

Proof of Concept Centers in the United States: an exploratory look

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Abstract:

In this paper we identify the population of 32 US university-related Proof of Concept Centers (PoCCs), and we present a model of technology development that identifies the economic role of PoCCs within that model. We examine the broad technology transfer challenges that PoCCs have been established to address. Further, we argue that PoCCs are a growing technology infrastructure in the United States, and they are important as a possible element of our national innovation system.

Keywords: Proof of Concept Center | university technology transfer | entrepreneurship | innovation

Article:

Introduction

Since the passage of the University and Small Business Patent Procedures Act of 1980 (Public Law 96-517), also known as the Bayh-Dole Act of 1980, there has been widespread and growing public-sector support of the commercialization of university-based research. Evidence of this is most visible through the trend at universities to establish and operate technology transfer offices and offices of innovation and commercialization.

More recently, the Obama Administration reiterated this support in September 2009 through the release of *A Strategy for American Innovation: Driving towards Sustainable Growth and Quality Jobs* (Executive Office of the President 2009).¹ Shortly thereafter, in March 2010, a Request for Information (RFI) was published in the *Federal Register* [75 (57): 14476]:

This RFI is designed to collect input from the public on ideas for promoting the commercialization of Federally funded research. ... the RFI seeks public comments on how best to encourage commercialization of university research. ... [and] on whether

¹ This September 2009 document was updated and released again in February 2011.

PoCCs [Proof of Concept Centers] can be a means of stimulating the commercialization of early-stage technologies....

And, in addition to stimulating the commercialization of early-stage technologies there are, of course, positive economic development consequences associated with any effort that enhances university technology transfer.

PoCCs gained broader recognition as a potentially important element of the nation's technology infrastructure when President Obama announced in March 2011, as part of the Startup America initiative, the i6 Green Challenge.² A total of \$12 million will be awarded to establish or expand PoCCs that have the potential to enhance the commercialization of technology and entrepreneurship in support of a green economy, increase US competitiveness, and leverage job growth. Six organizations received public funding.³

Despite this flurry of policy interest and activity, discussions as to the basic definition and specific role of PoCCs are conspicuously absent from both policy conversations about PoCCs and the academic and professional literatures. And, there is a void of any systematic investigation of the structure and analysis of the economic impact of these centers.

A broad definitional framework might view PoCCs as a collection of services to improve the dissemination and commercialization of new knowledge from universities in order to spur economic development and job growth. A more narrow perspective might simply view PoCCs as an investment by a university or universities for improved technology transfer.

This paper contributes to the literature by identifying what is, to the best of our knowledge, the population of university-related PoCCs in the United States. And, it sets forth an economic role of PoCCs in an effort to motivate future empirical research on the topic. More specifically, we present an economic model of technology development in Sect. 2 and we emphasize the role of PoCCs within that model. In Sect. 3, we define the current population of US university-related PoCCs, and we briefly describe each center. Finally, in Sect. 4, we conclude that PoCCs are a growing technology infrastructure in the United States, and they are important as a possible element of our national innovation system.

An economic model of technology commercialization

From a firm-level perspective, Maia and Claro (2012, p. 2), building on Auerswald and Branscomb (2003), argue that the most critical phase in technology commercialization:

... occurs between invention and product development, when commercial concepts are created and verified, appropriate markets are identified, and protectable Intellectual

² Partners in this cooperative effort included the Department of Energy along with the Economic Development Administration, the Department of Agriculture, the US Environmental Protection Agency, the National Science Foundation, the National Institute of Standards and Technology, and the U.S. Patent and Trademark Office.

³ The six organizations that received funding included the Iowa Innovation Network i6 Green Project in Ames; the Proof of Concept Center for Green Chemistry Scale-up in Holland, Michigan; the iGreen New England Partnership; the Igniting Innovation (I2) Cleantech Acceleration Network in Orlando, Florida; the Louisiana Tech Proof of Concept Center in Ruston; and the Washington State Clean Energy Partnership Project.

Property (IP) may have to be developed. This Proof of Concept ... phase has a funding gap, caused by information and motivation asymmetries and institutional gaps between the Science and Technology and Business enterprises.

Relatedly, in their examination of the University of California at San Diego's von Liebig Center and MIT's Deshpande Center definition, Gulbranson and Audretsch (2008, p. 250) define a PoCC as an institution "devoted towards facilitating the spillover and commercialization of university research." In other words, PoCCs seem to be taking aim at improving the transfer and development of technologies derived from public R&D funding, especially from universities and public laboratories.⁴

Figure 1 provides a representation of university technology transfer (Bradley et al. 2013); it is vastly improved over the simpler, linear heuristics that have long dominated the literature. The solid black arrows in Fig. 1 indicate processes of technology transfer, while the gray dashed arrows indicate factors that influence these processes. The process of university technology transfer begins with a scientific discovery. Once a discovery is made, the technology transfer process follows one of two paths: the inventor (e.g., university scientist) can choose to disclose his/her invention to the university's technology transfer office (TTO)—Process 1—or the inventor can choose not to disclose his/her invention thus bypassing the TTO—Process 2.⁵

Given the notional definition of a PoCC above, we posit that PoCCs target activities that occur within certain processes of the overall technology transfer process, namely those activities conceptualized by Process 1, 2, and 12. In other words, decisions for a university to claim ownership of intellectual property (IP), while related, is distinct from activities that seek to further develop and commercialize technology. Furthermore, barriers may exist at each subsequent process step due to information asymmetries and lack of resources that relate back to readiness of the technology and the capability for the faculty member (and university) to further develop it—the target of PoCCs.⁶

While PoCCs are focused on relatively early stages of university technology development, they have the potential to impact most of the university technology transfer process as described by Fig. 1. Typical PoCC services include seed funding, business and advisory services, incubator space, and market research. The university's TTO typically coordinates with the PoCC by assisting with IP and licensing responsibilities, providing representatives for advisory services, and connecting inventors with outside funding sources.

⁴ EERE (2011) views PoCCs within a broader context than a university, and thus they define PoCCs as institutions that "support all aspects of the entrepreneurship process, from assisting with technology feasibility and business plan development, to providing access to early-stage capital and mentors to offer critical guidance to innovators. Centers allow emerging technologies to mature and demonstrate their market potential, making them more attractive to investors and helping entrepreneurs turn their idea or technology into a business."
See: http://apps1.eere.energy.gov/news/progress_alerts.cfm?pa_id=503.

⁵ The inventor's decision to disclose is influenced by the university's reward systems and culture, as noted by the gray dashed arrows.

⁶ See Hayter (2011) for a complete discussion of spinoff success factors discussed in the extant literature.

