Faculty as Founder? An Examination of Faculty's Role in Biomedical Start-ups

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Executive Summary

In this thesis, I examine faculty inventors' involvement in university spin-off firms formed to commercialize their inventions. In particular, I analyze the association between a faculty inventor's various roles in commercializing his/her invention and the performance of the ensuing fledging ventures. The study is based on a group of spin-off firms from MIT in the biomedical / life science sector between 1976 and 2003. Structured questionnaires were distributed to the 110 faculty inventors identified by the technology licensing office (TLO) in April 2005, yielding 31 valid responses covering 60 companies.

Examining the descriptive statistics and using univariate analysis and multivariate logistic regression analysis, I found that a senior faculty inventor's involvement had a positive impact on the likelihood of receiving first round VC funding and forming strategic alliances, although this was not statistically significant. In contrast, a junior inventor's involvement had a negative impact on the chances of receiving first round VC funding and forming strategic alliances; nor has a significant association been found. More specifically, faculty inventors acting as a co-founder or SAB member were significantly associated with the likelihood of receiving first round VC funding, but not with forming strategic alliances with established biopharmaceutical corporations, even when adjusted for junior inventors' involvement and controlled for first round venture capital market condition.

1. Introduction

There are many factors that shape the timing and amount of early stage investment in technology-based start-ups. Venture capitalists place significant weight on the characteristics of the team. While managerial experience is probably the most important human factor, a well-known scientist and/or laboratory with previous entrepreneurial experience would more likely merit serious consideration. In addition, geographic location and geographic proximity may carry some weight (see Stuart and Sorenson, Gompers and Lerner, 2001). However, while the track record of academic scientists may be an important factor for venture capitalists to consider when they make a decision in funding an early stage biomedical venture spinning out of universities, the degree to which the academic is willing to participate in the venture may mediate the funding decisions..

The purpose of this study is to examine the following two issues: whether involvement of faculty inventors matters, and if so, what kind of faculty involvement has the most significant association with the performance of university spin-off firms. Using a survey instrument that asks faculty to report their involvement in a sample of university spin-outs, I examine the impact of different measures of involvement on a series of early-stage outcomes: raising venture funding, and forming strategic alliances with established BioPharma and medical technology corporations.

1.1 Background:

The dramatic rise in university patenting and the subsequent licensing of these patents to companies in the period following the 1980 Bayh-Dole Act has triggered a dramatic shift in faculty behavior and the strength of university-industry interactions. According to many observers, faculty inventors have become increasingly engaged in the transfer of their ideas to established firms, and particularly in the biomedical sector, to start-ups. This has led many faculty inventors to play a multiplex role at the university-start-up interface, from founder and temporary CEO, to chairman of the Scientific Advisory Board, and to consultant (Murray 2003). It has also meant potential changes to a faculty inventor's laboratory, with start-ups providing a new career option for graduate students. While these changes raise questions about the very nature of academia today, in this thesis we focus on the implications of the changes on the university spinouts. But before turning to the analysis, a view of the backdrop to this commercialization process is in order.

From a legislative standpoint, the passage of Bayh-Dole Act (Patent and Trademark Act) in 1980 and the Federal Technology Transfer Act in 1985 provided an incentive for universities to promote commercial utilization – through patenting and licensing – of inventions resulting from federally-funded research programs, and for industry to make high-risk investments in these inventions. Together, the two pieces of legislation created a uniform patent policy among those federal agencies that fund research. More importantly, they enabled nonprofits, specifically universities, to file for and own patents arising from research funded by federal research grants. Universities were further charged with an obligation to license these patents for further commercialization to start-ups, small businesses, and established firms.

As a result, the number of U.S. universities that engage in technology transfer and licensing has increased eightfold, to more than 200, and the volume of university patents has increased fourfold (Mowery & Shane, 2002). According to a survey by the Association of University Technology Managers (AUTM), respondents (academic institutions and teaching hospitals) executed 4,516 licenses and options in 2003, representing an 11.46% compound annual growth rate (CAGR) since 1991. As knowledge is transferred from the publicly-funded research projects to the private sector, the commercialization of these technologies is increasingly regarded as playing a significant role in new business starts, the growth of existing businesses, and new job creation (Siegel et al, 1999), driving forward an innovation-based U.S. economy. In the biomedical sector, especially biotechnology and pharmaceuticals, university research advances affect industrial innovation more significantly and more directly than any other sector (Mowery and Sampat, 2005).

There are several ways in which a university may choose to commercialize its inventions. The dominant and traditional way, especially among those universities with large research contracts, is licensing (Siegel et al., 1999), whether to smaller companies or to large established corporations. A university may charge the licensee an initial payment, and then receive subsequent royalty payments for the company's right to use a particular piece of intellectual property; Another increasingly popular option is to license the invention to university spin-offs – new companies founded specifically to exploit the intellectual property assigned to universities by virtue of the inventions by faculty, staff, and students, who make material use of university resources (Shane 2005).

