefront of supporting university R&D with the federal mission agencies—including the National Science Foundation, National Institutes of Health, National Aeronautics and Space Administration, and Department of Energy—overseeing the vast majority of R&D activity within the United States (Teich, 1982, 2009). The decentralization of authority from the federal government to states placed them in a favorable position to customize and initiate R&D programs (Feller, 1997).

Following the passage of the Bayh Dole Act of 1980, which granted university researchers the rights to intellectual property from publicly-funded research, state governments became more interested in playing a greater role in university R&D activity (Clarke & Gaile, 1992). This action, among others, promoted state rivalry. To level the playing field, the federal government created the Office of Experimental Program to Stimulate Competitive Research (EPSCoR) to support and encourage R&D for disadvantaged states (Hauger, 2004). EPSCoR goals are "(a) to provide strategic programs and opportunities for EPSCoR participants that stimulate sustainable improvements in their R&D capacity and competitiveness; (b) to advance science and engineering capabilities in EPSCoR jurisdictions for discovery, innovation and overall knowledge-based prosperity." Still in operation as a federal program, EPSCoR augments state efforts to build science capacities.

State policy makers have come to justify and sustain support for building science capacity under the premise that they can stimulate innovation by leveraging state universities and state-located universities. Scholars have found that states have great discretion to design customized science policies that better align to the economic and research climate (Bozeman, 1999). One noted problem is that, at first glance, these programs appear highly differentiated and unique and thus have difficulty being compared or classified. Of course, politicians have every incentive to want their initiatives to appear unique and groundbreaking; however, in practice scholars observe that good ideas diffuse in rather systematical ways across the 50 states (Berry & Berry, 1990; Gray, 1994; Karch, 1996; Volden, 2006). Although scholars trace the diffusion of state lotteries and tax credits, economic development initiatives have received less attention, perhaps because of the large portfolio of programs and policies that fall under the umbrella of technology-based economic development. In an effort to better understand economic development policy, we now turn to a closer examination of the efforts taken by states to promote state capacity building by leveraging universities.

Data and Method

The data for this study came from a variety of sources. We began by consulting with *Partnerships: A Compendium of State and Federal Cooperative Programs*—a 640-page description of R&D programs, economic development enterprise strategies, and specific institutes in each state (Berglund & Coburn, 1995). This study was a product of the 1993 State–Federal Technology Partnership and was recommended by the Carnegie Commission on Science, Technology, and Government in the Commission's report, *Science, Technology, and the States in America's Third Century.* Furthermore, this report resulted in the establishment of a spinoff organization, the SSTI—a national membership organization and think tank on state technology policies. SSTI holds annual conferences, maintains an extensive archive of historical materials and state reports, and provides a weekly digest that is broadly disseminated to practitioners and policy makers. This organization is the focal point for state technology-based economic development initiatives and was a gracious partner in our undertaking.

Next, to better understand the context, we interviewed 35 economic development practitioners to gather information on their experiences at the onset of this project. These organizations included SSTI, Battelle, the Association of Public and Land-grant Universities, the Association of University and Technology Mangers, the Kauffman Foundation, the State Higher Education Officers, and the National Governors Association. As another resource, we referred to individual states' websites, which provided supplemental information on a given set of programs and initiatives. In addition, we used the enabling regulations as a reliable source of information, augmented with newspaper articles and other program materials.

To limit the scope of our data collection, we use four general criteria. First, the program must be initiated and funded at the state level and the authorization must come from state government, either as direct appropriation or a pass-through from an agency or organization. We include programs with a regional administrative mechanism such as Pennsylvania's Ben Franklin program, but do not include regional programs that are autonomous. Second, the program must be codified in a policy document, state statute, or legislative act and not be a special initiative from the governor's office or state agency. This criterion excludes special discretionary funds provided by governors or other state officials, state earmarks, and other types of special initiatives. Third, to make this exercise tractable, the program description needed to mention academic research, universities, or higher education institutions as the designated target, implementing agency, partner, or advisory body to the program. We exclude programs that are targeted at specific institutions unless there was a provision that the program is beneficial for the entire state economy. Fourth, the program should be administrated by a state agency (either by the regents, the state [higher] education agency, or the department of economic development), quasi-public entities, or public–private partnerships. Programs that transfer funds directly to universities are excluded. We limit the focus of state science and innovation programs to those established from 1980 onward due to the difficulties of collecting reliable information before that time. We did, however, include data for older programs when complete information was available. We recorded only the earliest adoption of each program and disregarded a later program change, closing, or adoption of a similar program managed by another agency or established at a later point in time. We should also note that the lifetime of a program varies significantly and was not a variable in our research.

In our attempt to classify state activity, we recognize long-standing concerns over the comparability, consistency, and comprehensiveness of data on state policies. In a related exercise, McGeary (2001) finds that data on health research funding suffers from definitional inconsistencies between states. Specifically for economic development programs this task is complicated because initiatives may be administered by any number of agencies and this information is difficult to track. In addition, there are differences between the announcement of a new initiative and the legislative appropriation of funding. The actual programmatic expenditures may be different from the budgetary request. Thus, it is problematic to create a reliable time series. For this reason, we do not provide funding information but rather simply start by identifying and categorizing programs.

In many cases, the verification of facts involved short phone interviews or e-mails with staff from the organizations that administered the programs. After the programs were vetted, we synthesized the information and categorized the programs by discerning common characteristics that broadly described the same phenomena. This is discussed in detail for each set of policies in the next section. The common characteristics within the groups of the programs allowed us to create a taxonomy of state science and innovation programs and to identify trends within types of programs. Ultimately such a taxonomy would be needed if we are toadvance our understanding of how different programs and program attributes contribute to innovation and economic growth. With any undertaking like this we are sure that there will be omissions and inaccuracies. Nevertheless, our intention with this analysis is to begin providing a framework that others may build on, correct, and fill in additional details.

Categories of State Science Capacity Building Programs

Science capacity building programs attempt to create research expertise and attract talented researchers and students. Having the capacity to conduct research and cutting-edge science is a precursor to technology-based industrial activity. Building capacity is an attempt to establish university resources that bolster a stock of university research. Rather than placing a precedent on industrial collaboration, these programs are granted greater flexibility regarding the scope of research and instead attempt to promote the basic research enterprise. Although industrial partnership and commercialization may serve as more distant goals for these initiatives, these programs are premised on elevating the stature and quality of university research where the indirect potential for positive spillovers is increased.

We identified three major categories of capacity building programs—University Research Grants, Eminent Scholars, and University Research Centers programs. Related information on the Experimental Program to Stimulate Competitive Research (EPSCoR), a federal and state cooperative matching program, is provided in Appendix B. Each of the three major programs is described in turn.

University Research Grant Programs

Our defining criteria for the University Research Grant (URG) programs are the following: (a) grants oriented toward basic scientific research, (b) grants available to all researchers at universities or research institutions within the state, (c) grants that do not fund physical infrastructure, and (d) grants that do not require supplemental funding by an industrial partner.[2] By March, 2011, 29 states had adopted research grant programs that satisfied these common criteria.Table 1 in Appendix A lists all URG programs, the date of their first adoption, and the initial objective and main characteristics of the programs.

The first state to adopt an URG program was Arkansas in 1983. Named the Basic Research Grant Program, it was administrated under the Arkansas Science and Technology Authority (ASTA). The primary aim of the program was to build "the state's scientific infrastructure and improve the ability of Arkansas research scientists to compete for awards at the national level by awarding grants to researchers at the state's colleges and universities."[3] This program targeted individual researchers who had not previously received federal funding and required a 40% cash or in-kind contribution match by the individual's home institution. The primary intention of this program, as stated in the research objectives, was

> to use state funds as an incentive to get scientists interested in new areas of research and to provide them with a track record that will help them to compete for federal monies, thereby bringing more research funds to the state. (Berglund & Coburn, 1995, p. 84)

The ASTA program and others including the Louisiana Education Quality Support Fund, the Ohio Technology Action Fund, or the Michigan Smart Ideas program place precedence on improving the ability of scientists to compete for federal funds.

Other state programs are more concerned with expanding their state R&D sector, including the Delaware Research Partnership, Georgia Research Alliance, New York State Foundation for Science, Technology and Innovation (NYSTAR), and the New Jersey Stem Cell Research Grants. Despite this difference, the objective of these various programs encompasses the generic goals of improving greater university-based statewide research competiveness. Regardless of whether the state program is interested in leveraging federal funds, industry funds, or stimulating state-level R&D activity, it operates with the logic of increasing the amount of research activity within the state.

The language used to describe the objectives of the programs has evolved over time as well. In more recent years, we found that state programs are increasingly aimed to provide strategic leadership and create competitively focused areas of research. As an example of this shift, the Kansas STAR Fund (2000) promoted national competitiveness in strategic technology niches; NYSTAR (2000) aimed to make New York a national leader in high-technology academic research and economic growth; West Virginia's Research Challenge Grants (2004) targeted a broad spectrum of science, technology, engineering, and mathematics; and Arizona's 21st Century Fund (2006) focused on scientific, medical, and engineering research with an emphasis on biosciences. In an effort to improve a state's competitiveness, these states have narrowed their intended aims with the goal of cornering different niches of the R&D market.

