

University technology transfer through entrepreneurship: faculty and students in spinoffs

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Abstract This research informs our understanding of the technology commercialization process in university spinoffs, focusing in particular on student involvement in the early phases of the spinoff development process and on the impact of the larger university ecosystem. Detailed case studies indicate that graduate and post-doctoral students are important participants in university spinoffs. We offer a typology of spinoff development with four pathways, based on the varying roles of faculty, experienced entrepreneurs, PhD/post-doctoral students, and business students. The effects of the larger university ecosystem, beyond the university technology transfer office and the university's commercialization policies, are also considered, including an examination of programs and practices that may influence this process. We close with a discussion of guidelines for technology transfer and spinoff development at universities, based on the findings of this research.

JEL Classification L26 · M13 · O31 · O32

1 Objectives

Spinoffs play a critical role in moving early-stage technologies that are developed in universities to the market. This study offers a thorough analysis of the university spinoff development

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process, focusing in particular on student involvement in the initial phases of these technology commercialization efforts and on the impact of the larger university ecosystem.

Prior research examining technology transfer and entrepreneurship in universities has neglected the important role student entrepreneurship plays in the technology transfer process (Grimaldi et al. 2011). Our study of university commercialization efforts suggests that graduate and post-doctoral students are critical participants in university spinoffs, and we offer an in-depth examination of their roles, focusing on the preliminary stages of spinoffs initiated by faculty and students. Our research led to a typology of spinoff development with four pathways, based on the varying functions of faculty, experienced entrepreneurs, PhD/post-doctoral students, and business students. This typology provides insight into the diverse responsibilities of students and faculty in the technology commercialization process, the different relationships between students, faculty, and entrepreneurs that can lead to successful spinoff creation, and the relative strengths and weaknesses of each arrangement.

We also found that the larger university ecosystem has a significant impact on technology transfer. Prior research on this topic suggests that the university technology transfer office (TTO) (e.g., Colyvas et al. 2002; Jain and George 2007) and the university's commercialization policies (e.g., Di Gregorio and Shane 2003; Goldfarb and Henrekson 2003) are the key institutional mechanisms influencing technology transfer. The implicit assumption is that a capable technology transfer office with effective policies and a strong incentive system will lead to successful commercialization. In this study, we seek to broaden this perspective, suggesting that the overall ecosystem at a university and a broad range of practices are important aspects of efforts to facilitate technology transfer. We consider the scope of university programs and practices that may have an influence on this process.

2 Methodology

We used an embedded case study approach to obtain a thorough understanding of the technology commercialization process in university spinoffs. The study comprised detailed case studies at the following eight U.S. Universities: Harvard University (Harvard), Massachusetts Institute of Technology (MIT), Stanford University (Stanford), University of Arizona (UA), University of California, Berkeley (Berkeley), University of Maryland (UMD), University of North Carolina (UNC), and University of Utah (UU). At each institution, we studied between four and eight cases of technology commercialization attempts by faculty and students. As part of this process, we conducted a series of interviews at each institution, in addition to collecting secondary data from relevant websites. We spoke to a total of 130 individuals, including founders of forty-seven spinoffs, directors and staff of TTOs, Entrepreneurship Center Directors, faculty engaged in entrepreneurship education, students (or alumni) and faculty who have tried to commercialize their university inventions, and other key parties related to technology transfer.

3 Findings

3.1 Stages of early spinoff development

Faculty and students are most heavily involved in the earliest phases of the technology commercialization process. We, therefore, focused our research on these initial stages of

spinoff development to learn more about faculty and graduate student roles. We identified the following six stages for the early technology commercialization process at universities:

1. Idea generation
2. Commercialization decision
3. Prototype generation and establishment of commercial and technical viability
4. Founding team formation
5. Strategy and commercialization process determination
6. Fundraising to sustain activities, with the aim of convincing investors that the new technology has commercial and technical viability

3.2 Pathways of technology transfer

Our research suggests four primary pathways for university spinoff development, based on the varying roles played by faculty principle investigators (PIs), experienced entrepreneurs,