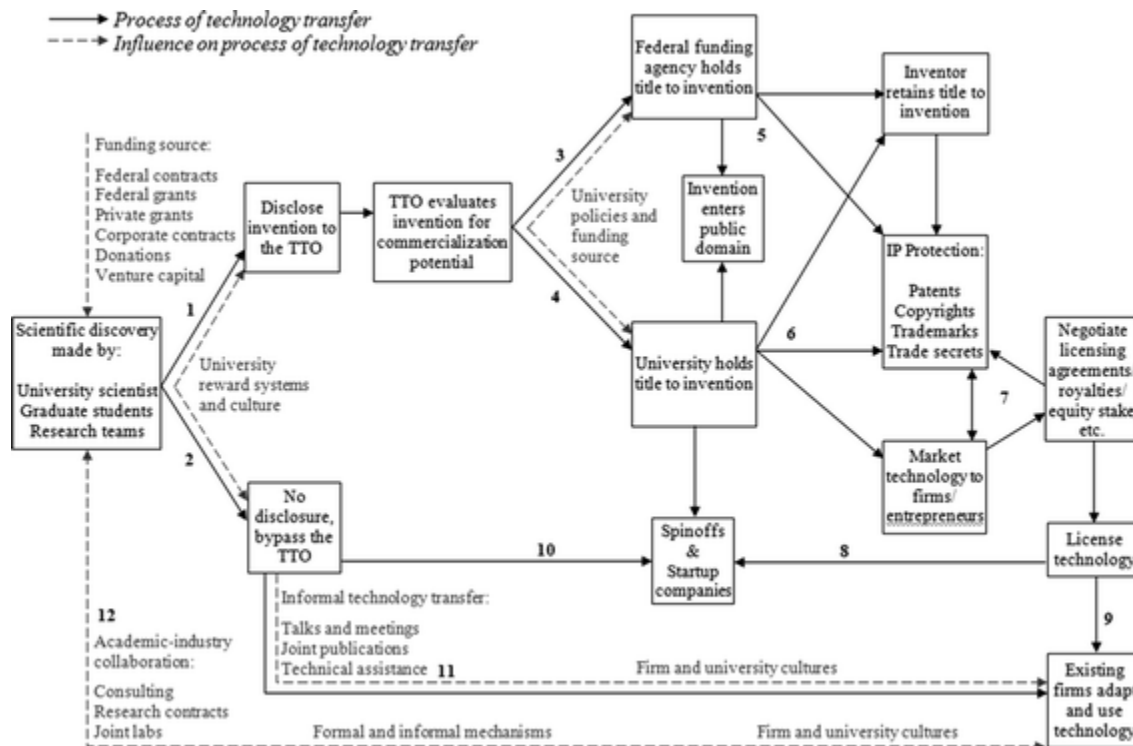


Fig. 1. Model of university technology transfer. *Source* Bradley et al. (2013)

Thus, PoCCs enable inventors to evaluate the commercial potential of their research; within PoCCs, early-stage products can be developed and prototypes can be tested. Proving a concept makes it easier for inventors to obtain funding from outside investors, such as angel investors or venture capitalists, for further product development.⁷

In Table 1 we offer an initial taxonomy of the challenges that PoCCs are intended to address in an effort to move toward a more systematic understanding of their economic role. This taxonomy comes from a review of the extant literature, and that literature is summarized in the Appendix to this paper.

Table 1. Challenges in technology transfer potentially addressed by Proof of Concept Centers

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| <ol style="list-style-type: none"> 1. University entrepreneurs tend to be older and often lack relevant business skills 2. Research productive faculty are not always inclined to re-direct their research toward transferable technologies 3. University faculty often lack the social networks necessary for successful technology transfer 4. University policies (e.g., promotion and tenure, financial, and intellectual property) do not always provide sufficient incentives for faculty to engage in technology transfer 5. External funding for startups is often difficult to obtain and thus hinders the success of technology transfer |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

PoCCs: an inferential analysis

Reflecting on a broader view of technology transfer, we conceptualize PoCCs as a critical technology infrastructure. PoCCs are important not only for remediating technology transfer

⁷ See Rasmussen and Sørheim (2012) for a discussion of PoCCs from a public-sector perspective of bridging the funding gaps for university spinoffs.

challenges but also for accelerating the advancement of Proof of Concepts into the market application stage.

To better understand this technology infrastructure, 32 PoCCs were identified from public sources based on the definitions discussed above.⁸ Table 2 describes what we have identified from public-domain sources as the current US population of university-related PoCCs. Also shown at the end of Table 2 are 6 additional PoCCs that are labeled as “forthcoming”.

From the description of the PoCCs in Table 2 it is clear that commercialization of university-generated technology is an important goal of each center, and that this goal is being approached differently in different PoCCs. For example, some PoCCs are based at a single university and others have an integral relationship with several universities. Differences in achieving commercialization success through a PoCC infrastructure underscores the relevance of our claim above that the economic role of the PoCC—accelerating innovation from the laboratory to the market—can occur throughout the university technology transfer process and thus is appropriately not given a particular node of reference in Fig. 1.

Geographic distribution of PoCCs

We examined several characteristics of the population of PoCCs summarized in Table 2. First, it is clear that PoCCs are fairly evenly located throughout the United States. Based on US Census Bureau regions, among the 32 operational PoCCs, 7 are in the West, 9 in the Midwest, 10 in the Northeast, and 6 in the South. Of the 6 forthcoming PoCCs, 4 are in the Northeast.

Growth trend of PoCCs

Second, based on the year that each PoCC was started (see Table 2), we constructed Fig. 2. The figure suggests a general upward trend in the formation of PoCCs beginning in 2007. That trend was exaggerated as a result of the Startup America initiative. The post-2007 trend in Fig. 2 suggests that PoCCs might have been a university response to the economic downturn in the United States that began in December 2007. Certainly, the Startup American initiative was designed to be pro-cyclical. However, if the United States is entering a period of sustained moderate growth, then the number of new PoCCs started in future years might level-off.

⁸ Some might take issue with the centers that we have subjectively classified as PoCCs. If this is the case, it underscores that an accepted definition of a PoCC is evolving.