In fact, AUTM's annual surveys have documented an increasing number of inventions being pursued by new ventures. In 2003, the share of inventor-university inventions licensed to startup companies (companies established specifically to develop the licensed technology) reached 14%; a number that has increased steadily since the group began to keep records in the early 1990s. However, due to the difficult market conditions for raising early-stage funds, the total number of start-ups in 2003 was 374, a retreat from the peak of 494 in 2001. Figure

1.1 illustrates the total number of start-ups created to commercialize technology and inventions licensed from universities from 1994 to 2003.

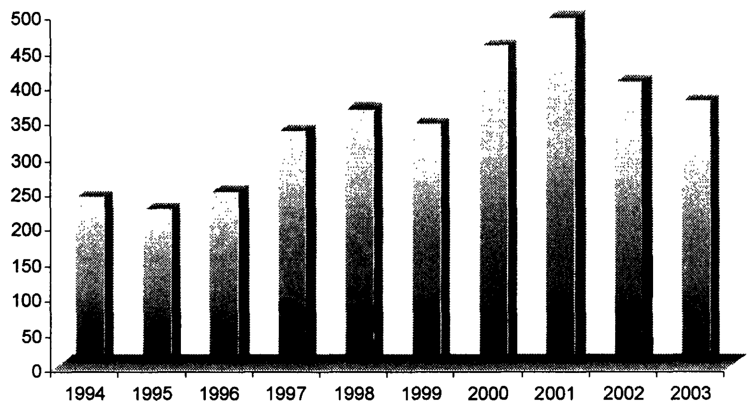


Figure 1.1: Start-up firms created to commercialize university technologies

The above-mentioned rise in university spin-offs has been driven by the following four important factors. First, with the increasing pressure from governments to manage university IP more effectively and to realize the investments in IP to generate long-term wealth for both universities and the wider economy (HM Treasury and DTI, 1998), universities are escalating their efforts to maximize all possible revenue streams (i.e., royalties and licensing fees) from the inventions. For one thing, this is deemed to be the most important measure of university Technology Licensing Offices' performance (Thursby et al. 2001). For another, spin-offs tend to license inventions that large, established firms will not license, thereby making spin-offs a useful mechanism to increase the number of licensing agreements (Thursby et al, 2001). In addition, university administrators see new firms as having several key benefits: they can generate considerable revenue for the institution in the long run if they do succeed – university spin-offs are 108 times more likely than the average new firm to go public, and thus create more jobs than the average new business (Shane, 2004); they can also make the university more attractive to current and potential faculty inventors; and they enhance local economic development (Shane, 2004). As a result, Technology Licensing Offices at innovative academic institutions such as Massachusetts Institute of Technology (MIT) have eased their policies and procedures to facilitate the formation of new ventures to exploit the commercialization of new inventions.

Second, the culture in universities has been changing, from in some cases, being openly hostile to private enterprise, to greater acceptance of and a more positive attitude towards entrepreneurship across university science departments (Etzkowitz, 1998; Wright et al., 2004). As a result, faculty inventors often view new ventures as potential sources of both personal wealth and career fulfillment (Lerner 2005), and more and more students see university spin-off companies as a jump-start to their future careers.

Third, and more importantly, biomedical scientific discovery on average takes longer and requires more capital to get to the stages that are attractive to typical technology licensees – established companies. While universities and faculty themselves do not have the necessary resources to carry the research that far, spinning out as an independent start-up, with exclusive license from the university, has become an important vehicle, attracting external funding which includes angel investments, SBIR grants, and venture capital funding.

Finally, anecdotal evidence suggests that investments by the venture capital community in technology firms founded by university students and faculty have helped push the above transformation. VC investment brings in not only financial resources but also venture operation expertise and management teams. Both are critical to the success of early stage ventures. In fact, the first modern venture capital firm, American Research and

Development (ARD), was designed to focus on technology-based spinouts from MIT. Many recent successes in the life sciences, as well as other high technology businesses have their roots in university spin-offs, as for example Genentech, Chiron, Cisco Systems, and Google, just to name a few. Therefore, today's universities have begun to view themselves as catalysts in new venture formation and regional development (G.D. Markman et al., 2005).

It should also be mentioned that the inherent disadvantages of the traditional licensing approach make university spin-offs a more attractive approach for universities who are licensing their technologies. For one, the nature of some new technologies may not be easily patented and transferred via a licensing deal. Following from Arrow's (1962) observations on the difficulty of contracting over knowledge, Hearn (1981) found that the licensing arrangement is only applicable when the assets can be protected by intellectual property law and can be easily stipulated in the form of a contract. Tacit knowledge, which is hard to articulate and is acquired through experience (Polanyi, 1966), in some fields, i.e. biotechnology, is hard to codify, especially in the early stages. Another disadvantage to the conventional approach is that universities may not be able to capture the full value of their technology through a licensing arrangement and thus, may seek a more direct involvement in the commercialization of an invention by spinning off a company (Franklin et al., 2001; Samson and Gurdon, 1993). Holding an equity position in such spin-offs may be attractive to universities. In a small sample survey, Bray and Lee (2000) found some evidence that taking equity in a spin-out company produced a greater than average return in the long run to universities. Shane (2004) confirmed that the financial returns from equity holdings in spin-off companies exceeded that from licensing to established companies.