In addition to the variation in program objectives, we found that states adopted these policies over three distinct phases. The first cohort of the URG programs was adopted during the 1980s. These early research grant programs envisioned limited involvement from industry and did not require a match from an industrial partner. Some of the programs (such as the ASTA program) required a match from the universities as a cash or in-kind contribution. These programs were awarded on a competitive basis that engaged in peer review followed by an approval from the administering body such as a governing board.

To distinguish this first cohort of research grant initiatives from the latter two, these early adopters did not mention technology transfer and commercialization. Rather, they had modest initial funding and were not oriented toward specific industries or technologies. Their intention was clearly oriented toward strengthening the research capacity of universities and, even more noticeably, toward targeting federal R&D funding rather than industrial funds.

On another note, during this initial adoption phase states began building their universities' research capacity in response to competition over federal research funding. As examples, Alabama (1984), Delaware (1984), and Nebraska (1988) established their research funding programs shortly before they qualified as EPSCoR states.[4] In 1987, four states established their basic research programs in conjunction with EPSCoR state matching funds. Namely, the Louisiana Education Quality Support Fund, the Kansas Strategic Technology and Research (KSTAR) Fund, the Oklahoma Health Research Program, and the South Dakota Expand Research Capacity at the Universities program provided matching funds for university scientists to enter a pool of federal funding supported by the EPSCoR federal matching program. Six other states (Montana, Arkansas, Kentucky, Maine, South Carolina, and Wyoming) established their research support programs after they were granted the status of EPSCoR states. Twelve more states[5] that entered the EPSCoR program, however, never established research grant programs in their portfolios of state science and innovation policies.

Although the majority of early research grant programs were not oriented toward developing specific industries or technologies, North Carolina (1984) and Oklahoma (1985) became the first states to align their research capacity-building efforts with specific sectors. North Carolina promoted microelectronics and biotechnology whereas Oklahoma established the Health Research Program, which concentrated on health care discoveries related to the diagnosis, prevention, and treatment of human diseases and disabilities. According to Battelle's report on bioscience initiatives, by 2006, 26 states and the territory of Puerto Rico established research programs supporting bioscience. The majority of these states' bioscience research efforts were supported by research science grants that matched our four criteria for an URG state program. Moreover, by 2008, among 30 states targeting the bioscience industry, 20 states provided matching research grants for federal R&D funding. This trend demonstrates a change in how these policies transformed from supporting broader research programs into programs more targeted at specific industries. To gain political credence, researchers started to orient their efforts toward specific industries that were promising in generating higher returns for investment.

On a final note for this first cohort, due to the focus of strengthening university research capabilities, several programs were administered through the state higher education governing body. For example, Texas' Advanced Research Program was administered by the Texas Higher Education Coordinating Board, which oversees all higher education institutions in the state; the Louisiana Board of Regents sponsored the Louisiana Education Quality Support Fund; and the Kentucky Council on Postsecondary Education administered the Kentucky Research Challenge Program under the "Bucks for Brains" initiative.

The second wave of the diffusion of URGs occurred in the late 1990s and was characterized by adopting research support programs within broader state initiatives. These initiatives were supported by greater funding dedicated not only to building research capacity but also dedicated to including technology transfer from universities to industries. Entities eligible to apply for funding were broadened as part of this commercialization effort to include research institutes and start-up companies if their projects satisfied the criteria of conducting scientific research and building a state's research capacity. At this point in time, states began large initiatives that focused on specific sectors and URGs fit strategically in these plans.

The last wave of research grant programs, which occurred after 2004, resembles the design of the programs initiated in the late 1990s; however, these encompassed an even broader, unrestricted focus. Three of the seven most recent programs—West Virginia's Research Challenge Grants (2004), Arizona's 21st Century Fund (2006), and Utah's Science and Technology Research Initiative (2006)—are available to fund any research project within the state. Two other programs in California and New Jersey were focused on stem cell research. While California and New Jersey's stem cell research grant support were the first programs supporting university research capacity within the parameters of this type of state program, by 2008 nine states had established dedicated stem cell research support grant programs. These trends suggest that there is sufficient heterogeneity between targeted programs and open-ended research grant programs.

What falls outside the scope of this analysis but remains to be determined are the implications associated with this heterogeneity. Do URG programs that are more narrowly construed benefit from greater political support or do the more broadly defined programs gain greater traction? How do these differences affect the nature of the state-level activity? In this section, we attempt to classify a common group of policies; however, this discussion serves as the first step in understanding the effect these policies have on state capacity building.

Eminent Scholars Programs

The second broadly diffused state initiative aimed at building research capacity comprises a set of programs targeted at recruiting highly productive researchers. Although known by different names, we term this type of initiative an *Eminent Scholars* (ES) program. Rather than investing in research projects directly as discussed with the research grants programs, the ES program seeks to attract world-class researchers to public and private universities located within the state boundaries. This program demands substantial up-front costs, often ranging between \$3 and \$6 million per scholar, to support the scholar's salary, lab materials, graduate students, administrative support, and overhead. Despite these notable costs, this program is centrally premised on the idea that these scholars will recover the state's investment by the following: (a) building research capacity within the university, (b) leveraging additional federal and private funds, (c) serving as research magnets for industrial recruitment, and (d) ultimately generating revenue from commercialized research (Bozeman, 2000; Feller, 1997). By providing funds for endowed chairs at research university campuses, states seek to increase innovative activity by cultivating a rich knowledge economy rooted by these individuals.

Recent studies on academic scientists have identified a valuable subset of university scholars who exhibit high levels of technology transfer productivity in terms of publications, patents, licenses, and even spin out companies (Zucker & Darby, 1996; Zucker, Darby, & Armstrong, 2002). These highly accomplished researchers contribute importantly to a region's economic infrastructure through their path-breaking science and strong ties with industry. By investing in these prolific researchers, states hope that they will increase the partnerships between universities and the state's private sector that in turn will stimulate economic activity and development.

As of March 2011, 21 states adopted an ES program. Table 2 in Appendix A lists the states that have adopted the program and includes information on the state programs and the year the policies were first implemented. Virginia was the first to adopt this program in the 1960s; however, the rest of the adopters did not introduce the program until the 1980s. With Ohio serving as the second adopter in 1983, only five additional states implemented the program within the following decade—Tennessee, North Carolina, Louisiana, Georgia, and Arizona. During the latter part of the 1990s, only a handful of states selected to adopt the program. This program gained the greatest traction after 2001, however, with nine states introducing it within a 6-year period between 2002 and 2007. Arguably, this recent surge may have resulted from state reports published in the late 1990s highlighting the notable benefits of the state programs. Two reports in particular are discussed below.

Although 21 states currently have adopted an ES program, the Georgia Research Alliance (GRA) and Kentucky's "Bucks for Brains" stand out as exemplary programs (Bozeman, 2000; SSTI, 2006; Youtie, Bozeman, & Shapira, 1999). To elaborate on the former of the two, with a primary mission of fostering economic development within the state, the GRA seeks to develop and leverage research capabilities within the state to assist and develop scientific- and technology-based industry, commerce, and business. In Combes and Todd's (1994) case-study examination of the GRA program, they found the program to be notably successful given the beneficial knowledge and technology spillover effects that resulted from a dense cluster of Eminent Scholars within the state. With the GRA organized as a 501(c)3 corporation, led by an alliance of industry, government, and university executives with the supplemental support of state funds, Combes and Todd argue that this model has been so successful given that it is premised to "assure a coalition of private, public and academic interests that conceive, direct, and implement science-based development throughout the state" (p. 75). In building a robust cluster of Eminent Scholars, Georgia has reaped considerable benefits in terms of leveraged funds and innovative output. One illustrative example of such benefits lies with a distinguished IBM researcher who was recruited to the GRA program for $1.055 million and in return secured a National Science Foundation (NSF) grant to establish an Engineering Research Center in Electronic Packaging worth a total value of $40 million over a 3-year period (Combes & Todd, 1994). By complementing the state's growing infrastructure with world-class personnel, the state of Georgia has cultivated a robust knowledge economy that is favorably positioned to stimulate additional R&D.

As for Kentucky's "Bucks for Brains" initiative, a 2011 review of the program conducted by a national economic development nonprofit lauded the program for increasing the number of endowed chairs and professorships in the state by more than fivefold from 1997 to 2010. Alongside this notable increase in endowed chair and professorship positions, the extramural research expenditures from two of Kentucky's research universities—the University of Kentucky and the University of Louisville—increased by roughly 250% over the same time period.[6] State and local officials interviewed as part of this report were very enthusiastic of the program's results, specifically the financial resources leveraged for university research in the state.

Although programs like GRA and "Bucks for Brains" definitively model the intended benefits of the ES program, skeptics would argue that this program is not the optimal mechanism for investing in human capital to stimulate economic development (SSTI, 2006). To reiterate, this program is premised on states supporting individuals who have a high probability of stimulating economic development for the university and more broadly within the state. Although accomplished scholars are selected as potential candidates based on their track record of previous work, providing a professorship does not directly ensure that the scholars will be successful in leveraging and delivering the intended benefits. It is the hope that by providing these scholars with an attractive set of amenities in terms of salary, lab, graduate students, and administrative support, this will result in external grants and successfully commercialized discoveries. Providing the resources for a chair, nonetheless, does not ensure that the scholar will recover the cost of the initial investment.