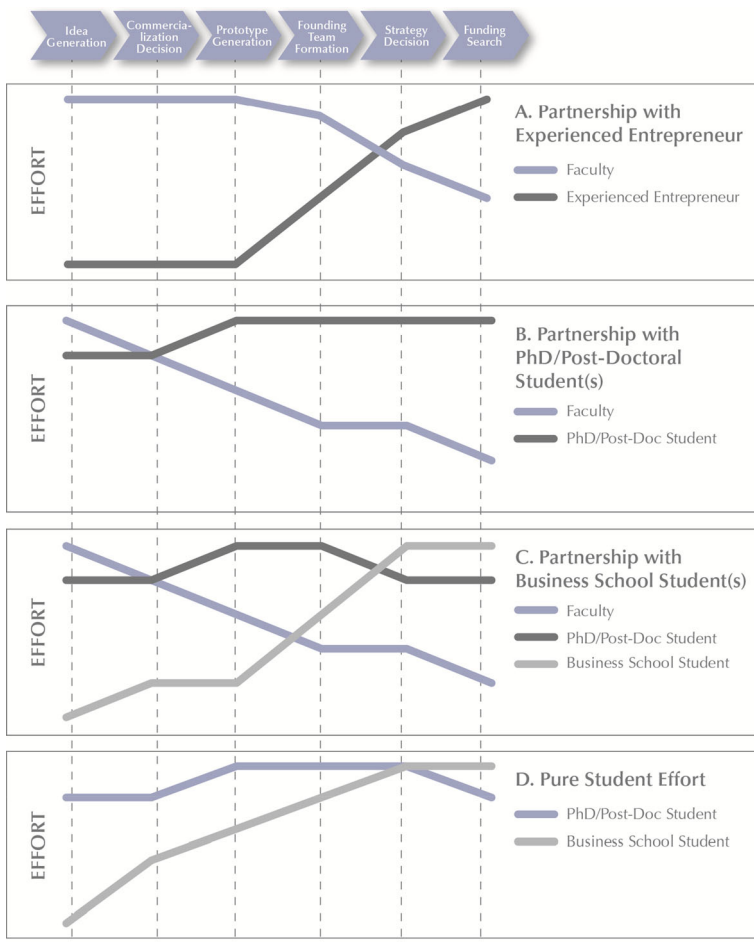


Fig. 1 Four pathways for university spinoff development

PhD/post-doctoral students, and business school graduate students. We present the four types of partnerships below:

- Pathway 1: Faculty PI and an experienced entrepreneur (23 % of cases)
- Pathway 2: Faculty PI and PhD/post-doctoral students (41 % of cases)
- Pathway 3: Faculty PI, PhD/post-doctoral students, and business school students (13 % of cases)
- Pathway 4: Pure student effort, typically involving a Master's/PhD student and business school student (23 % of cases)

Figure 1 provides a graphical overview of these pathways, illustrating the extent of effort and involvement by each individual at various stages in the startup process for the four pathways. While these phases appear to be linear in the figure, in reality there are often feedback loops, overlapping phases, and variations in the sequence (Bradley et al. 2013).

Pathway 1, a partnership between a faculty PI and an experienced entrepreneur, represents the ideal arrangement from the perspective of most faculty members who wish to commercialize their inventions. It allows faculty PIs to complement their technological expertise with a CEO who has the experience and network to help raise funds for the venture and guide its growth. It is, however, often difficult for faculty PIs to attract experienced entrepreneurs in the early stages of a venture. The other pathways, therefore, serve as alternatives that facilitate the growth and development of a venture until an experienced CEO is willing to join the effort.

Partnerships between faculty PIs and PhD/post-doctoral students from their labs (Pathway 2) are most common in our sample. These students are intimately familiar with the technology and often are highly motivated to work on the spinoff, but they typically lack business knowledge and experience. Adding a business school student to these partnerships (Pathway 3) allows for a stronger business perspective. Pathways 2 and 3 highlight the critical role students can play in the technology transfer process.