Interestingly, different technological fields have quite different propensities towards various licensees of the invention. Shane and Khurana (2003) found that drug and chemical related inventions are more likely to be exploited by newly-formed university spin-offs firms, at least from their study population of all U.S. patents assigned to MIT from 1980–1996. Another study (Thursby et al., 2001) found that the medical-related area usually has the largest amount of disclosure in technology licensing. Hence, the present study's focus on biomedical science and technology, specifically the study, research, and knowledge of health, and the application of that knowledge to improve health, cure diseases, and understanding how humans and animals function.

Despite the potentially great benefits from and contemporary interest in university spin-off firms, starting new ventures based on university technology is difficult (Lerner, 2005). Forming an independent company is quite different from an academic's typical activities. It requires a different set of core competencies and is much more complicated (Wright et al., 2004). Perhaps understandably, given the overall complexity of the situation, the factors that influence the founding and success of new firms in order to commercialize university inventions remain incompletely studied (MoIry and Shane, 2002).

1.2 Conceptual Framework

As illustrated in Figure 1.2, the growth of university-based biomedical technology firms can be segmented into the following three stages, each characterized by unique activities and a particular strategic focus that the firm must address (and "complete") before moving on to the next stage.

- Stage 1 is a purely academic research stage, supported by various public and private research grants, including federal and corporate research sponsorship. The research can be either basic scientific research or applied research. The key owners during this stage are the faculty inventors and other junior scientists, including research associates, technicians, staff inventors, post-doctoral fellows/associates, and graduate students. Their goal during this stage is to create

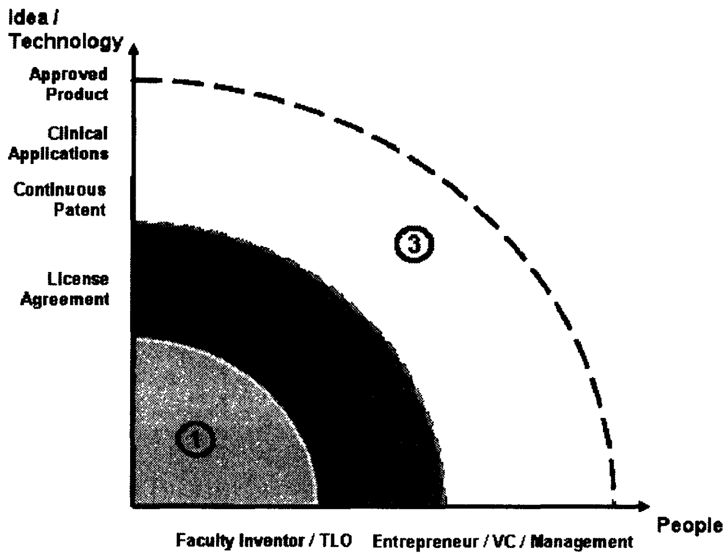


Figure 1.2: Three stages in the growth of university spin-offs

valuable know-how and technological assets, normally measured by the number of published papers, the scientific reputation/rank of the publications in which papers are published (i.e. Nature, Science), and/or the number of citations forwarded from those published papers. The number of patents may also be used as a loose indicator, but not necessarily in all cases. The intellectual property created during this stage becomes a prerequisite for stage two, although the time necessary to consolidate the intellectual property with respect to ranking, dissemination, acceptance, even issued patents, may not be sufficient.

- Stage 2 is the pre-commercialization stage where ideas/technologies begin to be transformed into a commercialized setting, but where there is not yet a fully operational enterprise. During this stage, scientific discovery is "framed" and explored for commercial applications. As an innovative scientific discovery may have many potential applications, founders must make critical strategic choices of applications to develop, if they are to attract the external resources needed for the risky development process. It is a challenging task for academic founders with little prior market knowledge and few linkages to select these applications. Nevertheless, at this stage, commercial expertise starts to combine with scientific contents to develop an idea/technology into a fundable opportunity. At a certain point, both the university and the scientist must agree that a spin-off is the most viable option for technology commercialization. They must then negotiate a spin-off deal. Key people involved in this stage include inventors (senior and/or junior faculty), university technology licensing officers, surrogate entrepreneurs, and sometimes investors, including angel, SBIR or venture capitalists. The stage ends in the creation of multiple legal documents, including corporate registration, licensing agreements (options or exclusive/non-exclusive licenses) between the university TLO and the spin-off firm, and most importantly, the first term sheet between investors and founder(s) of the spin-off firm. Like Stage 1, Stage 2 could be lengthy, involving multiple strategic changes in business models and market positioning in order to satisfy both potential customers' needs and investors' expectations. Some scholars (Vohora et al. 2003) break this stage down into three phases: the opportunity framing phase, pre-organization phase, and the reorientation phase. My study focuses on faculty inventors' involvement in university spin-offs during Stage 2.

