J Technol Transf (2014) 39:780–792
DOI 10.1007/s10961-014-9336-0

Parting the ivory curtain: understanding how universities support a diverse set of startups

Sonali K. Shah · Emily Cox Pahnke

Published online: 22 May 2014

Abstract Universities are widely recognized as a critical source of technological innovation and are heralded for the entrepreneurial ventures cultivated within their walls. To date, most research has focused on academic entrepreneurship—new ventures that spin out of academic laboratories. However, universities also give rise to startups that do not directly exploit knowledge generated within academic laboratories. Such firms—and the societal and economic benefits they create—are an important contribution of modern universities. We propose a framework for understanding the full scope of university entrepreneurship and its driving factors, with the goal of providing scholars, university administrators, and policymakers with insights regarding the resources required to foster entrepreneurship from within the ivory tower.

Keywords University-industry technology transfer · Entrepreneurship · Knowledge · Innovation

JEL Classification O31 · O32

1 Introduction

Universities provide a munificent environment for innovative ideas, human capital, and entrepreneurial drive to develop, comingle, and even result in the creation of new ventures. The fact that university research serves as the basis for startups is widely recognized: technologies that originate in academic laboratories are often licensed to startups that provide a vehicle for further developing and commercializing the technology (Shane 2004). However, there is a need to more broadly consider the factors that make universities "creative forces in the economy" (Nelson 2012; Feldman and Kogler 2008, p. 446). There are many startups that

S. K. Shah (✉) · E. C. Pahnke
University of Washington, Box 353200, Seattle, WA 98195, USA
e-mail: skshah@u.washington.edu

owe their origins to knowledge gained within university environments, but that do not coalesce around technologies developed within academic laboratories. The cultivation, prevalence, and pathways traversed by these startups has been less well understood and studied.

Consider two examples of successful startups with ties to Stanford University: Google and Instagram. Only Google would be captured by traditional definitions of academic entrepreneurship that center on the commercialization of technology developed within an academic lab. In contrast, Instagram's success is also tied the university, but is rooted in a different set of resources; Instagram benefited greatly from Stanford's entrepreneurship education initiatives. In both examples technological and entrepreneurial knowledge play a vital role in fostering entrepreneurship related to the university (Nelson and Byers 2005). Better understanding the role that universities can play in providing these resources can bring us one step closer to more effectively supporting university startups—and allow universities to adopt distinct approaches to stimulating entrepreneurship, approaches that make the best use of each university's unique and limited resources.

Building on the insight that startups draw upon a variety of university resources, we offer a framework for categorizing the startups that emerge from universities. We describe two key dimensions of university entrepreneurship: innovative knowledge and entrepreneurial knowledge. Innovative knowledge provides an understanding of a particular technology that serves as the basis of a commercial opportunity. Entrepreneurial knowledge provides an understanding of the entrepreneurial process, and networks from which to draw resources and expertise. We use these two dimensions to construct a framework that identifies four specific types of university entrepreneurship, based on the university-provided resources on which they draw. Our goal is to provide university administrators and policymakers seeking to promote entrepreneurship with a structure for understanding the resources that universities can provide to support entrepreneurship.

Our framework also serves as a useful tool for identifying gaps in our understanding of university entrepreneurship. Research on academic entrepreneurship, as traditionally defined, has provided deep insights into entrepreneurial patterns and outcomes involving star scientists and their graduate students; insight that, in turn, allow universities to create programs and systems designed to support such entrepreneurs (Oettl 2012; Zucker et al. 2002). Recognition of the other categories of university startups is the first step in better understanding how to design programs aimed at promoting them. We highlight three additional types of university-related entrepreneurship. Detailed data on these is sparse,; we provide suggestions on how data collection efforts might be structured. Overall, better understanding the genesis, needs, and contributions of each type of startup would provide the data necessary to allow universities to make investments towards supporting entrepreneurship, in light of a particular university's unique resources.

We illustrate our framework with examples from Stanford University. Many well-known ventures have been founded by Stanford faculty, students, and alumni, earning Stanford the nickname "Startup U". Stanford's long history of fostering innovation and entrepreneurship provides a basis for analyzing the resources underlying university-related entrepreneurship. Moreover, Stanford's contributions to startups, research endeavors, and entrepreneurship education programs are well documented, providing data and examples from which to draw.

2 A framework for university entrepreneurship

Knowledge is a critical resource in the development of new startups and is a pivotal factor that gives rise to and shapes innovative new ventures. The focus on the importance of

knowledge in spawning entrepreneurship dates back to Schumpeter (1934) and Hayek (1945), who suggested that information asymmetries explain why some individuals identify and exploit entrepreneurial opportunities before others (Kirzner 1997). Traversing particular knowledge corridors allows some individuals to innovate and/or assemble the resources required to transform an innovative idea into a viable commercial product or service (Venkataraman 1997). Moreover, knowledge shapes a firm's ability to learn, adapt, and therefore succeed over time: existing knowledge stocks facilitate the accumulation and integration of new knowledge, allow a firm to comprehend and apply new information in ways that firms lacking that knowledge cannot, and shape a firm's ability to successfully adapt to new situations (Weick 1996; Huber 1991; Nelson and Winter 1982; Dencker et al. 2009).