Table 2. Description of the US university-related Proof of Concept Centers

Center	Location	Year founded	Initial funding	University affiliation	Types of services	No. projects funded	Partners/affiliates
von Liebig Entrepreneurism Center	San Diego, CA	2001	\$10 million donation from the William J. von Liebig Foundation	Jacobs School of Engineering, University of California, San Diego	Seed funding, advisory services, educational programs, technology acceleration programs	10–12 annually	Center for Commercialization of Advanced Technologies, CONNECT, UCSD \$50 K Entrepreneurship Competition
Deshpande Center	Cambridge, MA	2002	\$17.5 million donation from Jaishree and Gururaj Deshpande	MIT School of Engineering	Grant program, catalyst program, innovation teams, special events	90+ to date	Lockheed Martin, Sanofi Aventis
VentureLab	Athens, GA	2002	From 2002 to 2010, GRA directed \$19 million of state funding into VentureLab	University of Georgia, Georgia Tech, Emory University, Georgia State University, Medical College of Georgia, Clark Atlanta University	Seed funding awarded in three phases Phase 1—\$50,000 grants. Develop business plans, market assessments, Proof of Concept studies Phase 2—\$100,000 grants with matching funds required. IP licensing, develop prototypes Phase 3—\$250,000 loans. Field trials, product distribution, facility and staffing, marketing	107+	Georgia Research Alliance
Ohio Third Frontier	Columbus, OH	2002	\$1.6 billion, 10-year commitment by the State of Ohio Extended through 2015 in May 2010	Kent State University, University of Akron, Cleveland State University, University of Dayton, University of Toledo, Case Western Reserve University, Ohio State University, Wright State University	Comprehensive state-wide system of programs and organizations that support the development and commercialization of new technologies, expand Ohio’s technology-based R&D capabilities, provide risk capital, and promote entrepreneurial skills Focus on developing 5 key technology clusters: advanced energy; advanced materials; biomedical; instruments, controls and electronics; power and propulsion	700+ companies created, capitalized, or attracted to Ohio by Third Frontier funds	
St. Louis BioGenerator	St. Louis, MO	2003	McDonnell Family Foundation, the Danforth Foundation, Bunge North America, the Monsanto Fund and CORTEX	Washington University, Saint Louis University, University of Missouri	Provide pre-seed or seed funding at the early stages of new company formation, continued support to milestones of follow-on funding or sustainable revenue, professional services (lawyers, accountants), management support	27	Danforth Plant Science Center, Missouri Botanical Gardens, Coalition for Life Sciences, Missouri Technology Corporations, InnovateVMS, CORTEX Life Science

Center	Location	Year founded	Initial funding	University affiliation	Types of services	No. projects funded	Partners/affiliates
University of Colorado Proof of Concept Program	Boulder, CO	2004	Income generated from commercialization of CU intellectual property	University of Colorado	Four types of grants Proof of Concept small grants (POCsg) Proof of Concept investments (POCi) Proof of Concept State of Colorado Bioscience matching grants (POCmbg) Renewable and Sustainable Energy Institute (RAESI) Proof of Concept energy grants (POCeg) (includes a Market Assessment Program (MAP) element)	139	District, St. Louis Arch Angels, Skandalaris Student Venture Fund University License Equity Holdings, Inc. (ULEHI) (non-profit organization that manages private equity for CU)
Commercial Ventures and Intellectual Property Technology Development Fund	Massachusetts	2004	Created and maintained through licensing revenues, initial \$50,000 contribution from the President's Office of CVIP	University of Massachusetts	Awards given annually to faculty members across all five UMass campuses to accelerate commercialization of early-stage technologies developed at UMass	66	
Alabama Innovation and Mentoring of Entrepreneurs Center	Tuscaloosa, AL	2007	Reconstitution of the Alabama Institute for Manufacturing Excellence	University of Alabama	Entrepreneurial training, Center for Green Manufacturing, Manufacturing Information Technology Center, Machine Process and Product Design Center, Operations Research and Statistical Analysis Center, teams of staff/students to conduct market research and business model plan/development, idea database, idea selection committee		Bama Technology Incubator
Boston University-Fraunhofer Alliance for Medical Devices, Instrumentation and Diagnostics	Boston, MA	2007	\$5 million, 5-year initiative jointly funded by Fraunhofer Gesellschaft and BU	Boston University	Fraunhofer CMI engineers work with BU researchers to develop medical innovations from BU labs into functional instruments and devices that can attract investment from VC's for a new venture creation or be licensed to existing companies in their space		Fraunhofer Gesellschaft
Stevens Institute for Innovation	Los Angeles, CA	2007	\$22 million donation from Mark and Mary Stevens	University of Southern California	Coaching, mentoring, networking and showcase opportunities for startups, connect innovators with funding, IP management, USC Student Innovator Showcase, Ideas Empowered program, planned 'Innovation Fund' for faculty and researchers in health sciences to develop proofs of concept		USC Office of the Provost
Biomedical Accelerator Fund	Cambridge, MA	2007	\$6 million in private donations	Harvard University	Development gap funding awarded to Harvard investigators to propel emerging	27	

Center	Location	Year founded	Initial funding	University affiliation	Types of services	No. projects funded	Partners/affiliates
Vermont Experimental Program to Stimulate Competitive Research Innovation Fund Awards	Burlington, VT	2007	Vermont EPSCoR funded by NSF	University of Vermont	technologies originating from Harvard's biomedical and life science research community into clinical development Provide funding and support for high-risk research that could revolutionize a Science, Technology, or Math (STEM) field	Awards up to \$12,000	
Institute for Advancing Medical Innovation	Kansas City, KS	2008	\$8.1 million gift from the Kauffman Foundation \$8 million matching from KU's endowment fund	University of Kansas	Annual request for proposals seeking POC projects, \$50–100 k funding per project, one-on-one support from project directors		Kauffman Foundation, Leukemia and Lymphoma Society, NIH, Kansas Bioscience Authority, Children's Mercy Hospitals and Clinics, Frontiers: The Heartland Institute for Clinical and Translational Research, Bioscience and Technology Business Center
Medical Devices Center	Minneapolis, MN	2008	\$10 million, 5-year investment from the University of Minnesota	University of Minnesota	Provide technical assistance and facilities for prototype development and testing to refine technology and ensure finished product is commercially viable 1 year Fellows Program	8 Fellows funded per year	Minnesota Department of Employment and Economic Development, Maslowski Family Trust
Blue Highway	Syracuse, NY	2008	Wholly owned subsidiary of Welch Allyn, Inc.	Syracuse University	Invention triage, technical evaluations, product development, rapid prototyping, IP landscape and valuation studies, Original Equipment Manufacturing	100+ active collaborations with academia, government, and industry	Welch Allyn, Inc.
QED Proof of Concept Program	University City, Philadelphia, PA	2009	\$300,000 grant from the Commonwealth of Pennsylvania's Ben Franklin Technology Development Authority \$300,000 grant from	Delaware State University, Drexel University, Harrisburg University of Science and Technology, Lehigh University, New Jersey Institute	Solicits life science R&D project proposals from the region's research centers and selects the most promising technologies for funding designed to bridge the valley of death	12	Fox Chase Cancer Center, Lankenau Institute for Medical Research, Monell Chemical Senses Center, New Jersey Institute of Technology, The Wistar Institute