- Stage 3 is a tangible enterprise stage, where the first external financial backing is secured, and the venture is well enough organized to explore the commercialization of the idea/technology. During this stage, the university spin-off is on its way to producing its core technology. It has set its goals, although significant changes may be expected. Human capital which is critical to this stage includes both academic inventors and professional management teams with solid commercial experience, as well as experienced VCs behind the firm. The quality of the technology is no longer measured by the published papers and/or original patents, but by the quality and scope of the continuous patent filed by the firm, and ultimately, by the progress it has made towards clinical application and commercial products. The goals for this stage are to hit the target milestones and to raise sequential rounds of funding.

1.3 The Relationship to Previous Studies

In short, university spin-off companies are typically technology-focused early stage ventures evolving from academic research. The development of these firms often is an iterative, non-linear process (Vohora et al, 2004), and uncertainty and information asymmetries often characterize such firms, particularly in the high technology industries (Gompers and Lerner, 2001). As a result, investors (including both VCs and pharmaceutical firms) use a range of different measures and metrics in making their investment decisions. Before turning to my analysis of inventor involvement, I will explore the existing literature for discussion of the key factors influencing a start-up venture's performance as well as its likelihood of raising venture backing and corporate backing (in the form of a strategic alliance). To this end, I will examine the following aspects of a faculty inventor's endowment: the inventor's human capital, both technical and social, the role of the management team, the importance of the quality of the idea, as well as other factors outside the university itself.

HUMAN CAPITAL: Human capital can include both technical and social capital. The critical role that human capital plays in influencing venture capital funding decision has been confirmed by empirical studies (MacMillian et al. 1985) as well as by anecdotal evidence from the VC community.

Stephan (1994) has shown that the proceeds of an initial public offering and the "day one" value of the firm are positively and significantly related to the scientific reputation of the inventor. Similarly, beyond the strong connection between intellectual human capital created by frontier research and the founding of firms in the biotechnology industry, Zucker, Darby and Brewster (1998) found the performance of many early stage entrepreneurial biotech firms was dependent upon a close relationship with "star" scientists as they embodied an un-codified knowledge which is complex and hard to exchange or move among different organizations (Winter, 1987). The scientific capabilities contributing to the performance of university spin-offs are mostly established through academic training and experience (Levin and Stephan, 1991; Stephan, 1996), and therefore, can be identified as technical human capital.

Besides technical human capital, other studies (Bozeman et al., 2001) have suggested that scientists accumulated valuable experience and critical resource in distinctive institutional settings, and in addition build social capital. Further, Murray (2004) found that faculty inventors' scientific careers built upon their scientific capabilities are central in shaping their social capital, which can then be translated into critical scientific networks, benefiting the university spin-offs in which the faculty inventor is involved. In another words, a successful scientific career may bring other social endowments (i.e. research collaborators, reputable investors, potential strategic alliance partners, etc.) to both a faculty inventor and the venture in which he/she is involved. Shane and Stuart (2002) found that two measures of a founder's social human capital, i.e., direct and indirect social ties to venture capitalists that predated the founding of their firms, increased the likelihood of receiving VC funding and lessened the likelihood of failure. Gulati and Higgins (2003) confirmed that such ties to prominent venture capital firms are beneficial to IPO success, although their study took an inter-organizational perspective rather than the individual faculty inventor's point of view.

MANAGEMENT TEAM: Prior studies have shown that an inventor's social capital, as well as that of the management team, are important determinants of success for early stage university spin-offs, contributing in various ways to a firm's performance in the different growth stages. The management team itself is critical. The often-mentioned tendency of VCs to bet on "people not ideas" serves to alleviate various risks associated with new technology. Further, Eisenhardt and Martin (2000) found that spin-outs with a management capability to change and refine their resource configurations to meet the emerging needs of the market will outperform those who do not. And Chrisman et al. (1995) have suggested that ventures created by "outside entrepreneurs" with "faculty assistance" grow more rapidly than those created by academics themselves. Other scholars have commented that a combination of academic and surrogate entrepreneurship is the best approach for successful technology-transfer based start-up companies (Franklin, Wright and Lockett, 2001).

IDEA QUALITY: Prior studies (Murray and Kanda 2004) have suggested that both the quality of the idea and the reputation of the inventor are significant determinants of the likelihood of a firm receiving initial financial endorsement from high status venture capital firms. However, they found that quality of idea had a less significant moderating effect when compared with inventor status (human capital). In another word, ideas and inventions emanating from prestigious scientists and inventors were perceived to have higher market value.

OTHER FACTORS: Although technical human capital, social human capital, the management team, and the idea quality mentioned above are among the major factors upon which previous studies have focused, Table 1.3 lists other factors that might influence the initial funding of university spin-offs. Clearly, any examination of the so-called "major" factors should be considered within a broader framework.