We build on these insights to show how universities can foster knowledge on two distinct dimensions to stimulate the formation of new startups: innovative knowledge and entrepreneurial knowledge. The majority of research on university entrepreneurship has focused on startups founded by faculty and students around technological knowledge developed within academic laboratories (Dechenaux et al. 2008; Jensen and Thursby 2001; Katila and Shane 2005). However, universities can also provide students with knowledge, skills, and networks through entrepreneurship education. We describe the involvement of universities in the development of innovative knowledge and in providing entrepreneurship education.

2.1 Innovative knowledge: cutting edge research provides entrepreneurial opportunities

Technological knowledge development and diffusion are at the heart of the modern-American university. Since the publication of Vannevar Bush's "Science the Endless Frontier" (1945), billions of dollars have been invested in the research activities of universities, and have resulted in the advent, growth, and diffusion of myriad technologies. The development of new technologies occurs across academic departments, from music to medicine to computer science (Nelson 2005). The innovative knowledge developed as part of academic research programs is an important resource for supporting entrepreneurship. There are at least two factors underlying this relationship: tacit and early knowledge of a technology and ownership of intellectual property. Most technologies, particularly those in the early stages of development, require considerable tacit knowledge to develop, understand, and use (Zucker et al. 1998). Hence, the individuals involved in a technology's development are often the ones with the tacit knowledge necessary to further develop the technology to bring it to commercial fruition. Numerous studies have documented the critical role played by faculty members and their lab members in developing and commercializing a technology even after the technology has left the university (Stuart and Ding 2006; Bercovitz and Feldman 2006; Feldman et al. 2002; Zucker et al. 2002).

Much of the knowledge developed as part of academic research programs falls under university ownership. As a result of the Bayh-Dole Act of 1980, universities were permitted to patent technologies whose development was funded by federal grants and contracts.[1] The technologies can then be licensed for specific commercial purposes, such that

[1] While Bayh-Dole and other legislation were enacted to facilitate the commercialization of university-developed technology, the commercialization of university technologies is ages old: "What was new in the 1980s was not the invention of commercial possibilities, but the discovery of commercializing activities that were already ongoing" (Mody 2011).

the same technology may be licensed to several start-ups pursuing different markets (Shane 2000; Mowery et al. 2004). The ability to license technology for a specific purpose provides the licensee with an advantage over other competitors in the form of intellectual property protection (Teece 1986).

2.2 Entrepreneurial knowledge and entrepreneurship education

Entrepreneurial knowledge is a critical resource for fledgling entrepreneurs, as it provides an understanding of the entrepreneurial process as well as networks from which to draw resources and expertise. Universities can play a role in providing this knowledge through entrepreneurship education. In the United States, formal university-provided entrepreneurship education traces its roots to courses offered by the Harvard Business School in the late 1940s (Katz 2003). Today, it is estimated that over 1500 US universities offer entrepreneurship education (Charney and Libecap 2000). Academic research in the social sciences has generated a body of validated and explicit knowledge pertaining to various elements of entrepreneurship. Many programs are centered on core courses that provide knowledge applicable to a wide variety of startups (e.g., topics such as intellectual property rights, venture financing, and managing growth) and are augmented with courses focused on specialized topics and particular industry segments (e.g., medical devices, cell phone applications, green technologies). Entrepreneurship curricula tend to be housed within either business schools or engineering schools, and serve students from across the university (Charney and Libecap 2000; Vesper and Gartner 1997). For example, many of Stanford's entrepreneurship courses are housed within the School of Engineering and students from engineering, business, medicine, and other fields are encouraged to engage in coursework and other offerings.

Entrepreneurship education serves a dual role: it establishes entrepreneurship as a viable career option, and exposes students to explicit and tacit knowledge and networks that might increase their chances of success if they do found a firm. Universities support a variety of programs to promote entrepreneurship and provide students and faculty with entrepreneurship-related experiences and skills including coursework, student associations, internships, exposure to high-profile entrepreneurs, and business plan competitions. Emerging evidence suggests that this diversity in programs is beneficial, as it allows students and faculty to develop knowledge in different ways and with varying levels of time commitment, thereby allowing for low risk exploration and the ability to access knowledge tailored to one's specific needs and interests (Vesper and McMullan 1988; Nelson and Byers 2013).

The ever-changing technological and business landscapes also create a need to provide students with the latest knowledge. Access to entrepreneurs through speaker series and immersive experiences in startups (internships), provide a way for universities to bring up-to-the minute—and often tacit—knowledge within students' reach. Yet another way that universities provide exposure and experience to entrepreneurship is through business plan competitions where students submit a business plan that is judged by a panel of entrepreneurs and investors. Although the cash prizes are often notable, business plan competitions also provide a low risk opportunity for students to solicit feedback, refine their ideas, and connect to broader entrepreneurial networks.