Center	Location	Year founded	Initial funding	University affiliation	Types of services	No. projects funded	Partners/affiliates
			the William Penn Foundation \$1.8 million commitment from University City Science Center and participating institutions	of Technology, Penn State College of Medicine Hershey, Philadelphia College of Osteopathic Medicine, Philadelphia University, Rutgers University, Temple University, Thomas Jefferson University, University of Delaware, University of Medicine and Dentistry of New Jersey, University of Pennsylvania, University of the Sciences in Philadelphia, Widener University			
New Hampshire Innovation Commercialization Center	Portsmouth, NH	2010	\$165,000 per year (2010–2012) seed investment from UNH Undisclosed private backers	University of New Hampshire	Select early-stage ventures with high commercialization potential and grow them into companies by providing business resources, seed capital, and management expertise	6	Elevate Communications, Pease Development Authority, PixelMEDIA, Whaleback Systems
Agile Innovation System	Pittsburgh, PA	2010	\$1 million grant from EDA	Carnegie Mellon University	Workshops, mentoring, funding through translational research grants, accelerator space	25	Innovation works
Oregon Innovation Cluster	Oregon	2010	\$1 million grant from EDA \$1 million grant from Oregon Innovation Council \$400,000 supplemental awards from NIH/NSF	Oregon State University, Oregon Health and Science University, University of Oregon, Portland State University	Technical and business assistance services, proof of concept grants, intern/sabbatical program for students and researchers, business accelerator and capital development fund		Oregon Nanoscience and Microtechnologies Institute, Oregon Translational Research and Development Institute, Oregon Built Environment and Sustainable Technologies, Pacific Northwest National Laboratory
Innovative Solutions for	Akron, Ohio	2010	\$1 million grant from EDA	University of Akron Research Foundation	Proof of concept prototyping in ABIA's Medical Device Development Center and		Austen BioInnovation Institute in Akron

Center	Location	Year founded	Initial funding	University affiliation	Types of services	No. projects funded	Partners/affiliates
Invention Xceleration					Center for Clinical and Community Health Improvement, design/manufacturing services, commercialization and marketing plans		
Maryland Proof of Concept Alliance	Maryland	2010	\$5.1 million in federal funding	University of Maryland system	Identifies and funds promising technologies developed through University System of Maryland institutions	21	US Army Research Laboratory
Iowa Innovation Network i6 Green Project	Ames, Iowa	2011	\$1 million grant from EDA	Iowa State University	Adding a next-stage Proof of Commercial Relevance Center to help start businesses bring product to market		Iowa Innovation Council, Iowa Innovation Corp.
Proof of Concept Center for Green Chemistry Scale-Up	Holland, MI	2011	\$580,000 grant from EDA \$500,000 from Michigan Economic Development Corporation Former pharmaceutical R&D and pilot plant facility donated by Pfizer	Bioeconomy Institute of Michigan State University	Business support services, green technology incubation, assist client firms in obtaining US Department of Agriculture BioPreferred designations		Lakeshore Advantage, Prima Civitas Foundation, NewNorth Center
iGreen New England Partnership	New England	2011	\$1.25 million grant from EDA	University of Maine	Networking roundtables, fund applied research in university labs, incubator space for startups, online tools (forums, stakeholder network, etc.)	20–30 expected over the next 2 years	40+ including: New England Clean Energy Foundation, ME Technology Institute, ME Regional Redevelopment Authority, MA Clean Energy Center, CT Clean Energy Finance and Investment Authority, NH Office of Energy and Planning, RI Renewable Energy Fund, VT Agency of Commerce and Community Development
Igniting Innovation (I2) Cleantech Acceleration Network	Orlando, FL	2011	\$1.3 million grant from EDA Matching funds from Space Florida and the	University of Central Florida	Virtual network linking Florida-based universities, business incubators, investors, and industry resources, 3 month I2 Accelerator Program (kickoff business	150+ companies have participated	Florida Energy Systems Consortium, Technological Research and Development Authority

Center	Location	Year founded	Initial funding	University affiliation	Types of services	No. projects funded	Partners/affiliates
Louisiana Tech Proof of Concept Center (LA_i6)	Ruston, LA	2011	Florida High Tech Corridor Council \$1.1 million grant from EDA	Louisiana Tech	bootcamp, 1 on 1 mentoring, presentations to I2 Ventures network) Support for field testing and prototyping, engage private sector partners, collaborate with researchers and organizations at Enterprise Campus research park	3 pilot projects: Geopolymer concrete Solar cell power conversion Piezoelectric generators	Louisiana Tech Enterprise Center, companies along I-20 Innovation Corridor
Washington State Clean Energy Partnership Project	Washington State	2011	\$1.3 million grant from EDA	South Seattle Community College	Annual analysis and reports on policy alignment, help eliminate regulatory barriers limiting clean energy development, assist Pacific Northwest energy companies in deploying products to global markets, build the Building Efficiency Testing and Integration (BETI) Center and Demonstration Network		Washington Clean Energy Regional Innovation Cluster, Puget Sound Regional Council's Prosperity Partnership, Cleantech Open Mentoring Program, Innovate Washington
UC Proof of Concept Program	California	2011	\$2.7 million invested by UC in 2011, \$2.6 million invested by UC in 2012	University of California system	Funds innovations based on IP owned by UC 35 that are within 12 months of commercialization		Lawrence Berkeley National Lab
Global Center for Medical Innovation	Atlanta, GA	2012	\$1.3 million grant from EDA \$1.3 million match from Georgia Research Alliance	Georgia Tech	Product-specific project teams, prototyping/design/engineering/product development, preclinical testing, clinical trials	2	Piedmont Healthcare, Georgia Research Alliance, Saint Joseph's Translational Research Institute, MetricIreland, Atlanta Pediatric Device Consortium, Interoperability and Integration Innovation Lab
Proof of Concept Fund	Lawrence, KS	2012	Funding from University of Kansas	University of Kansas	Provide funding (up to \$50 k per proposal) to mature KU research projects for one year The fund will support projects in all areas of technology—including electronics, software, communications and engineering—that aren't eligible for POC funding through KU's Institute for Advancing Medical Innovations (IAMI)	Will award a total of \$200,000 in funding in 2012, award notifications to be made February 2013	KU Center for Technology Commercialization