In Pathway 4, technology transfer takes place without faculty involvement. In these cases, PhD/post-doctoral students may take ownership of their own inventions, or structured programs and classes (such as Stanford's BioDesign program) may facilitate student-only collaborations.

3.3 University programs and practices to facilitate entrepreneurship

Our research suggests that universities often act as business incubators, allowing students and faculty to meet, form teams, and experiment with the idea of bringing technology from research labs to the market. Universities effectively offer spinoffs an incubation period, in which students and faculty have the freedom to develop the technology and form their strategic plans, incrementally reducing the venture's market and technological risk. During their time at the university, students can work on the initial stages of the spinoff without the opportunity cost of foregoing a paid job. And, after a year or two of work on the spinoff as students, they have sufficient information to determine if they will take the risk of working full-time on the spinoff after graduation.

This incubation and experimentation can only take place, however, if the university offers programs or opportunities for cross-disciplinary teams to meet, and provides resources to help teams develop the technology and plans for the spinoff. Prior technology transfer research has emphasized the role of university TTOs in providing necessary resources for commercializing university technologies (Colyvas et al. 2002; Jain and George

2007). We found that TTOs play a key role in evaluating invention disclosures, marketing inventions to potential licensees, filing patents, and licensing inventions to interested parties. Our research indicates, however, that the university's larger ecosystem also plays a critical role in providing resources and enhancing the competencies of faculty and students interested in commercializing university technology. We identified the following university programs and practices that enhance entrepreneurial efforts for commercializing university technologies, independent of the TTO:

- (1) *Project-based classes on technology commercialization.* Project-based classes bring together interdisciplinary teams or teams of MBA students to work on business plans and create roadmaps for the commercialization of university technologies. In nearly half of the spinoffs in our sample, founding team members took these classes. And in eleven of the spinoffs we studied, the founding team formed or attracted a new member in such a class. The instructors of these classes typically work with the TTO to identify university technologies that have invention disclosures or provisional or utility patents filed. They then invite the faculty PIs of the inventions to participate in the class. Interested faculty PIs or PhD/post-doctoral students also may apply to participate in the class with their technology for potential commercialization.
- (2) *Mentoring programs.* Universities often provide mentoring services that offer guidance and advice to new entrepreneurs, as well as referrals to lawyers, industry experts, potential customers, licensees, and investors who help founding teams build their networks.
- (3) *Accelerator/incubator programs.* Formal accelerator or incubator programs at universities often help startups intensively over a period of time, providing mentoring, funding, office space, enhanced credibility, and, in some cases, oversight and management.
- (4) *Business plan competitions.* Business plan competitions often play a key role in spinoff development. Not only do they provide a platform for team formation, but also they offer potential founding teams the opportunity to develop a business plan and strategic roadmap for the technology. Competitions also offer enhanced credibility and publicity for the winning teams.
- (5) *Entrepreneurship education for students.* Entrepreneurship education is critical for inspiring students to pursue entrepreneurship and for providing knowledge that will facilitate successful spinoff development.
- (6) *Entrepreneurship education for faculty.* Faculty members often are reluctant to participate in workshops or educational programs that are not directly related to their research. While proactive efforts to educate them regarding entrepreneurship may not be effective, it is important for universities to have educational programs and resources available for faculty to access when they choose.

It is important to note that experts, business people, entrepreneurs, and other alumni volunteers play a vital role in many of the programs listed above and make important contributions to the university's entrepreneurial ecosystem. While some of these programs focus specifically on technology transfer, others encourage student entrepreneurship more generally. Each, however, plays a direct or indirect role in providing opportunities for faculty and students to come together to create spinoffs for technology transfer.

These practices may not, on their own, ensure successful spinoffs for universities, but they provide rich ground for faculty and students to experiment in a relatively safe environment before they launch new ventures. And they allow universities to use their

resources, both inside and outside the school, strategically. Universities seeking to improve their technology transfer must examine their ecosystem more broadly, creating programs to ensure that faculty and students interested in commercializing technologies are able to access and leverage university resources both inside and outside the school.