University programs may also have an unanticipated, but highly beneficial effect: they may prevent poor ideas from launching. While the university provides a knowledge-rich environment and affords students the time to experiment with ideas, not all new ideas are good ones. Discussion, competitions, and mentorships can all come together to weed out

poor ideas, alter other insights into viable business ideas, and further develop and refine other ideas.

3 Painting a complete picture of university entrepreneurship

Building on the two dimensions highlighted above, we introduce a framework for categorizing university entrepreneurship. One dimension of the framework captures whether or not the startup draws on knowledge from the university through access to technologies developed within university laboratories; the other captures whether or not the startups draws entrepreneurial knowledge from the university through participation in entrepreneurship education programs (Table 1). The framework identifies four types of startups that can be linked to universities, based on the knowledge they draw from the university: Type 1 Spinouts, Type 2 Spinouts, Offshoots, and Seeds. We describe what is known about each type of startup below and provide an illustrative example for each based on the early histories of startups related to Stanford University.

3.1 Spinouts

The top two quadrants of the framework describe new firms that commercialize technologies developed by faculty, staff or students as part of academic research programs. Firms such as these are often referred to as "spinouts" or "academic spinoffs" and have been the focus of many previous studies. Academic entrepreneurship has been defined as the founding of firms by faculty, staff, and students who innovate in the context of universities (Audretsch and Feldman 1996; Lockett et al. 2005; Zucker et al. 1998; Feldman et al. 2005; Mowery 2005). Technically, our framework is inclusive of, but not limited to, academic entrepreneurship in that we include startups that are founded by scientists employees of the university, as well as startups founded around university technology by individuals who are not part of the university. Practically speaking, however, many academic technologies require the tacit knowledge and expertise of a lab member to be developed further (Stuart and Ding 2006; Bercovitz and Feldman 2006; Feldman et al. 2002).

Technologies are developed in a variety of ways within universities, and this is reflected in the histories of the startups that emerge from universities. Some startups are founded to commercialize technologies developed as part of an academic lab group's primary mission. For example, Professor Karl Deisseroth founded Circuit Therapeutics to commercialize his research on optogenetics (Stanford Office of Technology Licensing 2011). Other firms are founded around tools developed within academic settings; that is to say, user entrepreneurship occurs in academic settings (Shah and Tripsas 2007). For example, several

Table 1 Framework for university entrepreneurship

	Source of entrepreneurial knowledge	
	University provided entrepreneurial education	Other
Source of Innovative knowledge		
Academic research	Spinouts-Type 1 (e.g., Google)	Spinouts-Type 2 (e.g., VMware)
Other	Offshoots (e.g., Instagram)	Seeds (e.g., Netflix)

graduate students involved in building and designing microscopes that were used as tools to investigate other phenomena founded the first probe microscopy firms (Shah and Mody 2013). Similarly, a number of medical devices are created and commercialized by physicians engaged in developing devices to improve patient outcomes (Winston Smith and Shah 2013; Cox and Shah 2013; Lettl et al. 2006). Other firms are founded as part of translational research initiatives (translational research seeks to find practical applications for basic science in order to enhance human health and well-being).

We distinguish between two types of spinouts, based on whether or not they draw on entrepreneurship education provided by the university. The first type of spinout (Type 1) garners both technological and entrepreneurial knowledge through the university. Google is an example of a spinout that benefitted from both academic research and a deep array of entrepreneurial resources at Stanford In 1996, Ph.D. candidates Sergey Brin and Larry Page began a research project developing an improved method for ranking websites. Drawing on their research, and originally called PageRank, the Google search engine was initially hosted by Stanford servers and included "stanford.edu" as part of its URL (Brezina 2012). The patent underlying the PageRank mechanism is assigned to Stanford University with Lawrence Page listed as the inventor. Brin and Page originally worked with Stanford's Office of Technology Licensing to try to find an existing search engine company to license PageRank. However, when they were unable to make a deal at a price they liked, they began to explore the option of creating their own company. One of their Stanford professors introduced them to their first investor (the founder of Sun Microsystems) (Battelle 2006; Mac 2012; Brezina 2012). Thus, Google drew both innovative knowledge (from the academic lab that Brin and Page were part of) and entrepreneurial knowledge (funding, encouragement and experience from their professors) from Stanford University.

Spinouts (Type 2) form when technological knowledge comes from the university, but entrepreneurial know-how does not. These firms may or may not be founded by individuals associated with the university. VMware is an example of a firm based on technology from a university, but which did not draw on entrepreneurship resources related to the university. While working on a supercomputer project at Stanford, Professor Mendel Rosenblume and two of his PhD students (Edouard Bugnion and Scott Devine) developed a virtualization software that allowed a single server to effectively do the work of many servers (Hawn 2008). In 1998 Rosenblume (only a few years out of school himself) went on leave and along with the two graduate students, his wife, and another a friend cofounded VMware, which was a pioneer in virtualization software (Marshall 2010). In this case, the technology underlying VMware was directly connected to experience in a research lab. However, none of the founders participated in entrepreneurship courses, competitions, or training at Stanford. Thus, although much of the technological know-how behind VMware came from Stanford, little entrepreneurial knowledge did.