Center	Location	Year founded	Initial funding	University affiliation	Types of services	No. projects funded	Partners/affiliates
Proof of Concept Gap Funding Initiative	Chicago, IL	2012	\$500,000 from the Office of the Vice President for Research, the Office of the Vice Chancellor for Research, the Colleges of Engineering, Medicine and Pharmacy, and the Office of Technology Management	University of Illinois at Chicago	Commercial product development/testing, address technical or commercial risks, Attract potential licensees or additional third party funding	4 projects were funded in the 1st Round of the POC Initiative, an estimated 4–5 projects are anticipated to be funded in the 2nd Round	UIC Office of Technology Management
Proof of Concept Program	Tucson, AZ	2012	Revenue from UA licensing and options	University of Arizona	Generate data to support the potential commercial value of the invention, prototype development and testing, validate academic software code for commercial application, design, construct, and evaluate a prototype device, delivery system, software, etc.	Funding selections to be announced December 17, 2012 for research to begin January 7, 2013	Tech Launch Arizona
Oklahoma Proof of Concept Center	OK	Forth coming	Capital from i2E and Cowboy Technologies	Oklahoma State University, Oklahoma University	Virtual center that will accelerate products to the marketplace through coordinating efforts to validate markets, developing prototypes, obtaining guidance and feedback from industry mentors and providing access to capital necessary		I2E Inc., Cowboy Technologies LLC
Downstate Regional Energy Technology Accelerator	New York, NY	Forth coming	\$5 million awarded by New York State Energy Research and Development Authority	Columbia University	Fund the development of sustainable technologies and clean energy solutions		Brookhaven National Laboratory, Stony Brook University, Cornell University's NYC Tech
NYC Clean Economy Center for Proof-of-Concept	Brooklyn, NY	Forth coming	\$5 million awarded by New York State Energy Research and Development Authority	Polytechnic Institute of New York University partnered with City University of New York	Support applied science research that focuses on challenges specific to an urban environment		Power Bridge, NYU Center for Urban Science and Progress
High Tech Rochester, Inc.'s NYSERDA Proof of Concept Center	Rochester, NY	Forth coming	\$5 million awarded by New York State Energy Research and Development Authority	University of Rochester, Rochester Institute of Technology, Alfred University, Cornell University, Clarkson	Accelerate the creation and growth of clean energy startups across Western and Central New York		

Center	Location	Year founded	Initial funding	University affiliation	Types of services	No. projects funded	Partners/affiliates
Proof of Concept for Technology Commercialization Award Program	Piscataway Township, NJ	Forth coming		University, University at Buffalo, SUNY Research Foundation Rutgers	Enable Rutgers investigators to develop a commercializable product based upon Rutgers intellectual property that has not yet been licensed	Awards up to \$50,000	
ICE Commercialization GAP Fund Program 2012	Iowa City, IA	Forth coming	Seed funding provided by the Iowa Centers for Enterprise in conjunction with the Office of the Vice President for Research	University of Iowa	Support a range of stages in technology development, from initial concept (prior to intellectual property disclosure), through proof of concept, to licensing and commercialization	Awards from \$10,000 to \$75,000	

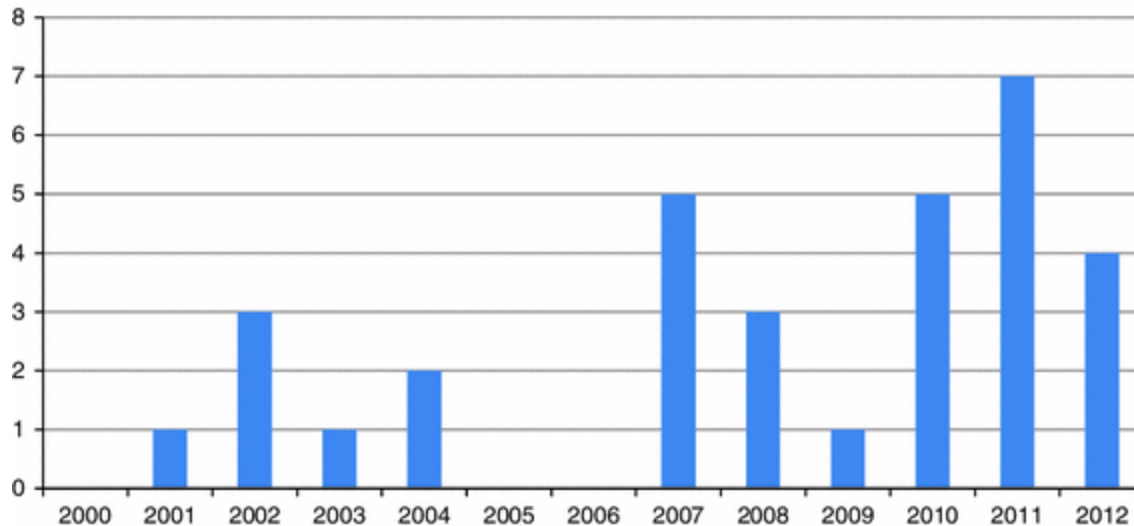


Fig. 2. Trend in the number of university-related Proof of Concept Centers in the United States, by year started

Institutional placement of PoCCs

Third, of the 32 university-related PoCCs identified in Table 2, we were able to identify the year that the TTO at 30 of the 32 universities was established.⁹ Five PoCCs are associated with universities with a TTO established before 1971, 4 with a TTO established between 1971 and 1980, 8 with a TTO established between 1981 and 1990, 11 with a TTO established between 1991 and 2000, and 2 with a TTO established after 2000. Thus, it appears that US PoCCs are associated with universities with more established technology transfer offices.

PoCCs and research expenditures

Fourth, we explored the relationship between the establishment of a PoCC and the level of R&D research conducted at universities. Based on the total level of R&D research funding of the largest 100 academic institutions in the United States, as reported by the National Science Board (Tables 5–10, 2012), 20 of the top 100 academic institutions have a PoCC based on information in Table 2. The mean amount of 2009 R&D research funding in those universities with a PoCC was \$460.2 million; the mean amount in those universities without a PoCC was \$406.9 million. These mean amounts are not statistically different from each other.¹⁰

PoCCs and university startups

⁹ Year of establishment was determined from the Association of University Technology Managers (AUTM) data. When more than one university is associated with a POCC, the year of establishment for the oldest TTO was considered.

¹⁰ The *t* value for a test of differences in means assuming equal variance is -1.07 and the *t* value assuming unequal variances is -1.01 . This same result follows from a probit model of the probability of a university being associated with a PoCC. Also held constant in the probit model was a binary variable for whether the university was public or private.