Another criticism with the ES programs revolves around the tension between investing in young promising scholars versus attracting established senior faculty. Hypothetically, an up and coming young faculty member could produce benefits over the course of his/her career in terms of grants received and technology transfer measures comparable to those of a senior star research scientist. Although it may take the young researcher a longer time to achieve such aims, the cost of investing in a young scholar is a fraction of the ES professorship. Some studies have found that the cost of one ES professorship is equivalent to 10 tenure-track positions (Teitelbaum, 2004). This is troubling for some policy makers given that universities are training more PhD scientists than there are academic jobs (Sarewitz, 1996). This is an important policy concern: State resources set aside for this program could be viewed either positively as an essential investment to stimulate the economy or negatively as a loss in 10 or more junior academic jobs for each eminent scholar position. Moreover, state recruitment may result in bidding wars for top talent.

Despite the interest in eminent scholar programs, there has been little systematic evaluation that considers the productivity of individuals who have been attracted to states.

Center of Excellence Programs

The Center of Excellence (CE) programs build capacity by way of investing in physical infrastructure and strengthening research partnerships with industry. These programs include state initiatives alternatively called University Research Centers, Advanced Technology Centers, and Centers of Advanced Technology. The important differentiating criterion of this program, compared with the other two, lies with the more central and active role of the university's industrial partners. Given the breadth of organizational forms and research foci across CE programs, both in terms of research scale and scope, scholars have struggled to reach a consensus on the definitive features that characterize these unique research organizations (Aboelela, Merrill, Carley, & Larson, 2007; Friedman & Friedman, 1982; Mallon & Bunton, 2005; Youtie, Libaers, & Bozeman, 2006). In our review of these CE programs, we identified four common features: (a) a directed research mission focused on basic and applied research, (b) emphasis on graduate training, (c) collaboration between universities and industry, and (d) a strong research orientation directed toward a specific industry sector or technology. Despite these common features, some states place greater emphasis on the partnership with industry, while others are more concerned with the research program. The Massachusetts' Centers of Excellence (2004) serves as an exemplar of the latter, placing a concerted aim on improving emerging technologies such as biotech and nanotech. The Florida Technology Development Initiative, however, exemplifies the former. This CE program promotes both functions of research excellence and collaboration with industry for conduit building.

The Connecticut Institute of Material Science (IMS) at the University of Connecticut was the first state program that met the defining criteria for the CE program. Even though it was called an "institute" and not a university center, this entity was established in 1965 by the Connecticut General Assembly with a goal to maintain an outstanding advanced material research center, provide superior graduate research education in the interdisciplinary fields of material science and engineering within the state, and provide materials-related technical outreach to Connecticut's industries.[7] This initiative predated the NSF Industry-University Cooperative Research Centers (I/UCRC) program. Only 10 years later after the establishment of IMS, Alabama adopted a similar program, the Aging Infrastructure Systems Centers of Excellence (AISCE). This statewide program targeted the life science industry of aging with a mission "to mitigate and reverse the effects of age on the Nation's public and private sector infrastructure through the development, dissemination, and application of intellectual property."[8] This program intended to accomplish its vision and mission via the creation of partnerships among government, commercial organizations, and universities.

After the remarkable success of the NSF-funded Industry–University Cooperative Research Centers program (1984), the NSF Engineering Research Centers program (1985), and the NSF Science and Technology Centers program (1987), NASA's Centers for Commercial Development of Space program followed.[9] This trend illustrates that many states started to counterpart the federal initiatives by starting their own programs modeled on federal programs.

As of March 2011, 37 states implemented a CE program. Table 3 in Appendix A provides an overview of the key characteristics for each program, as stated in their mission statements and objectives, and lists the diffusion of CE state adoption by year. In addition to a concerted research focus, 20 programs prioritized technology transfer or commercialization of their products as an objective. Moreover, out of all 37 states that adopted this program, 17 incorporated economic development into the center's goals. Sometimes the overall goal of economic development was not explicit and was limited to assistance in developing new companies or the expansion of existing ones, whereas others were more limited in their level of assistance and outreach capacity. All these characteristics differ not only in each state, but have exhibited a dynamic and evolving form over time. Serving as one of the most definitive features of capacity building, we found that these programs often established a separate operational unit at a university with both a business development function and a research focus on advancing science and innovation.

Connecticut and Alabama were the first two states to build the research capacity of universities by promoting university and industry collaboration to stimulate basic research and economic advancement. In analyzing the subsequent adoption of CEs following these first two, it is noteworthy that there was no clear diffusion of cohorts. Out of all 37 states, roughly two thirds were established during the 1980s and early 19902; this trend continued after the turn of the century. Many states supported these programs with the anticipated hope that centers would search for complementary funding activities. Furthermore, some centers were formed with the expressed intention to increase the amount of federal funding received using initial state support as an added incentive and to provide federally mandated matches (New York, New Jersey, Tennessee).

In our effort to account for the emergence of CEs, we found the organizational nature and form of CEs to be dynamic; they exhibited notable fluctuation over time. To highlight some of these shifts, many of the early adopters concentrated on a single type of technology or research area (e.g., the Michigan Biotechnology Institute and the Florida Institute for Simulation and Training). However, over the 1980s the CEs shifted and broadened their strategic and programmatic scope. They expanded their research portfolio to include multiple technologies that exhibited development or commercial potential, such as advanced combustion engineering, biopolymers and interfaces, controlled chemical delivery, engineering design, and space engineering.

In addition to fundamental shifts in research foci, CEs began to prioritize economic development as a key initiative. Up until the mid-1980s, CEs were not concerned with broader economic development objectives; however, in 1983 Kansas' Center of Excellence pledged "to assist in the expansion of existing companies and the formation of new ones,"[10] the Colorado Advanced Materials Institute promised to "coordinate and foster research in materials science and engineering leading to economic development,"[11] and the New York Centers for Advanced Technology Program aimed "to spur technology-based applied research and economic development in New York [. . . and] provide more resources to successful centers to expand their work with New York Businesses."[12] To facilitate these efforts, technology transfer activity and commercialization became more prevalent among CEs. Although economic development was not a central consideration during the early diffusion of CEs, it became and has remained a critical feature of these programs.

To elaborate on a third evolving trend among CEs, we found that educational capacity became less explicitly emphasized compared with some early adopting programs. The earliest program, IMS, not only outlined the primary disciplines related to the research center but also housed the Associate Program to enable state businesses to provide specialized training and short courses. Florida's Institute for Simulation and Training made a pledge in "supporting education in modeling and simulation and related fields,"[13] and Indiana's Institute for Molecular and Cell Biology purported to "foster excellence in molecular biology disciplines."[14] Only a few of the late adopters declared education as one of the central goals of the centers.

As with our discussion of the other two programs, what extends beyond this article but remains to be determined are the implications associated with this heterogeneity. Although we attempt to classify a common group of state programs, this discussion serves as only the first step in understanding the effect these policies have on state capacity building.

Descriptive Analysis

While the three sets of state-supported university-based programs share the common objective of building scientific

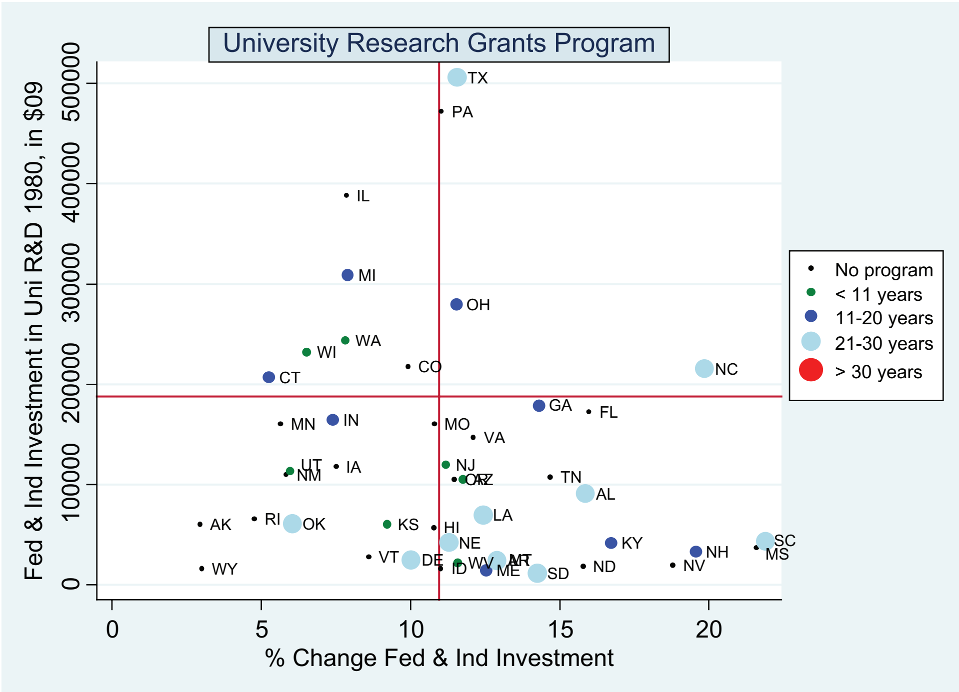

Figure 1. Scatterplot of university research grants program.