3.2 Offshoots

The bottom left quadrant represents entrepreneurship where the academic research is not the source of innovative knowledge, but where the university does provides critical entrepreneurial knowledge. We term this kind of entrepreneurship "offshoots." A recent high-profile example of a Stanford offshoot is Instagram, created in 2010 by Kevin Systrom and Mike Krieger and sold eighteen months later to Facebook for $1 Billion. Although Instagram was created after Systrom and Krieger finished their undergraduate degrees and did not stem from any Stanford research, the university played a vital role in

its creation and success. Both founders were Mayfield Fellows—a program for undergraduate students who take a series of courses on entrepreneurship, attend a weekly Entrepreneurial Though Leaders lecture series, are placed at an internship with a startup, and are provided with introductions to the Silicon Valley startup community (Sengupta et al. 2012). As a Mayfield Fellow, Systrom was placed at an internship with Odeo, which eventually became Twitter; Jack Dorsey, Twitter's founder, was one of Instagram's earliest investors (Bertoni 2012). Additionally, key advisors and investors to the company were met through various Stanford connections. Thus, although the university was not the source of technological ideas for Instagram, the entrepreneurship education, resources and connections it provided were pivotal to the company's success.

3.3 Seeds

The bottom right quadrant describes firms which neither commercialized ideas generated by academic research nor benefited from formal entrepreneurship education provided by a university. We refer to this category of university entrepreneurship as "seeds." This is perhaps the most inclusive category of university-founded startups as it comprises firms that have *not* benefited directly from innovative or entrepreneurial knowledge provided by the university. Nonetheless, these startups are strongly affiliated with the university, and are likely to have benefitted indirectly from the knowledge (e.g., problem-solving skills, domain-specific knowledge, etc.) and networks (contacts, friendships, etc.) that their founders were exposed to as they pursued their education. Because the innovative and entrepreneurial knowledge around which these startups are formed are garnered from non-university sources, a number of seeds may be formed after alumni have been away from the university for a number of years, and mirror the general trend identified by researchers that most successful entrepreneurs are middle-aged when they found their first venture (Wadhwa et al. 2010).

Netflix is an example of this type of entrepreneurship. Although the founder of Netflix Reed Hastings received a M.S. in computer science from Stanford, Netflix is not based on technologies that stem from his time there, nor did he gain explicit entrepreneurship education there. Rather, Hastings has said that his Stanford experience exposed him to the possibility of technology entrepreneurship and gave him a "license to dream" (Hamilton 2006). After leaving Stanford, Hastings worked for Adaptive Technology, founded Pure Software, and became involved with education reform in California (Copeland 2012). While Stanford introduced Reed Hastings to the world of technology development, and helped him to hone his programming skills, none of the knowledge or know-how that went into the creation of Netflix is directly traceable to Stanford. Rather, Stanford served as a seedbed where the skills gained enabled future entrepreneurship, and where the idea of entrepreneurship as a viable career option became firmly embedded.

4 The impact of university entrepreneurship: a need for additional research

Scholars have recently called for a "more comprehensive, more differentiated view of the university role [in economic development]… universities need a stronger awareness of the pathways along which local industries are developing and the innovation processes that are associated with those pathways (Lester 2005, p. 3)." Our framework is a first step towards understanding the different types of university entrepreneurship. Future research is required to fully understand them. Of the four types of university entrepreneurship

discussed here, systematic data exist only for spinouts. This focus on spinouts may have two causes: an interest in high technology entrepreneurship and the facilitation of data collection efforts due to the paper trail left by spinouts as they formally license technology from universities. Research on spinouts tends not to distinguish between Type 1 and 2 Spinouts.

Because most spinouts today license technology sourced from the university, they pay royalties to the university. As a result, most universities keep statistics on the number and identity of spinouts, and their financial effects on the university. For example, in 2010–2011 Stanford was given equity positions in eight startups, and received $66.8 million in royalty revenues from licensing technologies to *both* established and start-up firms (Stanford Office of Technology Licensing 2011). These royalties stem from a portfolio of 600 invention disclosures. The time period involved in reaping commercial dividends from university technologies is worth noting: "typically, 10–15 years may elapse between initial invention disclosure and any significant royalties (Stanford Office of Technology Licensing 2011)." Finally, it may be useful to put these numbers into perspective: total royalties represent only 1.6 % of Stanford's 2011 budget and 5.6 % of their sponsored research budget.