Table 1.3: Other factors might influence university spin-off's performance

	Study Findings	Sources
Roels of TLO	▪ University and its Technology Licensing Office (TLO) are fundamental to the birth and growth of university spin-off firms.	Kassicieh et al., 1996; Link et al., in press; Siegel et al., in press
	▪ Supportive environment featured by TLO's licensing-for-equity strategy and related spin-off policies is positively related to new venture formation and performance	Roberts, 1991; Lockett et al., 2003; Markman et al., 2004; DeGroof and Roberts, 2004
	▪ TLO's adequate networking not only allows university entrepreneurs to improve their understanding of opportunities in a changing market but also gains access to critical resources such as finance and to deal with business obstacles.	Johannisson et al., 1994; Sapienza et al., 1996; Hills et al., 1997
Factors outside of university	▪ The age of the industry that university spin-offs operate may have significant impacts on the performance	Shane, 2005
	▪ The level of industry R&D funding may have some impact on whether spin-off is the right licensee to transfer the technology and on their consequent performance	Powers and McDougall, 2005
	▪ The local availability of venture capital is also widely believed to play a significant role in the birth and growth of university spin-offs.	Martin Kenney, 1986; Joshua Lerner, 1994, 1995, Powers and McDougall 2005
	▪ The presence of venture capital funding is the single largest contributor to the likelihood that a start-up undergoes a successful initial public offering (IPO).	Shane and Stuart (2002)

1.4 The faculty inventor's roles in a biomedical start-up and hypothesis

While the aforementioned bearing of the inventor's reputation on technical and social human capital may be a useful signal to investors, the assurance of the inventor's involvement may also be critical. Such involvement may smooth the transfer of the idea from the university to the firm, given that the idea or technology is in an embryonic stage, and that the technology almost inevitably requires substantial additional development before coming to the market (Thursby, 2001). In addition, the tacit nature of knowledge in biotechnology (Pisano et al., 1988) and other biomedical technologies renders the scientific inventor one of the most valuable assets in biomedical university spin-offs. It is hard to transfer know-how without participation by the inventors.

As indicated in Figure 1.2, when the university spin-off venture grows from an academic research setting (Stage 1) into a tangible enterprise (Stage 3), the key individuals in the firm are no longer the faculty inventors. The emphasis shifts to the business and product development professionals who work full time at the new venture. Therefore, what would determine the success of a commercial venture in Stage 3 is not only the reputation of the original faculty inventors and the quality of technology required in Stage 1. At this stage, a key concern is how much of their knowledge and intellectual capital is transferred to the enterprise, becoming the property of that organization. In other words, it is the faculty inventor's role/involvement and the time he/she invests in both Stage 2 and Stage 3 that bridges the knowledge gap and integrates the tacit knowledge and value residing in the original idea/technology status into the new venture. I hypothesize that if the quality of the invention and the status of human capital are equal, the role that the faculty inventor plays in the university spin-off firm will have an important effect on venture's ability to secure first round VC funding and to form strategic alliances with established biopharmaceutical corporations.

A recent survey conducted by Jesen and Thursby (2001) confirmed the above hypothesis, finding that the faculty inventor's cooperation is important in technology development after the invention is licensed. Based on empirical evidence, other scholars (Wright et al. 2004) have echoed this, noting that the key to the successful commercialization of a university invention is the role played by the inventors. After studying the co-authorship between established biotech firms and the top 112 U.S. research universities, Zucker, Darby, and Armstrong (2002) found that research collaborations between firm scientists and university scientists had a significant positive effect on firms' performance.

Although Zucker, Darby, and Armstrong (2002) statistically studied the correlation between joint research (the involvement of faculty inventors) and the performance of established biotech companies, it was not clear whether other forms of involvement (i.e. faculty inventors as a co-founder, SAB member, BOD member, consultants, or even full-time employees of the spin-off firm) would influence the performance of more nascent university spin-offs. More interestingly, anecdotal evidence showed that some prolific entrepreneurial academics prefer to conduct research within a university setting, rather than jointly with the university spin-offs they co-founded. Therefore, I am prompted to ask the following question: given a similar quality of idea/technology and human capital, what influence does the role played by a faculty inventor in a university spin-off firm have on the initial round of VC funding and on the alliances it forms with other established players?

Although faculty inventors' involvement in start-ups is critical to the venture's long term growth, given the technology is still in its nascent stage (Jesen and Thursby, 2001, Wright et al., 2004), the opportunity cost for established faculty inventors is very high, if they join the start-up firm as full time employees (Kassicieh, 1996). Moreover, high growth young companies (including university spin-offs) tend to run leaner, with fewer managers and slimmer payrolls (Siegel et al. 1993). Therefore, how faculty inventors are involved in university spin-offs and the effects of their various involvement/roles are not clear.

In addition, anecdotal observations from venture investors show that too much intervention by the original inventors and founders may lower the venture's sensitivity to market conditions and consequently jeopardize the venture. It seems, however, that there is a "window" of involvement through which additional value can be added to the spin-offs firms.

Since there is a lack of systematic research with regards to what role faculty inventors play in the university spin-offs created to pursue their inventions, by examining the involvement of faculty inventors in the MIT spin-off biomedical start-ups, I found that the following are the typical roles inventors play in the newborn spin-off ventures:

- Faculty inventors found or co-found the new venture and contribute significant amount of time in defining business application and venture structure. Although in most cases, they remain as full time faculty inventors at MIT, they may or may not take a sabbatical leave to help shape the new venture at the very early stage (Harvard's policy does not allow its faculty inventors to do so at all). In this case, the faculty inventor brings knowledge directly into the new venture by him/herself.