Note. Data on expenditures were gathered from NSF WebCASPAR, Integrated Science and Engineering Resources Data System (https://webcaspar.nsf.gov/). CA, NY, MA, and MD have been dropped as outliers. The horizontal line denotes U.S. average of federal and industry investment in university R&D in 1980, in $09. The level of federal and industry investment on *y*-axis is in $1,000s. The vertical line denotes U.S. average of the annualized percent change over the 30-year period.

capability, each differs in its focus and expected *intermediate* outcomes. The URG programs aim to increase the amount of university scientific research projects by offering a state matching program; the ES programs attract world-class researchers to institutions within the state to leverage additional research funds; and the CE programs build capacity by investing in physical infrastructure and strengthening research partnerships with industry, thereby increasing industrial research conducted in the state.

In this effort to assess the diffusion and impact of the adoption of these programs on economic outcomes, we gathered data from the NSF WebCASPAR database, which provides annual data on federal and industry expenditures in university R&D from 1972 to 2009. As a preliminary assessment of each of these categories of programs, we plot of the level of federal and/or industry investment in university R&D in 1980 (adjusted to constant 2009 dollars) against the annualized percent change in federal and/or industry investment in university R&D over a 30-year period from 1980 to 2009.[15] The summation of federal and industry investment in university R&D is used to measure the expected outcome for the URG programs, federal R&D investment is used to measure the expected outcome for the ES programs, and industry investment is used for the CE program. Ideally, we would like the dollar amount invested by states in the programs. State programmatic expenditure data are not readily available and represent a topic where additional effort and research is needed. To account for difference in the duration of the program, we weight the size of each data point based on the length of time that the state had adopted the program. Table 4 in Appendix A lists the year of adoption for each of the three policies by state. In addition, we include horizontal and vertical lines, which indicate the U.S. average level for each variable.

Figure 1 presents data on federal and industry investment in university R&D for the URG program. In general, we find evidence that states with smaller federal and industry investment in university R&D in 1980 adopted the program at earlier stages. This would suggest that, among the myriad reasons for adopting the program, states chose to implement the URG program in an effort to address and improve the lagging university research activity, measured in terms of external investment to the university. We found that early

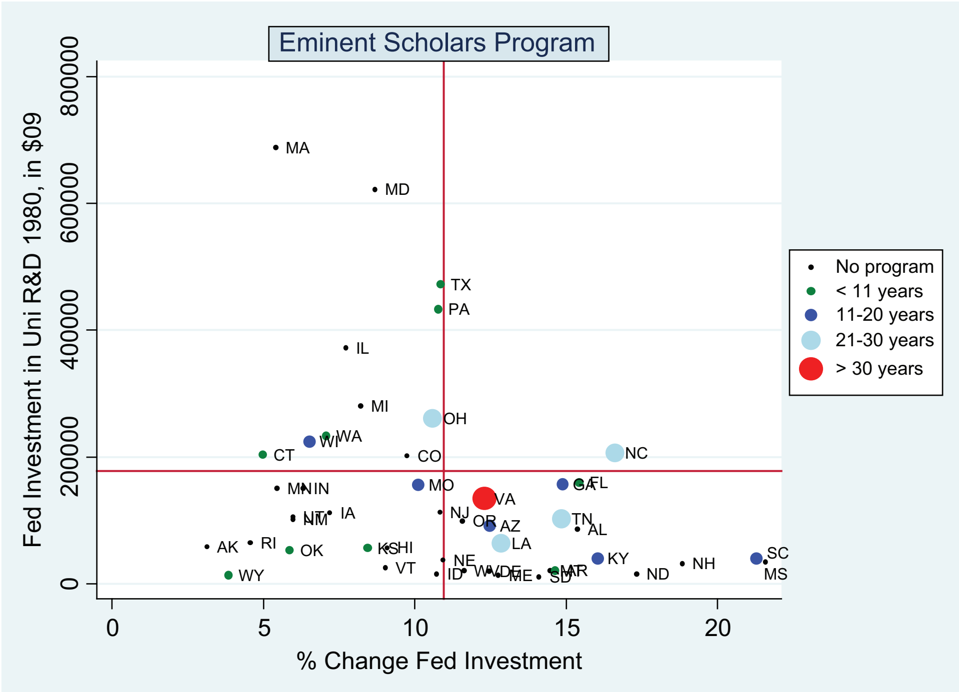

Figure 2. Scatterplot of eminent scholars program.
Note. Data on expenditures were gathered from NSF WebCASPAR, Integrated Science and Engineering Resources Data System (https://webcaspar.nsf.gov/). CA, NV, and NY have been dropped as outliers. The horizontal line denotes U.S. average of federal investment in university R&D in 1980, in $09. The level of federal investment on *y*-axis is in $1,000s. The vertical line denotes U.S. average of the annualized percent change over the 30-year period.

adopters of URG also qualified for the federal EPSCoR program. Moreover, the data suggest a positive association between the length of time a state has had the URG program (as indicated by the size of the point on the scatterplot) and the change in federal and industry investment over the 30-year period (as indicated on the *x*-axis). This provides preliminary evidence of long-term positive outcomes for those states with the program. More specifically, the trends suggest that this program has been beneficial—in terms of increasing the change in federal and industry investment beyond the rate of the U.S. average—for those states who adopted earlier compared with both later adopters and those who never adopted.

Figure 2 presents data on federal investment in university R&D for the ES program. Results in Figure 2 are relatively similar to Figure 1: (a) early adopters of the program generally lagged in terms of federal investments in state-level university R&D in 1980 and (b) earlier adopters are associated with disproportional increases, in relation to the U.S. average, in the percent change of federal investment over the 30-year period. This suggests that one of the reasons states chose to adopt the ES program was to improve the lagging level of federal investment in university R&D. Moreover, this preliminary evidence points to positive long-term effects of the program in terms of disproportionally increasing the change of federal investment over the past 30 years for those states who adopted earlier.

Figure 3 presents data on industry investment in university R&D for the CE program. With 37 states having adopted this program, this is the most diffuse program among the three. The patterns in this scatterplot are less pronounced than the previous two. The level of industrial investment in university R&D in 1980 does not appear to affect when the state adopted the CE policy. Moreover, in contrast to the trends highlighted above, the length of time a state has had the CE program does not appear to be strongly associated with disproportional increases in the change of industry investment in university R&D over the 30-year period. What the data do suggest, however, is that among the 13 states that have not adopted the CE program, only Washington has experienced increases in industrial investment in university R&D that exceeds the national average. Although many states that do have the program

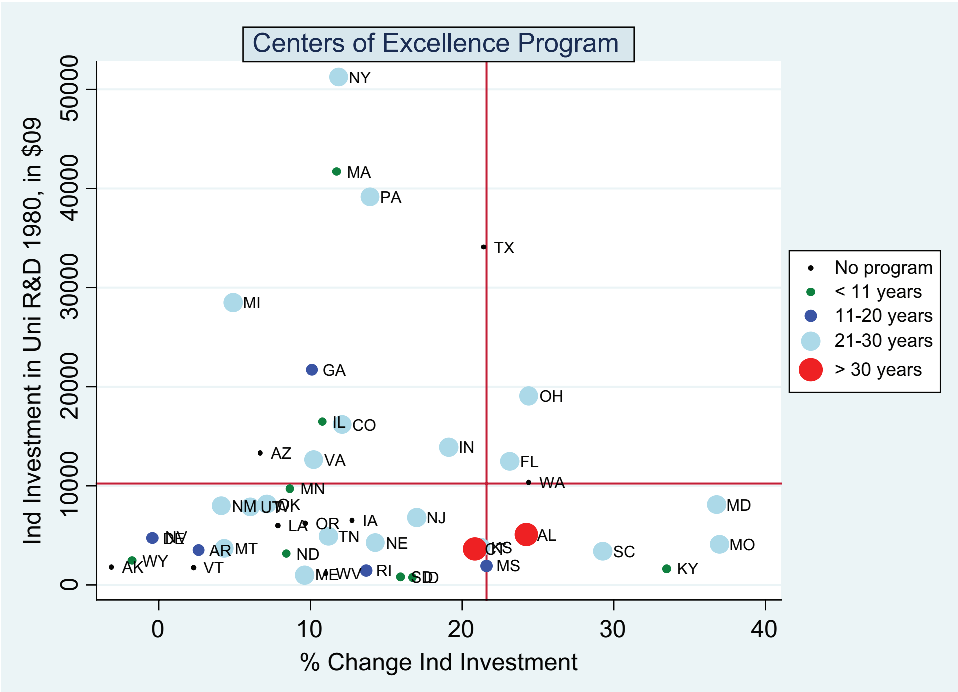

Figure 3. Scatterplot of centers of excellence program.
Note. Data on expenditures were gathered from NSF WebCASPAR, Integrated Science and Engineering Resources Data System (https://webcaspar.nsf.gov/). HI, NC, NH, and CA have been dropped as outliers. The horizontal line denotes U.S. average of industry investment in university R&D in 1980, in $09. The level of industry investment on *y*-axis is in $1,000s. The vertical line denotes U.S. average of the annualized percent change over the 30-year period.

lagged behind the national average in terms of industrial investment changes, those states without the program appear to be even more behind.