And fifth, in an exploratory manner, we considered the potential economic impact of PoCCs. For each single university related PoCC in Table 2, we calculated the number of university startups before and after the founding of the PoCC.¹¹ Table 3 shows that for the 9 PoCCs for which sufficient data were available, the number of new university startups increased in the years after the founding of the PoCC. Of course, no other factors related to changes in the number of university startups are held constant in this descriptive comparison.

Table 3. University startups before and after the establishment of the Proof of Concept Center

PoCC	University	Year founded	Number of startups before founding ^a	Number of startups after founding ^a
Deshpande Center	MIT	2002	119	125
Commercial Ventures and Intellectual Property Technology Development Fund	University of Massachusetts	2004	3	5
University of Colorado Proof of Concept Program	University of Colorado	2004	17	60
Boston University-Fraunhofer Alliance for Medical Devices, Instrumentation and Diagnostics	Boston University	2007	15	24
Biomedical Accelerator Fund	Harvard University	2007	25	43
Stevens Institute for Innovation	University of Southern California	2007	35	24
Vermont Experimental Program to Stimulate Competitive Research Innovation Fund Awards	University of Vermont	2007	11	14
Institute for Advancing Medical Innovation	University of Kansas	2008	4	8
Medical Devices Center	University of Minnesota	2008	11	21

^a The number of university start-ups before and after the founding of the PoCC was determined by counting the number startups from the date of the PoCC's founding to 2011, the latest available year of AUTM data, and then comparing that count to the number of startups for the same number of years prior to the date of the PoCC

Concluding remarks

The description of US PoCCs offered in this paper should be viewed as a possible starting point for future research on this subject. Putting aside the obvious caveats associated with assembling information on economic institutions from public sources, much more is to be learned about PoCCs. In particular, given the conceptual importance of PoCCs as an element of technology infrastructure that enhances university technology transfer, questions to be answered include, but are not limited to: (1) the motivation, from the university's perspective and from a faculty perspective, for establishing a PoCC, (2) sources of funding (e.g., state vs. private) used to establish the PoCC, and (3) the actual and expected impact that the PoCC has on the university (e.g., on its revenues and on its scholarly output) and on related regional economic development.

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¹¹ The underlying information came from the AUTM data.

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Appendix

Table 4. Summary of the literature on challenges in technology transfer potentially addressed by Proof of Concept Centers

Characteristics of the university entrepreneur	
Audretsch (2000)	University entrepreneurs tend to be older and more scientifically experienced
Druilhe and Garnsey (2004)	The type and intensity of resources academic entrepreneurs require for realizing a business opportunity vary considerably according to the type of activity undertaken and the amount of resources already possessed by the entrepreneur (e.g., prior knowledge, contacts, and experience)
Etzkowitz (2003)	Several persons may jointly undertake entrepreneurial roles in forming new firms and other organizations; some persons may not be willing or able to become entrepreneurs individually, but are able to do so collectively
Hayter (2011)	Academic entrepreneurs establish companies for various reasons including technology development, personal financial gain, public service, career enrichment, job creation, and skill enhancement; entrepreneurial motivations are also related to the influence of peers; spinoffs can act as a platform for consulting and access to government grants, especially SBIR awards
O’Gorman et al. (2008), Johansson et al. (2005), Clarysse and Moray	Successful spinoff entrepreneurs typically sever ties with the incubating institution; some scientists pursue academic entrepreneurship indirectly by leaving universities to work for corporations before they start their ventures

(2004), Samson and Gurdon (1993), Wright et al. (2011)	
Roberts (1991), Roberts and Peters (1981)	High-technology entrepreneurs have educational background in science or engineering, young, and have industry experience; high need for achievement
Kenney and Goe (2004)	The decision of a professor to engage in entrepreneurial activity and the process of doing so is influenced by the policies, formal institutional rules, and general ethos of support for faculty involvement in business activity promulgated by the university; and, by the reward incentives, normative expectations, and ethos of support by a professor's department, and network of colleagues in the discipline
Commercial experience	
Murray (2004)	Faculty attitudes are shaped by career in academic sciences that typically does not include industry experience
Nicolaou and Birley (2003), Franklin et al. (2001), Radosevich (1995)	When faculty spinoff a company they typically lack the business acumen needed for successful spinoff and instead focus on scientific aspects of the enterprise
O'Gorman et al. (2008), Audretsch et al. (2005), Grandi and Grimaldi (2005)	Previous experience working within industry, including co-publication, co-patenting, and serving on company scientific advisory boards may be prerequisite for commercialization success as an entrepreneur
O'Gorman et al. (2008), Dietz and Bozeman (2005), Gulbrandsen and Smeby (2005), Roberts (1991)	University scientists with industry experiences have a higher propensity to patent, license, consult, and establish a company
Vohora et al. (2004), Nerkar and Shane (2003)	Experience working with industry improves an entrepreneur's ability to recognize "entrepreneurial opportunities"
Highly productive faculty	
Agrawal and Henderson (2002)	Faculty involvement improves the performance of technology licenses
Di Gregorio and Shane (2003), Louis et al. (2001), Zucker et al. (1998)	Higher intellectual capital "rates" (or "intellectual eminence") within specific universities lead to greater numbers of university spinoffs
Meyer (2006)	Nano-scientists who patent appear to outperform non-inventing peers in terms of publication counts and citation frequency
Shane (2004), Jensen and Thursby (2001), Franklin et al. (2001), Thursby et al. (2001)	Faculty involvement is critical to the continuing development of university technology, including its scientific basis and application
Thursby and Kemp (2002)	Researchers in biotechnology tend to have a culture that is more encouraging of commercial activity than is the case in the physical sciences
Zucker et al. (2002), Zucker and Darby (2001)	"Star" scientists enhance the performance of US biotech firms in terms of patents granted, number of products in development, and the number of products on the market
Social networks external to the university	
Bercovitz and Feldman (2006)	Social interaction, local networks, and personal communication are important for knowledge transmission
Grandi and Grimaldi (2003)	Faculty relations with the non-academic, professional world help mediate how well technology is transferred to a spinoff
Grimpe and Fier (2010)	Informal contacts improve the quality of formal relationships; formal contracts are accompanied by an informal relation of mutual exchange on technology-related aspects
Link et al. (2007), Powell (1990), Liebeskind et al. (1996)	Social networks, which can include academic and industry scientists, university administrators, TTO directors, and managers/entrepreneurs, appear to play an important role in university-industry technology transfer processes
Martinelli et al. (2008), Landry et al. (2002)	Informal networks often facilitate more formal relationships that facilitate spinoff (and licensing arrangements with established firms)