Hypothesis 1.1: Being a founder or co-founder of a university spin-off firm, a faculty inventor would be significantly associated with the new venture's initial round of VC funding.

Hypothesis 1.2: Being a founder or co-founder of a university spin-off firm, a faculty inventor would be significantly associated with new venture's capability of forming strategic alliances.

- The faculty inventor becomes a member of the Scientific Advisory Board (SAB) of the university spin-off firm which pursues the technology invented by the faculty inventor. In this case, the faculty inventor helps guide the future direction of scientific research conducted at the new venture on a periodic basis and brings knowledge indirectly into the spin-off firm.

Hypothesis 2.1: Being a member of Scientific Advisory Board (SAB) of the spin-off firm, a faculty inventor would be significantly associated with the new venture's initial round of VC funding.

Hypothesis 2.2: Being a member of Scientific Advisory Board (SAB) of the spin-off firm, a faculty inventor would be significantly associated with the new venture's capability to form strategic alliances.

- Another form of involvement by a faculty inventor could be as a inventor of the Board of Directors, representing both core invention and intellectual capital. In this case, the faculty inventor provides high level strategic vision and guidance for the venture, but knowledge transferred from the faculty inventor into the new firm is very limited. In addition, given faculty inventors' domain expertise and familiarity with the technology, in many cases, they are hired as external consultants to provide a relatively neutral perspective on the scientific and/or technological issues. This is a more pragmatic way to engage the faculty inventors in day-to-day technological issues, so that they can bring practical know-how directly into the new venture. Another effective way to transfer tacit knowledge to codified technology is through research collaboration. Given that science and technology in university spin-offs are in an embryonic stage, joint research would improve both the faculty inventor's and the spin-off firm scientist's understanding of the future commercial potential of the original invention. In very rare cases, faculty inventors might join the university spin-off firm as full-time employees, and take on a hands-on day to day operation role to commercialize their scientific invention. In this case, faculty inventors are fully committed to the success of the new venture and bring their knowledge directly into the organization.

Hypothesis 3: Any form of a faculty inventor's involvement (as a co-founder, SAB member, BOD member, full-time-employee, consultant or co-researcher) would be significantly associated with the new venture's initial round of VC funding and strategic alliances it would be able to form.

- In some cases, a faculty inventor co-founds the spin-off firm along with his/her junior inventor. In this case, both the faculty inventor and the junior inventor contribute a significant amount of time to establishing the firm, and they work together to find a commercialized application for the core invention. They bring the knowledge to the firm directly, at least at the very beginning. In other cases, knowledge can be transferred into the venture through junior inventors working as full-time employees at the firm. Given the high opportunity cost for senior faculty inventors to move into the business world, sending junior inventors who have been working closely with the faculty inventor to the spin-off firm seems an extremely efficient way to transfer knowledge.

Hypothesis 4: A junior inventor's involvement as either a co-founder or full-time-employee of the university spin-off firm would be significantly associated with the new venture's initial round of VC funding and strategic alliances it would be able to form.

By no means comprehensive, the list above provides a number of possible ways to involve faculty in university spin-off firm. I now go on to analyze whether each of these involvement modalities is associated with the initial round of VC funding or the capability to form strategic alliances. In addition to testing the four hypotheses, I will try to find what combination of these factors has the most profound impacts on the outcome (the selection and definition of end-points will be discussed in section 2.3.

2. Method

2.1 Sample and Data Sources

The original sample population includes 154 biomedical start-up firms founded between 1977 and 2003 to further develop and commercialize inventions assigned to the MIT. Inventors at these firms include faculty from MIT, Harvard Medical School (HMS), HMS's teaching hospitals and some other universities. Licensing agreement at 50 of these 154 firms were led by a non-MIT technology licensing office (i.e. TLO at HMS or one of its teaching hospitals) where I don't have access to. Eight spin-off firms did not register any faculty inventor as inventor – only junior scientists such as research associates, technicians, or graduate students were recorded as inventors. Thus, 110 faculty inventors who had been involved in 96 of these 154 biomedical start-up firms were identified from MIT TLO's database and were contacted via email. I asked structured questions about what role they played in the spin-off firms. Appendix 1 is a sample questionnaire. Within two weeks, 35 faculty inventors responded; 31 responses were valid. A breakdown of responses is shown in Figure 2.1. During the five telephone interviews and three face-to-face interviews, I also asked some unstructured questions about their involvement; these responses cover 60 of the spin-off ventures. The age profile of the 60 firms is shown in Table 2.1.