3.4 Models of university entrepreneurship ecosystems

Many of the programs described above were in place at each of the eight universities we studied. There were, however, subtle differences in the implementation of these practices and in the approach to technology transfer more generally at each school. We found that the implementations and approaches at these institutions differed along two primary dimensions.

3.4.1 Systematic versus organic development

Some institutions systematically created a very structured network for their entrepreneurship ecosystems, while others allowed the ecosystem to develop more organically. Among the institutions we studied, Stanford and MIT had the most laissez-faire approaches to building ecosystems for technology transfer. This approach was successful, in part, because there are strong entrepreneurial cultures throughout both schools and because they can draw upon robust regional entrepreneurship ecosystems. These institutions also have deep traditions of developing and maintaining industry partnerships that further strengthen their entrepreneurial cultures. It appears that these schools can expend less effort because students and faculty already are interested in starting companies and spinning off university technologies.

While Harvard and UC Berkeley share the same regional entrepreneurial ecosystems as MIT and Stanford, respectively, these schools have a long history of focusing on basic research rather than applied research. Harvard, UC Berkeley, and the other universities in our sample stand at the other end of the spectrum; these schools deliberately created a coordinated system for technology transfer to ensure that interested faculty and students are able to access and leverage the entrepreneurial resources available.

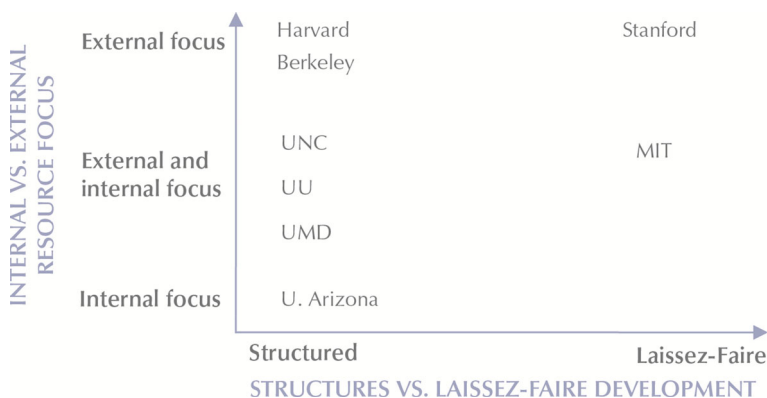


Fig. 2 Models of university entrepreneurship ecosystems

3.4.2 *Internal versus external resources*

These ecosystems also differ in terms of their focus on internal versus external connections. Universities that focus internally cultivate entrepreneurial resources within the university and work to make these resources available to university startups and spinoffs. In contrast, universities that focus externally seek to leverage more outside resources for entrepreneurship. Some institutions appear to focus both internally and externally, creating connections between internal programs and individuals, in addition to drawing in resources from outside the university.

Figure 2 below illustrates these two dimensions and characterizes the institutions we examined along both spectrums:

4 Conclusion: guidelines for technology transfer and spinoff development

We identified three widely applicable guidelines for technology transfer and spinoff development at universities: (1) align the objectives of the university, TTO, faculty, and graduate students; (2) leverage all potential university resources; and (3) encourage graduate students to see technology commercialization as a career option. Each of these guidelines is described in more detail below.

1. **Align the objectives of the university, TTO, faculty, and graduate students** Some university administrators consider technology transfer an additional source of income (Litan and Cook-Deegan 2011). However, university technology transfer has not historically led to financial gains at most institutions, and we question this view of the effort. Most of the universities in our research focused on the potential impact of their faculty research rather than on financial gains, seeking primarily to optimize the application of the technologies developed at their universities. The university's objectives have important implications for the metrics used to evaluate TTO success. If the university seeks to focus on the impact that can be achieved by commercializing faculty and student research, the appropriate metrics for TTO success should be the number of quality invention disclosures and license deals, rather than financial metrics.

Universities that offer additional sources of funding for commercialization efforts, including intellectual property protection and prototype building, also may help to align objectives by motivating researchers to pursue technology transfer.