Systematic data on the other types of university entrepreneurship are rare, but data collection efforts have been initiated. Recently, a few scholars have attempted to assess the magnitude of university entrepreneurship through large-scale surveys. These studies focus on measuring the extent of entrepreneurship by alumni, and hence document firm founding by university graduates, but not faculty. For example, Chuck Eesley and his colleagues have surveyed tens of thousands of engineering alumni at Stanford, MIT, and Tsinghua University in order to better understand the process and extent of new venture creation (Roberts and Eesley 2009). These efforts indicate that many new ventures stem from ideas, connections, and education that occurred at the universities and hint at the magnitude of startup activity stemming from universities with strong technological and entrepreneurial infrastructures in place. Data from a 2011 survey find that Stanford Engineering alumni founded nearly 40,000 companies employing 5.4 million people and generating annual revenues of $2.7 trillion (Eesley and Miller 2012). In addition, Roberts and Eesley (2009) reported that in 2006 there were over 4,000 California-based firms founded by MIT alumni that collectively generated over $130 billion in sales. Moreover, their data suggest that firms founded by MIT alumni employed nearly one million people worldwide. Both studies only report data from survey respondents; hence the actual economic impact generated by these alumni through entrepreneurship is likely to be greater. To our knowledge, further data on the relative numbers, contributions, and valuations of spinouts, offshoots, and alumni-founded firms are not available.

Gathering systematic data on the full spectrum of university entrepreneurship would require significant data collection and analysis efforts. A four-pronged approach would be required. First, data pertaining to the entrepreneurial activities of a university's faculty, staff, and graduates during and *subsequent* to their time at the university would need to be collected. Second, data on the prevalence of each of the four types of entrepreneurship would be collected. Third, data pertaining to the university-provided knowledge and resources that inspired and supported each startup would be collected. Finally, data pertaining to a variety of outcomes generated by each type of startup would be collected in order to deepen our understanding of the contributions of each type of startup to economic development (e.g., job creation, survival), social change (e.g., environmental consciousness, domestic job creation, domestic manufacturing), and innovation (e.g., products and technologies developed and commercialized, position in the industry life cycle). In

addition, as multiple founders of a single firm may have stemmed from the same university, data collection and analysis would require that the resources reported by each founder be linked with the startups founded.

Finally, the importance of collecting both large-scale quantitative data and in-depth qualitative data on university entrepreneurship should not be overlooked. In this essay, our focus has been on identifying critical resources at a high-level, however many nuances need to be identified and considered. In depth-case study research—ideally followed by large sample tests of the causal explanations identified in qualitative work—is invaluable for this purpose.

5 Discussion: stimulating university entrepreneurship

Our framework for university entrepreneurship suggests the importance of understanding and cultivating diverse and resource-rich technological and entrepreneurial ecosystems within universities. Given the variety of firms emerging from universities, universities interested in promoting entrepreneurship should think carefully about the resources required to promote each type of entrepreneurship—and whether or not they have such resources in place or are willing to invest time and resources into building resources.

5.1 The development of innovative technologies

Understanding and cultivating the culture and resources required to generate innovative knowledge is a core component of the academic endeavor. It is often taken for granted that faculty across fields will develop novel ideas and technologies. Many institutions appear to place the burden of knowledge generation fully on faculty, and underestimate the effects that the culture, norms, and policies of institutions are likely to have on the ability of faculty members to engage in breakthrough research.

The pathways to entrepreneurship identified in this essay apply to research-intensive, as well as non-research intensive universities; creative university administrators and faculty might encourage potential entrepreneurs to draw upon university resources, as well as access knowledge from other sources. Non-research intensive universities might consider challenging students to build on the wealth of knowledge found in the external environment. For example, one class at Stanford challenged student groups to build Facebook applications. A number of apps were created, resulting in an aggregate of 16 million users and over $1million in ad revenue by the end of the 10-week quarter (Helft 2011). Moreover, many of the apps were acquired, or lead to the formation of successful student-founded startups. Such an approach also has the benefit of allowing educational processes to reflect reality: the knowledge landscape is rich and varied—spanning universities, established firms, startups, platforms, user communities and knowledge in the public domain (Chesbrough 2003)—and is becoming increasingly democratized through the efforts of users, makers, and other innovators.

5.2 Entrepreneurship education

Responsibility for promoting these activities tends to reside in different areas of the university: academic labs and departments, entrepreneurship education units, and technology commercialization offices. Developing a technology and launching a firm are difficult enough without having to coordinate across various elements of often highly-bureaucratic

university infrastructures. Programs and policies might seek to lessen the burden on founders as they search for information and approval.

Bio-X is an example of a university effort to bridge domains of knowledge across the university in order to increase collaboration between the business, medicine and engineering schools at Stanford. The program's aim is to bring together students and faculty from across domains to facilitate the creation of medical technologies. The program also focuses on giving students and faculty the tools to commercialize promising breakthroughs. This kind of interdisciplinary focus both brings together expertise to create technologies and provides entrepreneurial knowledge necessary to create startups to commercialize those technologies. Research underscores the benefits of such a strategy: universities that provide their scientists with entrepreneurial resources in the form of programs designed to support entrepreneurship (tech transfer offices, social networks and infrastructure), policies (licensing policies, leaves of absence to found firms, etc.), and culture (academic attitudes towards commercialization, entrepreneurial role models) are more likely to have higher rates of entrepreneurship (Bercovitz and Feldman 2008; Hsu and Bernstein 1997; Kenney and Patton 2011; Shane 2004; Stuart and Ding 2006; Lockett and Wright 2005).