These figures offer preliminary evidence regarding both reasons why states might have adopted a policy in the first place and the impact these programs have had in increasing the level of R&D federal and/or industrial investment to universities within the state. These results are preliminary and we must be cautious in interpreting these results. This analysis only captures the trends of one outcome variable for each policy, without any intervening variables or underlying casual model. A robust analysis of these three sets of programs, which lies outside the scope of this article, would need to control for possible confounding variables and certain endogeneity that are endemic with regional economic analysis.

Reflective Conclusions

This article has classified and reviewed three sets of state-level policies targeted at leveraging university-based R&D policies with the objective of generating economic development over the past 30 years across the United States. Our intention in this analysis is to lay a foundation to advance an understanding of state science initiatives, the reasons behind their adoption, and their ultimate impact on achieving the intended objective of creating innovation, jobs, and wealth. There is simply too much at stake for our economic future as policy makers strive to find effective and transformative policies that best use scarce public resources. Understanding the experimentation among American states requires codifying and classifying programs and initiatives. Just as Charles Darwin was motivated to try to organize species into a coherent schema, it is our belief that a systematic classification benefits understanding and increasesour ability to compare and evaluate programs and understand why types of policies and mechanisms are most appropriate in specific circumstances. With this information, scholars can begin to systematically understand program design and assess impacts. Rather than evaluating individual state programs, scholars and policy makers can engage in systematic comparative evaluation. In this way, the results of states' rich experimentation with programs can be analyzed and more effective policies created. It appears that states have often experimented with program design and implementation uncritically, even copying other states' efforts without considering the state's economic circumstances, university characteristics, and research capacity (Fagerberg, 2003).

Our purpose was to examine state programs that focus on building science capacity for economic growth. Our criterion was programs that build capacity at state or state-located universities. Despite the variation in the portfolios of these initiatives across the United States over the past 30-year period, we find compelling similarities among state programs in terms of their objectives, incentives offered, and instruments used. Our major categories include University Research Grants, Eminent Scholars, and Centers of Excellence programs. Each of these programs focuses on a different aspect of research capacity. University Research Grants provide funding for academics within the state. The intention is that increased capacity would translate into tangible measures such as increased publications and notoriety and additional research funding from industry and federal government sources. These awards provide funding for current faculty at universities largely concentrating on developing young local talent. In contrast, Eminent Scholars programs attempt to induce highly qualified faculty to relocate to universities within the state to serve as a foundation for stimulating economic development. As such, these programs augment state resources. Prominent scholars with established research portfolios and high levels of technology transfer productivity are given priority. The final category, Centers of Excellence, connects universities to local industry and moves academic research toward practical applications and the building of technology capability within the state. By creating Centers of Excellence programs, states aim to build a research capacity that is beneficial for broader economic development goals and to cultivate a culture of collaboration between academic and industry environments. This program serves as a surrogate research capacity for private companies that are incapable of bearing the costs of individual research units. This type of program benefits universities by giving them industrial targets for academic research, which moves the university research products closer to commercialization. All three major types of capacity building programs are still popular among the states in the high-intensity research areas where basic research is critical and where industry demands guidance to increase a probability of success.

This review of state-based science policy initiatives not only provides an overview of state initiatives since 1980 but also lays the groundwork for future analysis to systematically examine state science efforts on a broader scale. The data presented provides a strong baseline and foundation for both the diffusion and policy evaluation literature. There have been few attempts to systematically study the origins of state policy and their diffusion across states, and the policy initiatives' relationships to the specific contexts of their home states and universities. In practice, scholars are able to trace the diffusion of specific programs such as state lotteries and tax credits in systematical ways across the 50 states (Berry & Berry, 1990; Gray, 1994; Karch, 1996; Volden, 2006). Economic development initiatives have received less attention, perhaps because of the large portfolio of programs and policies that fall under the umbrella of technology-based economic development.

The evaluation of state economic development policies has also been limited, because it is difficult to construct a series of state expenditures and attributes on these programs. Berglund and Skinner (1998) already attempted this endeavor by providing a review of all state expenditures on research, conducted by surveying all state agencies that conduct research. In total, they found that states had funded more than $3 billion of research in 1991. This is certainly a notable finding; however, the results are now dated and an update and extension would be valuable. State economic development budgetary and expenditure data are not centralized and an opportunity exists to collect this information in a concise and meaningful way. In addition, every state retains rich program data about the awards that have been made over time, and programs have now been in existence for long enough that statewide evaluation of similar programs is now within reach. We hope our efforts will motivate additional research on this topic.

Moreover, although this research holds unique appeal for both diffusion and evaluation, future analysis building off of this research could benefit from synergy. In the policy diffusion literature, scholars aim to identify macro- and micro-level antecedent factors that account for the adoption of a policy; the policy evaluation literature, on the other hand, aims to examine the unbiased treatment effect of a policy. Much of policy evaluation research designs, however, rely on ex post analysis by examining natural experiments, which hinges on the critical assumption of an exogenous policy switch (Shadish, Cook, & Campbell, 2002). This would assume that the policy is randomly adopted. Evidence from the policy diffusion literature, however, provides ample evidence that the adoption of these policies is not random, but in fact systematic. Given that diffusion scholars explicitly aim to identify the antecedent factors leading to the adoption of a policy, evaluation scholars could leverage this research and include those significant antecedent factors to essentially control for the policy switch. This article thus serves as the beginning of what could surmount to be a long line of research that systematically examines the factors that not only lead a state to initiate state-based university R&D policies, but also that assesses the efficacy of the program or policy once implemented.

Appendix A

Table 1. University Research Grants Programs.

State	Name of the program	Year initiated	Key characteristics
Arkansas	Basic Research Grant Program	1983	Rising the overall capabilities of Arkansas researchers to compete for federal research dollars, to provide them with a track record
South Carolina	South Carolina Research Authority (SCRA)	1983	To promote and encourage expansion of the R&D sector, with emphases on capital formation and investments in R&D
Alabama	Basic Research Grants/AL Research Institute	1984	To support new researchers who conduct either basic or applied research
Delaware	DE Research Partnership	1984	To support research at the University of Delaware on projects with potential for enhancing ED in the state
North Carolina	Academic Research Initiation Grants	1984	To strengthen the biotechnology research capabilities of NC's institutions of higher education
Oklahoma	OK Health Research Program	1985	To build the state's R&D base by attracting and retaining outstanding health researchers and improving their competitiveness for national health care awards
Louisiana	Louisiana Education Quality Support Fund	1987	To strengthen the state universities' ability to compete for federal funds and to encourage cooperation between businesses and universities
South Dakota	The Future Fund	1987	To expand research capacity for universities
Texas	Advanced Research Program	1987	To attract and retain the best students and researchers and to help provide the knowledge base needed for innovation
Nebraska	Nebraska Research Initiative Grants	1988	To enhance Nebraska's basic and applied research capacity
Georgia	GA Research Alliance	1990	To foster economic development within Georgia by developing and leveraging the research capabilities of research universities and to assist and develop scientific and technology-based industry, commerce, and business
Maine	Maine Research Enhancement Program	1990	To increase the number of competitive researchers in the state
New Hampshire	New Hampshire Industrial Research Center	1991	To create high-quality jobs through technology development and innovation by fostering collaboration between New Hampshire businesses and universities to promote applied and basic scientific research, engineering, and associated technology transfer
Connecticut	Critical Technologies Grant Program	1993	To promote technology deployment in advanced materials, marine science, photonics, pharmaceuticals, and environmental technologies
Kentucky	Research Challenge (The Bucks for Brains Program)	1997	Creates research-oriented endowed chairs, professorships, graduate fellowships, and endowments for research support and for the university libraries (recent statement)
Ohio	Technology Action Fund	1998	Leverage federal and industrial support; provide a potential return on investment to the state's economy
Indiana	Indiana 21st Century Research and Technology Fund	1999	To increase the capacity of Indiana institutions of higher education, businesses, and nonprofit organizations to compete successfully for federal or private research and development funding
Michigan	Smart Ideas (State Smart)	1999	To help academic researchers leverage federal and private funding in information technology, electronics, and emerging sectors
Montana	Montana Board of Research and Commercialization Technology	1999	To provide a predictable and stable source of funding for research and commercialization projects to be conducted at research and commercialization centers in Montana

(continued)

Table 1. (continued)