O’Gorman et al. (2008)	Networks helped academic entrepreneurs understand the opportunities for applying and commercializing their expertise in retrieval software—and help the entrepreneur develop a business plan, raise early-stage finance, and develop links with potential customers
Rappert et al. (1999)	Informal networks are important to the commercialization success of a spinoff
Rothaermel et al. (2007), Johansson et al. (2005), Murray (2004)	The quality depth, and diversity of a faculty member’s non-academic, professional network is important to the success of their spinoff
<i>University factors: academic culture</i>	
Bercovitz and Feldman (unpublished)	Faculty members have difficulty combining commercial and academic goals
Etzkowitz (2003), Jacob et al. (2003), Clark (1998), O’Shea et al. (2004)	Universities must transform their mission and culture to encourage technology transfer and entrepreneurship if they are to promote better commercial outcomes
Friedman and Silberman (2003)	A mission focused on licensing and royalty income is indicative of leadership and university culture; an entrepreneurial climate is conducive to a university generating more licenses
Kenney and Goe (2004)	Faculty are more likely to engage in entrepreneurial activity when socially embedded in departments and a larger university community that are supportive of entrepreneurship
Samson and Gurdon (1993)	Academic culture is a key inhibitor to spinoff formation and success
Shane (2004), Bauer (2001), Feldman and Desrochers (2004), Hsu and Bernstein (1997), Roberts (1991)	Entrepreneurial culture, social norms, and role models are critical to the formation of university spinoffs
Slaughter and Rhoades (2004), Franklin et al. (2001), Chiesa and Piccaluga (2000), Samson and Gurdon (1993), Lee (1996), Siegel et al. (2003)	“Traditional” norms, attitudes, and institutional rules of academia often clash with a more recent focus on commercialization outcomes
Owen-Smith and Powell (2001)	A key to successful tech transfer is creating an entrepreneurial culture among faculty and an institutional environment supportive of commercial and basic science activities
<i>University policy</i>	
Bekkers et al. (2006), Kenney and Goe (2004), Shane (2004), Tornatzky et al. (1995)	Leave of absence and other personnel policies help faculty become involved in commercialization activities including spinoff
Di Gregorio and Shane (2003)	The policies of making equity investments in technology licensing office start-ups and maintaining a low inventor share of royalties increase new firm formation activity
Friedman and Silberman (2003)	Policies to attract technology industries and private sector research will have spillover benefits and generate feedback effects through increasing university technology transfer
Golub (2003)	Spinoff activity increased at New York University when restrictions were removed on the use of facilities by spinoff companies
Lockett and Wright (2005)	University policies to pursue growth in the size of TTOs without also focusing on the faculty capabilities base may not be conducive to meeting revenue objectives for technology transfer activities
Markman et al. (2004), Colyvas et al. (2002)	Financial incentives play little or no role in motivating faculty to commercialize their research compared to traditional academic awards and the prospect of additional federal R&D grants
O’Gorman et al. (2008), Siegel et al. (2003)	Faculty reward systems influence technology transfer; faculty members take traditional academic awards into account when considering the payoff of commercialization activity

Renault (2006), Shane (2004), Matkin (1990)	Conflict of interest rules have a “chilling” effect on the formation of university spinoffs
Siegel et al. (2003)	Public universities may have less flexible university-industry technology transfer policies than private universities regarding startup companies and interactions with private firms
University IP policy	
Clarysse et al. (2007), Steffensen et al. (2000)	Aggressive university patenting and conflicts over intellectual property rights are one of the biggest barriers to the dissemination and commercialization of new knowledge
Conceicao et al. (1998)	Successful technology transfer initiatives should consider the integration of technology policies as part of an overall policy portfolio for economic and social development
Di Gregorio and Shane (2003), Jensen et al. (2003), Shane (2004)	Making equity investments in lieu of charging patent and licensing costs is important to spinoff success; the inventor’s share of royalties also matters
Roberts and Malone (1996)	Nonexclusive licenses favor the open dissemination of new knowledge from universities
Shane (2004)	Exclusive licenses encourage spinoffs especially in the biosciences
Siegel et al. (2003)	IP policies and organizational practices can enhance or impede technology transfer effectiveness
University TTO characteristics	
Audretsch et al. (2005)	Scientists who lack entrepreneurship networks typically seek guidance from the TTO; the TTO typically recommends licensing the technology. Conversely, scientists not assisted by their TTO are more likely to choose entrepreneurship as their mode of commercialization
Bercovitz et al. (2001)	The structure of the TTO provides a set of independent variables (information processing capacity, coordination capabilities, and incentive alignment properties) that may be used to explain technology transfer outcomes across universities
Chapple et al. (2005)	Invention disclosure, total research income, number of TTO employees, and protection of licensee affect TTO’s licensing performance
Shane (2004), Bauer (2001)	The perception of the TTO as a regulator or enabler matters to the success of university spinoffs
Jensen et al. (2003)	University TTOs act as an agent for both the administration and the faculty
Lockett and Wright (2005)	Expenditure of IP protection, business development capabilities, and the royalty regime of the university impact spinoff success
Markman et al. (2004)	The experience of TTO staff is negatively related to university entrepreneurial activity
Siegel et al. (2003)	A lack of requisite business skills and expertise could have a significant deleterious effect on TTO productivity; some TTOs may be too narrowly focused on a small set of technical areas, or too concerned with the legal aspects of licensing
Thursby et al. (2001)	The payment of choice for TTOs is running royalties, followed by patent fee reimbursement, up-front fees, annual fees, and minimum royalty fees
Business development factors: development funding	
Aldrich (1999), Aldrich and Fiol (1994)	Less than one percent of all start-ups founded in the US raise more than \$1 million in financing
Clark (1998)	A common element among successful entrepreneurial institutions is a diversified funding base such as industry and private benefactors, though much of university funding is still derived from government sources
Gulbrandsen and Smeby (2005)	There is a significant relationship between industry funding and research performance; faculty with industry funding conduct more applied research,