Our framework suggests that entrepreneurship education should not be limited to spinouts, as is often the case, but should focus on developing skills that might be applied across a diversity of opportunities that arise within the university context. While potential blockbuster technology startups that create breakthrough products and large numbers of jobs should be promoted and supported, these rare creatures are already at the center of most university entrepreneurship education and technology commercialization efforts. Expanding the reach of programs to support and educate fledgling entrepreneurs across a variety of fields reflects the reality that most startups do not operate in high-tech industries (data from the Kauffman Firm Survey find that just 5.5 % of US startups founded in 2004 operate in high technology industries) and that startups are generated from across university departments—including music, social sciences, and humanities (Nelson and Byers 2013). Recognizing the variance amongst the types of startups founded within universities is a first step towards improving our pedagogical methods and entrepreneurship programs and resources.

5.3 Resources and the environment around the university

Our focus here has been on understanding the resources that a university might develop internally to facilitate the creation of entrepreneurial ventures. There is a third building block to consider: the surrounding environment (Saxenian 1996; O'Mara 2005). For example, several geographic factors have been found to be particularly conducive to entrepreneurship: rich human capital resources afford startups the ability to hire managers and employees, and attract board members and advisors (Wright et al. 2007; Powell et al. 1996; Saxenian 1996); an attractive physical and cultural environment can be helpful in drawing skilled individuals (Mellander et al. 2011; O'Mara 2005); a strong economy can provide regional employment alternatives if a startup fails (Saxenian 1996) while local policies effect the availability of human capital (Marx et al. 2009; Feldman et al. 2011). Resources available from the external environment are likely combine with university resources to encourage students and faculty to engage in entrepreneurial endeavors. For example, Stanford occupies a privileged geographic position: Silicon Valley affords nearly all the benefits described above and hosts a rich entrepreneurial ecosystem from which startups can draw resources and knowledge.

6 Conclusion

The economic impact of US universities on their alumni, surrounding communities, and society at large is immense. As more universities face hostile legislatures, providing a more accurate assessment of the full scope of university entrepreneurship is one way to create a compelling case for continued funding based on the university's benefits to society. Entrepreneurship—and the societal and economic benefits it creates through improved products and services and job creation—are just one of a university's contributions to society: the development of innovative knowledge, the dissemination of existing knowledge, the education of the young generation, and the molding of thoughtful citizens are and should continue to be the heart of the university.

Acknowledgments This manuscript has benefited from conversations with Rajshree Agarwal, Chuck Eesley and Cyrus Mody as well as from comments received from the editor, Andrew Nelson, and two anonymous reviewers.

References

Audretsch, D. B., & Feldman, M. P. (1996). R&D spillovers and the geography of innovation and production. *The American Economic Review, 86*(3), 630–640.

Battelle, J. (2006). The search: How Google and its rivals rewrote the rules of business and transformed our culture: Portfolio Trade.

Bercovitz, J., & Feldman, M. (2006). Entprepreneurial universities and technology transfer: A conceptual framework for understanding knowledge-based economic development. *The Journal of Technology Transfer, 31*(1), 175–188.

Bercovitz, J., & Feldman, M. (2008). Academic entrepreneurs: Organizational change at the individual level. *Organization Science, 19*(1), 69–89.

Bertoni, S. (2012). Instagram's Kevin Systrom: The Stanford billionaire machine strikes again. Fobes.Com (Vol. 2014).

Brezina, C. (2012). *Sergey Brin, Larry Page, Eric Schmidt, and Google (Internet Biographies)*. New York: Rosen Publishing Group.

Bush, V. (1945). *Science: The endless frontier*. US GPO: Washington D.C.

Charney, A., & Libecap, G. (2000). *Impact of entrepreneurship education*. Kansas City: Kauffman Center for Entrepreneurial Leadership.

Chesbrough, H. (2003). *Open Innovation: The new imperative for creating and profiting from technology*. Boston, MA: Harvard Business School Press.

Copeland, M. V. (2012). Reed hastings: Leader of the pack. Fortune.com (Vol. 2014).

Cox, E., & Shah, S. K. (2013). Whose startups innovate? The effects of entrepreneurial origins on innovation in the minimally invasive surgical device industry.

Dechenaux, E., Goldfarb, B., Shane, S., & Thursby, M. (2008). Appropriability and commercialization: evidence from MIT inventions. *Management Science, 54*(5), 893–906. doi:10.1287/mnsc.1070.0780.