State	Name of the program	Year initiated	Key characteristics
Kansas	The STAR Fund	2000	Promotes national competitiveness in strategic technology niches that hold the most promise for the Kansas economy
New York	The James D. Watson Investigator Program, Matching Grants Leverage Program, Office of Science, Technology, and Academic Research; New York State Foundation for Science, Technology and Innovation (NYSTAR)	2000	To increase the state's investment in research universities and help turn that research into new jobs
Massachusetts	Research Center Matching Grant Program, Massachusetts Technology Collaborative	2004	To provide state matching funds for proposed academic research centers in Massachusetts that are seeking funding from the federal government, where there is an expectation that the state match will improve the competitive position of their proposal and enhance collaboration with companies in the Commonwealth
West Virginia	Research Challenge Grants	2004	Provides strategic leadership for infrastructure advancement and development of competitive research opportunities in science, technology, engineering, and mathematics disciplines
California	Stem Cell Research and Cure Initiative	2005	To promote rapid progress in stem cell research leading to treatments and cures for diseases and to the growth of a stem cell and regenerative medicine industry critical to future clinical applications
Washington	Life Sciences Discovery Fund	2005	To promote life sciences research to foster a preventative and predictive vision of the next generation of health-related innovations, to enhance the competitive position of Washington State in this vital sector of the economy, and to improve the quality and delivery of health care for the people of Washington
Arizona	21st Century Fund	2006	Support scientific, medical, and engineering research programs and infrastructure in targeted fields, particularly biosciences
Utah	Utah Science and Technology Research Initiative (USTAR)	2006	Funding for strategic investments at Utah State University and the University of Utah to recruit world-class researchers and build state-of-the-art interdisciplinary research and development facilities and to form first-rate science, innovation, and commercialization teams across the state
New Jersey	Stem Cell Research Grants	2007	To create and build a vibrant stem cell research community that will develop innovative treatments for patients and generate economic opportunity and job growth in New Jersey
Wisconsin	University of Wisconsin System's Growth Agenda	2007	Expand an existing research initiative to compete for additional extramural research funds, hire 20 leading faculty in targeted clusters such as biomedical and health technologies, advanced manufacturing, and other science and engineering areas, and enhance the level of graduate and undergraduate education research

Table 2. Eminent Scholars Programs.

State	Name of the program	Year initiated	Key characteristics
Virginia	Eminent Scholars	1964	The purpose of the Eminent Scholars program and, therefore, the intent governing the utilization of such funds as may be appropriated is to attract and retain certain individual faculty members who have achieved national eminence in their chosen and acknowledged field of endeavor.
Ohio	Eminent Scholars	1983	Established the Ohio Eminent Scholars Program with the purpose to invest in educational resources to address problems that are of vital statewide significance while fostering the growth in eminence of Ohio's academic programs.
Tennessee	Governor's Chair Program	1984	The Governor's Chair program seeks to catalyze the development of cutting edge research under the auspices of four joint institutes between the UT and ORNL: Biological Sciences, Computational Sciences, Neutron Sciences, and Advanced Material Sciences. The GC appointment includes an ongoing discretionary research fund equal to 12 months' salary.
North Carolina	Trust Fund for Faculty Recruitment	1986	The goal of this program is to aid recruitment of outstanding research faculty into tenure-track positions at the senior level to non-research extensive colleges and universities.
Louisiana	Endowment Chairs for Eminent Scholars	1987	Endowment Chairs for Eminent Scholars, introduced in 1987, is a highly competitive program designed to enhance the recruitment and retention of distinguished university faculty at institutions throughout Louisiana. The program pairs a 60% private sector match with a 40% Board of Regents award to endow a chair to be filled by a scholar of high renown and great ability.
Georgia	Eminent Scholars Program	1990	Georgia Research Alliance's (GRA) Eminent Scholars supports over 60 enterprising scientists. For each scholar, GRA invests $750,000 for an endowment, an amount that the research university matches in private funds on a minimum 1-1 basis. GRA also makes investments in developing the world-class research laboratories the scientists need.
Arizona	Eminent Scholars Matching Grant Program	1991	The fund provides universities with monies to encourage long-term endowment growth and to match the interest earned on nonpublic endowments donated to attract and retain eminent faculty (ARS 15-1663).
Missouri	Endowed Chair and Professors Program	1995	The Missouri State-Matched Endowed Chairs and Professorships Program is a faculty development program through the University of Missouri System that is supported through an annual $4 million state appropriation. Professorships are created when private donations to the university are matched by $550,000 in state appropriations. Similarly, endowed chairs are created when private donations to the university are matched by $1.1 million in state appropriations. Each campus provides a tenured faculty line and salary for the position.
South Carolina	Center of Excellence Faculty Recruitment Program	1997	Establishments of incentives for the senior research universities of South Carolina consisting of Clemson University, the Medical University of South Carolina, and the University of South Carolina to raise capital from the private sector to fund endowments for professorships for the purposes of developing and leveraging the research capabilities of the universities for the creation of well-paying jobs and enhanced economic opportunities in knowledge-based industries for all South Carolinians.
Kentucky	Kentucky Research Challenge Trust Fund (Buck for Brains—B4B)	1997	The program, administered by the Council on Postsecondary Education, creates research-oriented endowed chairs, professorships, graduate fellowships, and endowments for research support and for the university libraries. Funds raised help UK recruit and retain world-class faculty and exceptional students who choose UK because of its innovative research and new economic development.
Wisconsin	Eminent Scholars Program	1998	Current information on program unavailable.
New York	Faculty Development Program	1999	NYSTAR's goal is to attract distinguished faculty from throughout the world to New York's academic research centers by providing additional support to leading researchers already working in New York's academic research centers. In turn, top scientists and scholars bring in more financial support for research and draw the best junior researchers and graduate students. Research conducted by top flight scientists also generates the greatest interest from the business and investment communities.

(continued)

Table 2. (continued)

State	Name of the program	Year initiated	Key characteristics
Arkansas	Arkansas Research Alliance	2002	With the full support of the ARA, Arkansas research universities have identified and recruited scholars with exceptional research credentials and entrepreneurial records. Scholars are experts in their respective fields and will strive to convert research into economic growth in areas identified as strategic focus areas for the state.
Kansas	Kansas Bioscience Authority	2004	The Kansas Bioscience Eminent Scholars Program is designed to recruit distinguished bioscience researchers to conduct their research and commercialization activities at Kansas research institutions. An Eminent Scholar is a world-class, distinguished, and established investigator recognized nationally for research, achievements, and the ability to garner significant federal funding on an annual basis. Eminent scholars are recognized for their scientific knowledge and entrepreneurial spirit to enhance the innovative research that leads to economic gains. Eminent scholars are either members of or likely candidates for the National Academy of Sciences or other prominent national academic science organizations.
Texas	Research Capacity Program	2005	As part of the faculty development programs, the Texas Emerging Technologies Fund sets aside 25% for a Research Capacity Program. The law defines this as including recruitment of faculty research groups from out of state.
Wyoming	Higher Education Endowment Faculty Chair	2005	The endowment, authorized under W.S. 21-16-1202 (b), will allow the university to establish endowed faculty positions and to acquire instructional and resource materials, classroom equipment, and other resources necessary to support the work of endowed faculty members.
Connecticut	Connecticut Innovations	2006	SB 702, an Act Concerning Jobs for the 21st Century, a major component of the economic development strategy includes a faculty recruitment program and Entrepreneur Center at the University of Connecticut to help support state business and economic development.
Florida	World Class Scholars Program	2006	Designed to recruit and retain the very best faculty in the STEM areas of science, technology, engineering, and mathematics at universities in Florida, the World Class Scholars program serves to both attract new research opportunities and to add prestige to existing university research programs.
Pennsylvania	Keystone Innovation Zone Starter Kit	2006	Keystone Innovation Starter Kits (KISKs) provide funds to Pennsylvania academic medical centers, nonprofit research institutions, and Keystone Innovation Zone (KIZ)-participating Institutions of Higher Education (IHEs) for recruitment of top faculty researchers in the areas of nanotechnology and energy only. The Starter Kit program is a companion program to the Keystone Innovation Zone (KIZ) program.
Oklahoma	Health Research Science and Retention	2006	Through the Economic Development Generating Excellence program, the state of Oklahoma supports an endowed chairs program at the state's colleges and universities.
Washington	Innovation Research Teams "STARS Program"	2007	Strategically Targeted Academic Research teams (STARS), which are also known as Innovation Research Teams (IRTs), were initiated by the Washington State Legislature in 2007. House Bill 1091 directed the Washington Economic Development Commission (WEDC) to work with multiple agencies to establish Innovation Partnership Zones (IPZs) across the state and to initiate Innovation Research Teams, STARS. STARS create an ecosystem facilitating technology transfer from research institutions to the private sector, launching new products, validating new processes, and creating new jobs for Washington state citizens.

Table 3. State Center of Excellence Programs.