Table 2.1: Age profile of the study subject

Year of spin-off venture incorporated	Number of ventures in the study cohort
Before 1979	1
Between 1980 and 1989	13
Between 1990 and 1999	31
Between 2000 and 2003	15
	60

Figure 2.1: Means of Responses

I compiled other data about each of these firms through both published and unpublished sources. Intellectual property and patent information was retrieved from MIT's TLO database and in some cases, verified and confirmed through Delphion (www.delphion.com), now part of Thomson Corporation; each firm's strategic alliance information was retrieved from Recombinant Capital (www.recap.com) by manually determining the first major strategic alliance. Each firm's detail financing information and the overall venture capital market statistical data were retrieved from a commercial venture capital information database – Venture Economics' VentureXpert. Each firm's idea quality score was acquired from previous research conducted by Murray and Kanda (2005). Please see Section 2.4.2 for details.

Where start-ups were later merged or acquired by another start-up firm in the list, their original identity was preserved for purposes of tracking, and their original founders were contacted regarding first round VC funding. Every effort was made to track firms and founders through name changes, corporate alliances, and business combinations.

2.2 Independent variables

2.2.1. Faculty as founder or co-founder

As shown in Table 2.2, this variable is binary categorical: if the faculty inventor considers himself/herself a founder or co-founder in the survey response, it is denoted as 1, otherwise 0. In a firm with multiple faculty inventors, this variable is set to 1 if at least one of the faculty inventors considers him/herself a founder or co-founder, otherwise, 0.

Table 2.2: Independent variables

Variables	Code	Meaning
Independent Variables		
Faculty inventor as co-founder	0	No faculty inventor consider him/herself as founder of the new venture
	1	At least one of the faculty inventor consider him/herself as one of the founders
SAB member	0	No faculty inventor serve on the SAB
	1	At least one of the faculty inventor serve as a SAB member
BOD member	0	No faculty inventor serve on the BOD
	1	At least one of the faculty inventor serve as a BOD member
Faculty as FTE	0	No faculty inventor joined the spin-off firm as a full time employee
	1	At least one of the faculty inventors joined the spin-off firm as a full time employee
Consultant	0	No faculty inventor provided consulting services for a pre-negotiated pay/rate
	1	At least one faculty inventor provided consulting services for a pre-negotiated pay/rate
Co-research	0	No faculty inventor conducted any joint research with the spin-off venture
	1	At least one faculty inventor conducted any joint research with the spin-off venture
Junior inventor as co-founder	0	No junior inventor co-founded the spin-off venture
	1	At least one junior inventor co-founded the spin-off venture
Junior inventor as FTE	0	No junior inventor joined the spin-off venture as a full time employee
	1	At least one junior inventor joined the spin-off venture as a full time employee
Dependent Variables		
First round VC funding	0	Havn't received first round VC funding yet
	1	Have successfully received first round VC funding or corporate VC funding
Strategic alliances	0	Hávn't formed any co-market, co-promotion, collaboration or distribution alliances with prominent corporations
	1	Have formed at least one co-market, co-promotion, collaboration or distribution alliances with prominent corporations
Control Variables		
1st round VC funding accessibility	Continuous	Resource richness for 1st round deals - ratio of dollar amount invested in first round VC deals divided by total dollar amount invested in all stages
Idea Quality	0	Not-so-High quality of idea/invention using a patent-paper pair approach
	1	High quality of idea/invention using a patent-paper pair approach

2.2.2. Member of Scientific Advisory Board (SAB)

In the survey, each faculty inventor was asked if he/she was a member of the Scientific Advisory Board (SAB) at the firm. This is also a binary categorical variable: those faculty inventors sitting on the SAB were denoted as 1, otherwise 0. In a firm with multiple faculty inventors, this variable is set to 1 if at least one of the faculty inventors sits on the

SAB, otherwise, 0. Some firms don't even have a formal SAB established and therefore, denoted as 0.

2.2.3. Member of Board of Directors (BOD)

Each faculty inventor was also asked if he/she was a member of the Board of Directors (BOD). As a binary categorical variable, faculty inventors sitting on the BOD were denoted as 1, otherwise 0. In a firm with multiple faculty inventors, this variable is set to 1 if at least one of the faculty inventors sits on the BOD, otherwise, 0.

2.2.4. Faculty jointed spin-off firm as a full-time employee (FTE)

In the survey, each faculty inventor was asked if he/she joined the start-up firm as a full-time employee after it was incorporated, and if so, what position he'she held. A binary categorical variable was used to record the answer. Faculty inventors did join as full-time employees were denoted as 1, otherwise 0. In a firm with multiple faculty inventors, this variable is set to 1 if at least one of the faculty inventors joined as FTE, otherwise, 0.

2.2.5. Faculty acted as a consultant

In the survey, each faculty inventor was also asked if he/she had been involved in a consulting engagement with the spin-off firm. Acting as a consultant is defined as providing scientific and technical consulting services with a pre-negotiated pay/rate. Providing advices as a member of SAB was not considered a typical consultant status. I included this type of involvement as SAB member rather than consulting.

This is a binary categorical variable too. Faculty inventors who have been a consultant to the firm were denoted as 1, otherwise 0. In a firm with multiple faculty inventors, this variable is set to 1 if at least one of the faculty inventors did consulting for the spin-off firm, otherwise, 0.