Dencker, J., Gruber, M., & Shah, S. (2009). Knowledge acquisition activities, prior knowledge and the survival of new firms. *Organization Science, 20*(3), 516–537.

Eesley, C. E., & Miller, W. F. (2012). *Impact: Stanford University's economic impact via innovation and entrepreneurship*. Stanford: Stanford University.

Feldman, M., Feller, I., Bercovitz, J., & Burton, R. (2002). Equity and the technology transfer strategies of American research universities. *Management Science, 48*(1), 105–121.

Feldman, M., Francis, J., & Bercovitz, J. (2005). Creating a cluster while building a firm: Entrepreneurs and the formation of industrial clusters. *Regional Studies, 39*(1), 129–141.

Feldman, M. P., & Kogler, D. F. (2008). The contribution of public entities to innovation and technological change. In S. Shane (Ed.), *The handbook of technology and innovation management* (pp. 431–459). Hoboken: Wiley.

Feldman, M., Lanahan, L., & Miller, J. M. (2011). Inadvertent infrastructure and regional entrepreneurship policy. In M. Fritsch (Ed.), *Handbook of Research on Entrepreneurship and Regional Development* (pp. 216–251). Edward Elgar: Cheltenham.

Hamilton, J. O. C. (2006). Home movies. http://alumni.stanford.edu/get/page/magazine/article/?article_id=33351.
Hawn, C. (2008). The F|R Interview: VMware Co-Founder Mendel Rosenblum. http://gigaom.com/2008/06/28/the-fr-interview-vmware-co-founder-mendel-rosenblum/2014.
Hayek, F. A. (1945). The use of knowledge in society. *The American Economic Review, 35*(4), 519–530.
Hsu, D., & Bernstein, T. (1997). Managing the university technology licensing process: Findings from case studies. *Journal of the Association of University Technology Managers, 9*, 1–33.
Huber, G. P. (1991). Organizational learning: The contributing processes and the literatures. *Organization Science, 2*(1), 88–115.
Jensen, R., & Thursby, M. (2001). Proofs and prototypes for sale: The licensing of university inventions. *The American Economic Review, 91*(1), 240–259. doi:10.2307/2677907.
Katila, R., & Shane, S. (2005). When does lack of resources make new firms innovative? *Academy of Management Journal, 48*(5), 814–829.
Katz, J. A. (2003). The chronology and intellectual trajectory of American entrepreneurship education: 1876–1999. *Journal of Business Venturing, 18*(2), 283–300. doi:10.1016/S0883-9026(02)00098-8.
Kenney, M., & Patton, D. (2011). Does inventor ownership encourage university research-derived entrepreneurship? A six university comparison. *Research Policy, 40*(8), 1100–1112.
Kirzner, I. M. (1997). Entrepreneurial discovery and the competitive market process: An Austrian approach. *Journal of economic literature, 35*(1), 60–85.
Lester, R. K. (2005). Universities, innovation, and the competitiveness of local economies. A summary report from the local innovation systems project: Phase I. Massachusetts Institute of Technology, Industrial Performance Center, Working Paper Series.
Lettl, C., Herstatt, C., & Gemuenden, H. G. (2006). Users' contributions to radical innovation: Evidence from four cases in the field of medical equipment technology. *R&D Management, 36*(3), 251–272.
Lockett, A., Siegel, D., Wright, M., & Ensley, M. D. (2005). The creation of spin-off firms at public research institutions: Managerial and policy implications. *Research Policy, 34*(7), 981–993.
Lockett, A., & Wright, M. (2005). Resources, capabilities, risk capital and the creation of university spin-out companies. *Research Policy, 34*(7), 1043–1057.
Mac, R. (2012). Professor Billionaire: The Stanford academic who wrote Google its first check. Forbes.com (Vol. 2014): Forbes.
Marshall, D. (2010). Where are VMware's virtualisation Fab Five now? http://features.techworld.com/virtualisation/3232139/where-are-vmwares-virtualisation-fab-five-now/2014.
Marx, M., Strumsky, D., & Fleming, L. (2009). Mobility, skills, and the Michigan non-compete experiment. *Management Science, 55*(6), 875–889.
Mellander, C., Florida, R., & Stolarick, K. (2011). Here to stay: The effects of community satisfaction on the decision to stay. *Spatial Economic Analysis, 6*(1), 5–24.
Mody, C. C. M. (2011). *Instrumental community: Probe microscopy and the path to nanotechnology*. Cambridge, MA: MIT Press.
Mowery, D. C. (2005). The Bayh-Dole act and high-technology entrepreneurship in US Universities: Chicken, egg, or something else? *Advances in the Study of Entrepreneurship, Innovation & Economic Growth, 16*, 39–68.
Mowery, D. C., Nelson, R., Sampat, B., & Ziedonis, A. (Eds.). (2004). *Ivory tower and industrial innovation: university-industry technology transfer before and after the Bayh-Dole act in the United States*. Stanford, CA: Stanford University Press.
Nelson, A. J. (2005). Cacophony or harmony? Multivocal logics and technology licensing by the Stanford University Department of Music. *Industrial and Corporate Change, 14*(1), 93–118. doi:10.1093/icc/dth045.
Nelson, A. J. (2012). Putting university research in context: Assessing alternative measures of production and diffusion at Stanford. *Research Policy, 41*(4), 678–691. doi:10.1016/j.respol.2011.11.004.
Nelson, A., & Byers, T. (2005). Organizational modularity and intra-university relationships between entrepreneurship education and technology transfer. *Advances in the Study of Entrepreneurship, Innovation & Economic Growth, 16*, 275–311.
Nelson, A., & Byers, T. (2013). Challenges in University Technology transfer and the promising role of entrepreneurship education. University of Oregon Working Paper.
Nelson, R. R., & Winter, S. G. (1982). *An evolutionary theory of economic change*. Cambridge, MA: Harvard University Press.
O'Mara, M. P. (2005). *Cities of knowledge: Cold war science and the search for the next silicon valley*. Princeton: Princeton University Press.
Oettl, A. (2012). Reconceptualizing Stars: Scientist helpfulness and peer performance. *Management Science, 58*(6), 1122–1140. doi:10.1287/mnsc.1110.1470.