	collaborate more with external researchers both in academia and in industry, and report more scientific publications and entrepreneurial results
Heirman and Clarysse (2004), Shane and Stuart (2002), Hellmann and Puri (2002)	Initial and operational resources differentiate firms and help predict their success
Powers and McDougall (2005)	R&D investment by industry appears to be a key element in successful technology transfer; the positive impact of venture capital funding in the university's immediate geographical vicinity supports anecdotal beliefs about perceived disadvantages to universities in venture capital poor states
Roberts (1991, 2009)	Venture capital, angel capital, bank loans, and friends and family are all important sources of financing among spinoffs in the Boston area
Wright et al. (2004)	Spinouts typically lack the financial means and managerial expertise to exploit the commercial potential of their technologies; joint venture spinouts may provide a faster, more flexible, less risky and less costly business venturing route to commercializing university IP in comparison to venture backed university start-ups
<i>Founding team and surrogates</i>	
Franklin et al. (2001), Radosevich (1995)	"Surrogate" entrepreneurs and managers are critical to the success of spinoffs; they bring commercial experience, social networks, and a motivation for financial gain
Grandi and Grimaldi (2005)	The founding teams' intention to set up relations with external agents and their frequency of interaction with external agents are two features that are likely to lead to the success of academic spin-off companies
Nicolaou and Birley (2003)	The identification and attraction of a befitting surrogate entrepreneur increases the propensity for a technology spinout
Rothaermel et al. (2007), Moray and Clarysse (2005), O'Shea et al. (2005), Shane and Stuart (2002), Roberts (1991)	Composition of the founding team, their collective industry experience, management capability, and knowledge are critical factors to spinoff success. Unfortunately, most university spinoff teams lack these characteristics
Shane (2004)	Managerial experience among academic entrepreneurs increases their chances for obtaining development financing
<i>Linkages with the "home" institution</i>	
Debackere and Veugelers (2005), Link et al. (2007), Owen-Smith and Powell (2001)	University incentive schemes may need to be altered to encourage researchers' cooperation and involvement throughout the commercialization process
Druilhe and Garnsey (2004)	Informal relationships with industry are often precursors to formal spinouts that do not involve the university
Johansson et al. (2005), Rappert et al. (1999)	Academic entrepreneurs maintain strong ties to universities with high degrees of trust; spinoffs benefit through access to university expertise, the use of equipment and instruments, and by keeping abreast of university research
Klepper and Sleeper (2005), Cooper (1973, 1984)	Spin-offs usually inherit general technical and market-related knowledge from their parent organization (company, university, etc.)
Nicolaou and Birley (2003)	"Exoinstitutional research networks" encourage scientist involvement in direct or orthodox spinout formations that do not involve the university
Samson and Gurdon (1993), Doutriaux (1987)	Spinoff success may depend on completely "breaking away" from university culture, norms and regulations
Thursby et al. (2001)	The university, and sometimes the inventing scientist, might continue to be involved with the organization or entrepreneur to help develop the technology or to maintain the licensing agreement
Zahra et al. (2007)	Academic spinoffs differ from company-based spinoffs given that their technology is initially incubated in a non-profit educational institution: the university
<i>Characteristics of the technology and related industry</i>	

Bekkers et al. (2006)	Spinoff success factors differ greatly among biotech and IT-related industries
Gulbrandsen and Smeby (2005), Shane (2004), Golub (2003), Lowe (2002), Thursby et al. (2001), Jensen and Thursby (2001), Geuna and Nesta (2006)	Spinoffs are concentrated in high-technology areas such as biotechnology, computer software, medical devices, and pharmaceuticals. Spinoff success is likely impacted by various characteristics of these industries
Litan et al. (2007), Thursby et al. (2001), Jensen and Thursby (2001), Shane (2004), Lerner (2005), Siegel (2011), Goldhor and Lund (1983)	Potential to generate royalties and other financial returns influences which technologies TTOs choose to develop
Nerkar and Shane (2003)	The “radicalness” of a technology combined with broad patent scope helps reduce new firm failure
Perez and Sanchez (2003), Nerkar and Shane (2003), Utterback (1994)	Spinoff success is dependent on technological advance; the characteristics of technology inventions affect the likelihood that firms commercialize inventions
Siegel et al. (2004)	The TTO must understand the field and evaluate where its technology is moving in order to decide whether or not to file a patent should on the discovery
Thursby and Thursby (2003), Thursby et al. (2001), Jensen and Thursby (2001), Colyvas et al. (2002), Mitchell (1991)	University inventions are very early-stage technologies and have a very high failure rate
Regional factors	
Audretsch and Feldman (1996), Jaffe et al. (1993), Jaffe (1989)	Knowledge tends to spillover within geographically-bounded regions and this promotes clustering among firms in similar industries
Audretsch and Lehmann (2005)	Spillovers from universities may affect firm growth; the closer that firms are located to a university and the higher the number of academic papers published at the university, the higher the growth rates for these firms
Bekkers et al. (2006), Almeida and Kogut (1999)	Company success is correlated with its proximity to industry clusters due to the mobility of labor within
Cohen and Levinthal (1990)	The capability of a region to “absorb” knowledge spillovers is dependent on the scientific and innovation capacity of the industries in the region
Di Gregorio and Shane (2003)	The availability of VC in the region where the university is located and the level of sponsored research does not have a significant impact on the number of spinoffs from that university
Friedman and Silberman (2003)	Entrepreneurial climate has a positive and statistical significant impact on all outputs from university technology transfer; policies to attract technology industries and private sector research will have spillover benefits and generate feedback effects through increasing university technology transfer
O’Shea et al. (2004)	Local and regional economies with a sophisticated technology infrastructure and populated by startups are better positioned to attract knowledge-seeking investment from multinational corporations
Powers and McDougall (2005), Degroof and Roberts (2004)	Universities in regions with strong entrepreneurial support require little provision of support from the university and vice versa
Rogers et al. (2001)	Emphasizing spinoffs as a technology transfer strategy can lead to an agglomeration of high-tech firms around the university, eventually resulting in a technopolis or technology-based cluster
Saxenian (1994), Piore and Sabel (1984)	Industrial networks aid in the transmission and absorption of knowledge
Public policy	
Audretsch et al. (2005)	Incubators improve the flow of knowledge spillovers to university spinoffs

Blair and Hitchens (1998)	Access to infrastructure, such as entrepreneurship services, financial and technical resources, and incubators is important to university spinoff success
Dietz and Bozeman (2005), Dietz (2000)	<i>How</i> university research is supported, especially by the federal government, may have a profound impact on the propensity of academic entrepreneurs to spinoff and the subsequent success of these spinoffs
Gulbranson and Audretsch (2008)	Proof of Concept Centers such as the University of California at San Diego's Von Liebig Center and MIT's Deshpande Center offer intensive services designed to provide resources, technical assistance, and guidance for faculty members (and students) interested in technology commercialization; they may be critical to spinoff success
Link and Scott (2005)	University spinoffs constitute a larger proportion of firms in parks that are geographically closer to their university as well as parks that have a biotechnology focus
Shane (2004), Lowe (2002)	Spinoffs from the most prestigious institutions like MIT and Berkeley, respectively, often need to obtain public sector capital before they can obtain private capital
Siegel et al. (2003)	Firms located within science parks have slightly higher research productivity than off-park firms
Westhead and Storey (1994, 1997)	Firms located in science parks (though not specifically university spinoffs) those with relationships with universities have a higher survival rate than those firms without such a relationship