State	Name of the program	Year initiated	Key characteristics
Connecticut	Institute of Materials Science (IMS), University of Connecticut	1965	Funds basic and applied research and encourages collaboration with industries, provides industry outreach with specific concentration on material science and engineering, strengthens educational capacity of universities, and provides training for industries.
Alabama	The Aging Infrastructure Systems Center of Excellence (AISCE)	1975	Funds basic and applied research and encourages collaboration with industries, concentrates on specific industries and technologies, and promotes partnership of governmental agencies.
North Carolina	Microelectronics Center of North Carolina (MCNC)	1980	Funds basic and applied research and encourages collaboration with industries. Promotes technology transfer and strengthens capacity of universities. Acts as nonprofit entity.
Michigan	Michigan Biotechnology Institute (MBI)	1981	Funds only applied research and encourages collaboration with industries. Supports start-ups and encourages technology transfer. Nonprofit entity.
Florida	Institute for Simulation and Training (IST)	1982	Funds basic and applied research, encourages collaboration with industries, and provides industry with technical assistance and outreach concentrating on specific industries and technologies. Strengthens educational capacity of universities.
Indiana	Institute for Molecular and Cell Biology	1983	Funds basic and applied research and provides physical infrastructure for industries. Concentrates on specific types of industries and technologies.
Kansas	KTEC Centers of Excellence, Advanced Manufacturing Institute, National Institute for Aviation Research	1983	KTEC supports basic research through Centers of Excellence—university-based research centers—each with its own technology specialization. The five centers conduct innovative research and provide technical assistance with the overlapping aims of creating new companies, strengthening existing companies, and serving as expert resources to other KTEC programs. The Centers of Excellence provide applied and basic research, product development, networking programs, training, seminars, and technological consulting for client companies.
Colorado	Colorado Advanced Materials Institute (CAMI)	1983	CAMI coordinates and fosters research in materials science and engineering leading to economic development. Located at CSM, the institute functions as a consortium of state government, research universities (CSM, CU, CSU, and DU), and private industries. It concentrates on specific industries and technologies and aims at enhancing economic development.
New Mexico	Centers of Technical Excellence	1983	Supports basic and applied research concentrating on specific industries and technologies.
New York	Centers for Advanced Technology Program (CAT)	1983	The CAT Program is designed to spur technology-based applied research and economic development in New York; encourage applied research collaboration and innovation with industry; promote workforce development; better leverage state funds with investments from the federal government, industry, foundations, and not-for-profit economic development organizations; and increase the competitiveness of New York State companies.
South Carolina	South Carolina Research Authority	1983	Funds applied research and collaboration with industries, promotes technology transfer with concentration on specific industries and technologies, and supports start-up companies and business development.
Tennessee	Centers of Excellence	1984	Funds basic and applied research, strengthens education capacity of universities, encourages technology transfer and state economic development. Leverages outside funding and encourages research teams between disciplines and between the various stages of research. Funds the dissemination or “spin-off” of research findings and the transfer of technology to business and industry.

(continued)

Table 3. (continued)

State	Name of the program	Year initiated	Key characteristics
New Jersey	Advanced Technology Centers Program	1984	Supports basic and applied research and collaboration with industries. Strengthens educational capacity of universities. Encourages technology transfer concentrating on specific industries and technologies. Leverages federal funding and spurs economic development through workforce development.
Ohio	Edison Technology Centers	1984	The seven Edison Technology Centers fund basic and applied research and provide a variety of product and process innovation and commercialization services to both established and early-stage technology-based businesses, such as new product design, CAD/CAM, prototyping, materials selection and handling, plant layout and design, quality systems, information systems, machining, joining technology assistance, and biotechnology business consulting. These centers became more of networking and advocacy institutions, or company serving centers.
Maryland	University of Maryland Biotechnology Institute (UMBI)	1985	Maryland Technology Initiative Program (TIP) supported Centers of Excellence that are important to industry. The goal of the program was to establish and augment capabilities in the College of Engineering of the University of Maryland. The college provided quality academic resources, promoted excellence in key areas of research that furthered the interests of industrial development in Maryland, provided specialized training, and fostered collaborative research between UM and industry.
Missouri	Centers for Advanced Technology	1986	Funds basic and applied research, serves as a comprehensive economic development resource and to deliver programs to serve students, business, and industry, and community needs in Mexico and the state of Missouri consistent with the missions of the participating institutions. The purpose of the program is to strengthen educational capacity of universities, concentrating on development of specific industries, growing jobs, and spurring economic development of state for the benefit of residents, business, and industry.
Utah	Centers of Excellence	1986	The Centers of Excellence program provides grant funding to applied research to help technologies developed at Utah's colleges and universities transition out of the lab and into industry. Such advanced technologies can help create great new companies and great new products at Utah's existing companies. Both of these mechanisms create high-paying, long-term jobs for Utah's citizens.
Virginia	Technology Development Centers through the Center for Innovative Technology Program (CIT)	1986	The mission is to enhance the basic and applied research and technology transfer activities of Virginia universities, develop new technologies, entrepreneurs, and technology companies that make innovation happen.
Nebraska	Nebraska Research Initiative, Center for Biotechnology	1987	The UNL Center for Biotechnology promotes basic and applied research on all aspects of molecular life-sciences research, leading to improvements in agriculture, health care, and the environment. Its mission is to improve the health of Nebraska through premier educational programs, innovative research, the highest quality patient care, and outreach to underserved populations.
Montana	Center of Excellence in Biotechnology, Center for Advanced Minerals Processing (1989)	1988	The center provides core services and instrumentation to support basic research that can be applied to a range of biotechnology efforts. The Center for Advanced Mineral and Metallurgical Processing facilitates cooperation between the university system and industry to enhance the economy of the state of Montana.

(continued)

Table 3. (continued)

State	Name of the program	Year initiated	Key characteristics
Pennsylvania	University-based research centers (Centers of Excellence) through Ben Franklin Partnership Program (BFP)	1988	A Center of Excellence (CoE) is an entity that focuses on a specific technology area and conducts both basic and applied research and development. The goal is to inspire and nourish ideas that have commercial benefit for an entire industry within the state. The funding and support provided by Ben Franklin is instrumental in making these centers a reality. There are 12 CoEs.
Maine	Maine Aquaculture Innovation Center (MAIC)	1988	MAIC promotes applied aquaculture research, assists in the formulation of policies favorable to industry growth, serves as a clearinghouse for aquaculture information, and liaises with government organizations, aqua farms, and the general public.
Oklahoma	Centers of Excellence under OCAST	1989	Oklahoma Center for the Advancement of Science and Technology (OCAST) funds a variety of programs to assist universities, nonprofits, manufacturers, and businesses performing science and technology-based research,The agency provides programs that fund basic research as well as programs that fund applied research. OCAST also assists groups commercializing their product, process, or service.
Georgia	Food Processing Consortium, Georgia Consortium for Technological Competitiveness in Pulp and Paper	1990	Georgia Research Alliance (GRA) has the Centers of Research Excellence program as one of its three major programs. GRA's 24 Centers of Research Excellence leverage strategic investments in technology to push the boundaries of science and foster collaboration. The investments help ensure that the centers have sophisticated infrastructure to support both fundamental and translational research.
Arkansas	Centers for Applied Technology	1990	The Arkansas Science & Technology Authority's Centers for Applied Technology Program supports applied technology in areas of advanced materials and manufacturing systems, agriculture, food and environmental sciences, biotechnology, bioengineering and life sciences, and information technology. The benefits of establishing a center is a 33% income tax credit.
New Hampshire	Industrial Research Center	1991	The NHIRC helps companies upgrade old products or develop new products. Promotes applied and basic scientific research, engineering, and associated marketing research and technology transfer to support the New Hampshire industrial and business community for the purpose of creating high-quality jobs through technology development and innovation. The supported research, innovation, and technology transfer activities preserve and increase the number of jobs in New Hampshire.
Delaware	Agricultural Biotechnology Center, University of Delaware	1994	Promotes research, education, and technology transfer for biotechnology applications to the benefit of the environment, agriculture, and human health. Funds basic and applied research, supports collaboration with industry, promotes educational capacity of universities, and funds industry outreach. Concentrates on workforce development.
Rhode Island	Rhode Island Center for Cellular Medicine (RICCM), Ocean Technology Center of Excellence	1996	Helping local businesses develop and become globally competitive. Funds basic and applied research and collaboration with industry, supports business development, and provides physical infrastructure to companies.

(continued)

Table 3. (continued)

State	Name of the program	Year initiated	Key characteristics
Mississippi	Centers for Advanced Infrastructure Technology	1999	Funds basic and applied research concentrating on specific industries and technologies.
Illinois	University of Illinois at Urbana Champaign Post Genomics Research Institute	2003	Will provide common laboratory facilities for biologists, chemists, physicists, bioengineers, and bioinformation scientists. A core infrastructure will provide faculty, students, and staff in the seven research themes with shared, state-of-the-art instrumentation and support facilities. The new institute will provide Illinois a foundation for economic growth and job creation in the emerging field of genomic biology.
Kentucky	The Kentucky Innovation and Commercialization Centers (ICCs)	2003	The mission of the center is to support applied research and development that will lead to new commercial ventures and high-tech growth for Kentucky. Supports technology transfer, business development, and economic development of the state. Supports broad high-tech initiatives and business-building talent.
Idaho	Boise State University Center for Orthopaedic and Biomechanics Research	2003	Supports basic and applied research and promotes collaboration in biomechanics and biomedical engineering. Provides industry assistance and technology transfer, strengthens educational capacity of universities, and provides physical infrastructure for industry.
South Dakota	University Research Center	2004	Four Research Centers: (1) Center for Infectious Disease Research and Vaccinology, South Dakota State University; (2) South Dakota Signal Transduction Center, University of South Dakota; (3) Center for Accelerated Applications at the Nanoscale, South Dakota School of Mines and Technology; (4) Center for the Research and Development of Light-Activated Materials, University of South Dakota
Minnesota	Centers of Excellence	2005	The centers of excellence fund basic and applied research, concentrate and promote collaboration with specific industries, provide industry technical assistance and support technology transfer, provide for companies' physical infrastructure, and help their business development. They strengthen educational capacity of universities and are heavily involved in K-12 programs and workforce development.
North Dakota	Centers of Excellence	2006	Centers have been approved statewide and have helped attract funds to North Dakota's campuses for public-sector and private-sector projects dealing with renewable fuels development, energy workforce training and technology, aerospace, electronics, advanced manufacturing, and other technical research and development areas. They fund basic and applied research and support collaboration with industry, technology transfer, and business development.
Massachusetts	Holyoke High-Performance Computer Center	2009	The center is managed by a consortium of state agencies, universities, and technology companies including MIT, the University of Massachusetts, Cisco Systems, and EMC Corporation. Universities and high-tech businesses will be able to access the center's resources, which local leaders hope could boost the local high-tech economy.