Powell, W. W., Koput, K. W., & Smith-Doerr, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly, 41*(1), 116–145.

Roberts, E. B., & Eesley, C. E. (2009). *Entrepreneurial impact: The role of MIT (Vol. Online Only)*. Kansas City: Kauffman Foundation.

Saxenian, A. (1996). *Regional advantage: Culture and competition in Silicon Valley and route 128*. Cambridge, MA: Harvard University Press.

Schumpeter, J. (1934). *The theory of economic development*. Cambridge, MA: Harvard University Press.

Sengupta, S., Perlroth, N., & Wortham, J. (2012, April 13) Behind instagram feat, networking the old way. *The New York Times*.

Shah, S., & Mody, C. C. M. (2013). Creating innovations, technologies and organization: Uncovering the true scope of users' innovation-related activities. Working paper. Seattle.

Shah, S. K., & Tripsas, M. (2007). The accidental entrepreneur: The emergent and collective process of user entrepreneurship. *Strategic Entrepreneurship Journal, 1*(1), 123–140.

Shane, S. (2000). Prior knowledge and the discovery of entrepreneurial opportunities. *Organization Science, 11*(4), 448–469.

Shane, S. A. (2004). *Academic entrepreneurship: University spinoffs and wealth creation*. Cheltenham: Edward Elgar Publishing.

Stanford Office of Technology Licensing. (2011). *Entreprenurture: The Stanford office of technology licensing annual report 2010/2011*. Stanford, CA: Stanford University.

Stuart, T. E., & Ding, W. W. (2006). When do scientists become entrepreneurs? The social structural antecedents of commercial activity in the academic life sciences1. *American Journal of Sociology, 112*(1), 97–144.

Teece, D. J. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy, 15*(6), 285–305.

Venkataraman, S. (1997). The distinctive domain of entrepreneurship research: An editor's perspective. In J. Katz & R. Brockhaus (Eds.), *Advances in entrepreneurship, firm emergence, and growth* (Vol. 9, pp. 119–138). Greenwich, CT: JAI Press.

Vesper, K. H., & Gartner, W. B. (1997). Measuring progress in entrepreneurship education. *Journal of Business Venturing, 12*(5), 403–421.

Vesper, K., & McMullan, W. (1988). Entrepreneurship: Today courses, tomorrow degrees? *Entrepreneurship Theory and Practice, 13*(1), 73.

Wadhwa, A., Phelps, C., & Kotha, S. (2010). Creating exploratory innovations by learning from entrepreneurial ventures. In D. B. Audretsch, G. B. Dagnino, R. Faraci, & R. E. Hoskisson (Eds.), *New frontiers in entrepreneurship. International Studies in Entrepreneurship* (Vol. 26, pp. 147-173). New York: Springer

Weick, K. (1996). drop your tools: An allegory for organization studies. *Administrative Science Quarterly, 41*, 301–314.

Winston Smith, S., & Shah, S. K. (2013). Do innovative users generate more useful insights? *An Analysis of CVC Investment in the Medical Device Industry Strategic Entrepreneurship Journal, 7*(2), 151–167.

Wright, M., Hmieleski, K. M., Siegel, D. S., & Ensley, M. D. (2007). The role of human capital in technological entrepreneurship. *Entrepreneurship Theory and Practice, 31*(6), 791–806.

Zucker, L. G., Darby, M. R., & Armstrong, J. S. (2002). Commercializing knowledge: University science, knowledge capture, and firm performance in biotechnology. *Management Science, 48*(1), 138–153.

Zucker, L. G., Darby, M. R., & Brewer, M. B. (1998). Intellectual human capital and the birth of U.S. biotechnology enterprises. *American Economic Review, 88*(1), 290–306.