2. **Leverage all potential university resources for technology transfer** Coordinating mechanisms and entrepreneurship programs allow universities to leverage their own assets, bridging the gaps between public funding of basic research, private funding of applied research, and research commercialization efforts. These programs are consistent with the universities' missions to educate, create knowledge, and disseminate knowledge.

Cross-disciplinary courses and entrepreneurship centers may serve as the best examples of these programs. Cross-disciplinary courses bring together knowledge resources, human capital, and social networks inside and outside the university. And entrepreneurship centers work with the TTO, offering leadership and skills to help universities incubate new technologies. Each of the universities in our research had at least one entrepreneurship center; some had independent entrepreneurship centers at multiple schools within the university. These centers develop and administer entrepreneurship courses, initiate outreach activities, such as business competitions, promote entrepreneurship on campus, and reach out to the university's entrepreneurial ecosystem. Universities can facilitate

enhanced technology transfer by ensuring that the entrepreneurship center (which focuses primarily on education and outreach) works cooperatively with the TTO (which focuses on invention disclosures and licensing).

3. Encourage graduate and post-doctoral students to see technology commercialization through spinoffs as a potential career option Our research indicates that graduate student entrepreneurs play a critical role in many of the pathways for technology transfer through spinoffs. In fact, graduate students were involved in 77 % of the cases we studied. These students are knowledgeable about the technology and highly motivated. They have access to expertise inside and outside the university, and their opportunity costs as students are low. While they lack business expertise and experience, our research suggests that they are savvy enough to drive the transition phase from public to private funding with appropriate university support.

Students often see the commercialization of their laboratory's technology as an affordable loss; even when these efforts fail, the entrepreneurial experiences at the start of their careers are tremendous learning opportunities that may be helpful to them in the future. And, for those spinoffs that succeed, the students may pursue entrepreneurship as a career, either continuing to manage the new venture as it grows, or taking on a different role once a more experienced CEO joins the company.

Ultimately, spinoffs may serve as an alternative and viable career path for students. Indeed, there is currently an oversupply of PhD graduates in the United States and, therefore, a need for these individuals to identify career options outside of academia. *Nature* recently published a series of articles regarding this shortage of jobs for PhD graduates: "In some countries, including the United States and Japan, people who have trained at great length and expense to be researchers confront a dwindling number of academic jobs..." (Cyranski et al. 2011). Those with degrees in the sciences are particularly likely to leave academia; data from the Division of Science Resource Statistics of the National Science Foundation (SRS-NSF) for 2008 indicate that only 41 % of employed holders of doctorates in science, engineering, and health fields remain in universities, while the remainder leave academia to pursue careers in business or nonprofits (39 %) or government (10 %) (Hoffer et al. 2011). Entrepreneurial efforts to commercialize technologies generated from their research labs, then, would allow students who do not have the interest or ability to obtain an academic position to pursue a different but viable career path that builds on their graduate training.

Universities can encourage graduate students to look beyond their laboratories and consider this type of career by offering business and entrepreneurship classes. While some schools offer these classes through their business schools, others may develop specific programs for science graduate students. Examples include the University of Wisconsin-Madison's 1-week boot camp, the TI:GER program at Georgia Tech, and the PhD minor program at the University of Arizona. Some researchers have even proposed a Master of Science degree in Entrepreneurial Science and Technology (Fleming et al. 2010), which PhD students could pursue in conjunction with their doctoral work. These classes offer students the different perspectives and opportunities they need to consider a broader future.

While successful commercialization of faculty research always will depend, to a certain extent, on the ideas generated in university laboratories and the personalities and talents of the individuals involved in the research, universities can create an environment that fosters new business creation on university campuses. Recognition of the value and potential impact of university technologies for the broader population, of the need for university

resources and support, and of the important role students can play in these processes is a critical first step. These student experiences, after all, are not only the logical extensions of their work in university laboratories and a means to build new skills. These efforts also have the potential to inspire the future entrepreneurs who will bring continued innovation and growth to our economy.

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Conflict of interest The authors declare that they have no conflict of interest.

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