Table 4. Aggregate List of Adoption Year by State for Three State-Level Capacity Building Programs.

State	University Research Grant Program	Centers of Excellence	Eminent Scholars Program
Alabama	1983	1975	
Alaska			
Arizona	2006		1991
Arkansas	1983	1990	2002
California	2005		
Colorado		1983	
Connecticut	1993	1965	2006
Delaware	1984	1994	
Florida		1982	2006
Georgia	1990	1990	1990
Hawaii			
Idaho		2003	
Illinois		2003	
Indiana	1999	1983	
Iowa			
Kansas	2000	1983	2004
Kentucky	1997	2003	1997
Louisiana	1987		1987
Maine	1990	1988	
Maryland		1985	
Massachusetts	2004	2009	
Michigan	1999	1981	
Minnesota		2005	
Mississippi		1999	
Missouri		1986	1995
Montana	1999	1988	
Nebraska	1988	1987	
Nevada			
New Hampshire	1991	1991	
New Jersey	2007	1984	
New Mexico		1983	
New York	2000	1983	1999
North Carolina	1984	1980	1986
North Dakota		2006	
Ohio	1998	1984	1983
Oklahoma	1985	1989	2006
Oregon			
Pennsylvania		1988	2006
Rhode Island		1996	
South Carolina	1983	1983	1997
South Dakota	1987	2004	
Tennessee		1984	1984
Texas	1987		2005
Utah	2006	1986	
Vermont			
Virginia		1986	1964
Washington	2005		2007
West Virginia	2004		
Wisconsin	2007		1998
Wyoming		2008	2005

Appendix B

EPSCoR State Match Programs

The Experimental Program to Stimulate Competitive Research (EPSCoR) is a special federal program that was established in 1979 and began in 1980 to support and encourage certain disadvantaged states to improve their research and development activities (Hauger, 2004). Despite the fact that EPSCoR is a national program that aims to build R&D capacity, up until 2006 the program required cost sharing from nonfederal funds. Between 1980 and 1994, the nonfederal match was required at the level of one-to-one with a cap at $3 million. After 1994, only a 50% match was required over the term of the award. In 2005, NSF dropped the matching requirement; yet in 2008 it was reinstated (Melkers & Wu, 2009). As an example of this regulation, the current EPSCoR RII Track-1 offers up to $4 million support over 5 years and also requires a 20% match from any nonfederal sources for all proposals;[16] however, the level of matching varies across the myriad programs. State funds must be committed to participate in EPSCoR.

Eligibility to participate in EPSCoR is based on the level of the preceding 3 years that has been awarded to the state. Specifically, a state qualifies for this program if its previous 3 years of cumulative awarded support does not exceed 0.75% of its current budget.[17]

The first cohort of EPSCoR states included Arkansas, Maine, Montana, South Carolina, and West Virginia. These states over the years have demonstrated a variety of ways to develop their research infrastructure in terms of focus area and programmatic approach. Arkansas, for example, focused its NSF support on developing nanotechnologies. This state placed an emphasis on an interdisciplinary approach, entrepreneurial culture, and commercialization of new technologies that extended beyond the traditional increase of scientists and strengthening ability to compete for more deferral dollars on the national scale. Uniquely enough, it defined interdisciplinary research both "within and between academic institutions and the private sector" as part of its primary goals.

Maine created its EPSCoR vision around bioproducts research. It funded Centers for Biomedical Research Excellence out of NIH IDeA and tapped both the Department of Energy and NASA. Montana also focused its research area around bioproducts by widening the spectrum to biofilm, bioinspired nanomaterials, biomolecular structures and dynamics, and other bio-related areas. Through this effort, Montana established research centers and infrastructure by way of the Science- and Technology-Enhanced Partnerships. As stated in the research mission, this program seeks "to maximize the potential inherent in the state's science and technology resources and use those resources as a foundation for economic growth."[18]

South Carolina and West Virginia were both engaged in a wide range of EPSCoR programs. Although neither state focused its efforts on developing research infrastructure within a specific focus area, these states provided a wide variety of programs and opportunities to their university faculty and students to pursue their own research interests through different venues.

Shortly after these five states began their EPSCoR initiatives, a second cohort was added to the list in 1985. These states included Alabama, Kentucky, Nevada, North Dakota, Oklahoma, Puerto Rico, Vermont, and Wyoming. These states were engaged in a variety of EPSCoR activities receiving support from different federal agencies, including the Department of Energy, NASA, EPA, and NIH. Whereas Kentucky and North Dakota increased their research competitiveness through technology transfer, Vermont supported programs specifically for the private sector, where the state established Funding Opportunities for Private Businesses at the same level as it had research support for university and baccalaureate college faculties. Among this second cohort, only Wyoming set up a Collaborative Plant Biology program.

The last cohort of states added to the EPSCoR program in 1987 included Idaho, Louisiana, Mississippi, and South Dakota. Idaho and Mississippi concentrated their research efforts in bio-related fields whereas Louisiana, South Dakota, and even Mississippi set as their goals to improve research infrastructure and strengthen the opportunity to compete for federal funding, which was similar to the approach that Arkansas had taken. South Dakota took a unique stance by promoting entrepreneurship through its Entrepreneurship Academy and by launching grant programs for internships, graduate research opportunities, and development assistantships.

The other states added to the program between 1992 and 2004 emulated some of the initial efforts of the early qualifiers. To elaborate on a few, Kansas and Nebraska concentrated on STEM education, bio-related activities, and collaborative cross-disciplinary research efforts. In addition, Kansas encouraged university–industry partnerships, whereas Nebraska, in turn, "foster[ed] economic development through support to technology transfer."[19]

The literature on the EPSCoR program and its effects on state economic development uses different measures of success (Feller, 2000; Lambright, 2000; Melkers & Wu 2009). Dietz (2000), in particular, built a social capital model of research development. Although both institutional and infrastructural capacity is critical to R&D clusters, he placed emphasis on the critical role of social and human capital. As highlighted in his account, these programs

> would benefit by considering a social capital model of research development because capacity generation and institution building are central to the objectives of these initiatives. Furthermore, capacity generation and institution building necessitate a recognition of the role of social and human capital in meeting these ends. (p. 144)

Besides emphasizing the necessity of more systemic economic and scientific development in EPSCoR states, social and human capacity building warrant greater attention and support among policy makers and researchers. Although this program has increased in size since its inception, interestingly we find that no states ever graduate from EPSCoR.

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Notes

1. Source: http://www.nhinet.org/ccs/docs/nc-1776.htm
2. We consider research grants that require matching funds from firms as a separate category that creates collaboration and leverages university resources. See the later discussion of Centers of Excellence.
3. Source: ASTA's website, http://asta.ar.gov/
4. Additional information about EPSCoR can be found in Appendix B of this article.
5. These states are MS, NV, NH, NM, ND, RI, VT, AK, HI, ID, TN, and WY.
6. Source: http://cpe.ky.gov/news/mediaroom/releases/nr_110811.htm
7. Source:IMSwebsite,http://www.ims.uconn.edu/about/about_us.html
8. Source: AISCE website, http://aisce.ua.edu/
9. Source: http://www.ncbi.nlm.nih.gov/books/NBK45051/
10. Source: KTEC website: http://www.ktec.com/sec_research/section/centers.htm
11. Source:ColoradoSchoolofMinesGraduateBulletin,2003-2004: http://inside.mines.edu/UserFiles/File/bulletins/2003-2004_Grad.pdf, p. 165
12. Source: NY CAT website: http://www.nystar.state.ny.us/cats.htm
13. Source: Florida Institute for Simulation and Training: http://www.ist.ucf.edu/
14. Source: Indiana Molecular Biology Institute: http://imbi.bio.indiana.edu/
15. We also ran the analysis for 1980 and 2006—the year prior to the recent economic recession. The similarity in trends are notable; thus, we opted to use the more comprehensive set of data.
16. Source: http://www.nsf.gov/pubs/2009/nsf09570/nsf09570.htm
17. The historical level of funding that defined eligibility of states to participate in the NSF EPSCoR research Infrastructure Improvement Grant Program (RII) was 0.70% in 2002.
18. Source: Montana EPSCoR website: http://www.mtnsfepscor.org/about.html.
19. Source: Nebraska EPSCoR website: http://epscor.unl.edu/

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