2.2.6. Faculty conducts joint-research with the spin-off firm

Each faculty inventor was also asked if he/she has conducted joint research with the spin-off firm. In contrast to a consulting project, join research allows the faculty inventor work closely with the spin-off firm to further explore and develop the original invention, leading to a possible joint patents or co-publications. Similar to above binary categorical variables, faculty who has conducted join research was denoted as 1, otherwise 0. In a firm with multiple faculty inventors, this variable is set to 1 if at least one of the faculty inventors conducted joint research with the spin-off firm, otherwise, 0.

2.2.7. Junior inventor founded or co-founded the firm

Each faculty inventor was also asked in the survey if any junior co-inventor he/she had worked with founded or co-founded the university spin-off firm. A binary categorical variable is set to 1 if there was at least one of the junior co-inventor helped co-found the firm, otherwise, 0.

2.2.8. Junior inventor joined the spin-off firm as a full-time employee (FTE)

In the survey, I also asked if there was any junior co-inventors joined the spin-off firm as a full-time employee. And if so, what position he/she held with the firm. Again, using a binary categorical variable, I denote the firm as 1 if there was at least one of the junior inventors joined the firm as a full-time employee, otherwise, 0.

2.3 Dependent Variables

In this study, I ask the question whether faculty inventor's various involvement and roles matters in the performance of spin-off firm. There are many different ways to gauge the performance of a biomedical science and technology oriented ventures, including number of cumulative patents granted, number of products in development, total number of products launched (general available) to the market place, as well as total number of employees etc. (Zucker, Darby, and Armstrong, 2002). Since the subject cohort in this study is relative young, I chose to use following two variables to measure their initial performance:

2.3.1. First round VC funding

I use whether the spin-off firm received first round venture funding as the first dependable variable (binary categorical) to gauge university spin-off's initial performance. As shown in Table 2.2, firms that have successfully received typical venture capital funding or venture funding from large established biomedical corporations (corporate venture capital) are denoted as 1. Others who didn't receive any VC funding or just receive small amount from angel investors are denoted as 0. All venture financing information from private VC firms and corporate VC organizations were double-checked with VentureXpert database.

2.3.2. Strategic alliances

I use whether the spin-off firm formed any strategic alliances with prominent pharmaceutical or health care corporations as another dependent variable (binary categorical) to gauge university spin-off's performance. Primary alliance information was retrieved from Recombinant Capital where all kinds of alliance deals are included. For the purpose of this study, licensing deals with academic institutions and pure research and development partnership among biomedical firms were excluded. Firms formed co-market, co-promotion, collaboration and distribution alliance with prominent established corporations are manually identified and denoted as 1, otherwise 0.

2.4. Control Variables

Variables at two levels, market level (overall venture capital accessibility) and firm level (idea quality), were included as controls to minimize potential confounding issues.

2.4.1. First round VC funding accessibility

I include a time-changing measure of resource richness of the venture capital industry. First round VC funding accessibility, is a continuous variable representing the ratio of dollar amount invested in first round VC deals divided by total dollar amount invested in all stages VC deals within 12 months prior to a given firm's first round VC investment. Since on average it took about 20 months for those firms that have successfully received VC funding to ink their first round deal within my study cohort, I choose 8^{th}-20^{th} month after its incorporation date as the "at risk" period for those firms who haven't received VC funding. All of the data was retrieved from VentureXpert database. According to VentureXpert's definition, only firms under the industry code of 4000 (Medical/Health/Life Sciences) were included.

2.4.2. Idea quality

The variable of idea quality in this study is built from the concept of patent-paper pair (Murray and Stern, 2005) and obtained from a detailed idea quality scoring system developed by Murray and Kanda (2005). Each firm's "Idea score" is a binary measure of invention quality taking into account of each invention's forward citation of patents and each invention's corresponding journal score which is a product of journal impact factor and the number of forward citation of published paper related to that invention. The journal impact factor of the publication is computed by ISI Web of Science, and it measures the average "impact" of articles in a particular journal on the basis of the average forward citations to articles (Murray and Kanda, 2005). A sample table is shown below.

Company name	Journal impact factor	Idea score	Binary	Key research publication journal	Journal name	# of Fwd citations	Journal impact factor	Journal score	Fwd citations of patents
Company 1	8.603	9	0	Noninvasive Detection of Fibrillation	IEEE Trans Biomed Eng	0	1.93	4	10
Company 2	7.252	7	0	A Method to Improve the Estimation of	IEEE Trans Biomed Eng	3	1.525	5	0
Company 3	5.033	5	0	Novel polymerized liposomes as potential	ABSTRACTS OF PAPERS OF THE	0	1.98	0	0
Company 4	12.822	13	1	J. 1990. "Calcium	Journal of Surgical Research	41	1.663	68	16
Company 5	1.964	2	0	POLYANHYDRIDES FOR CONTROLLED	BIOMATERIALS	46	2.489	114	68
Company 6	2.163	2	0	CONTACT SENSING FROM FORCE	INTERNATIONAL JOURNAL OF	19	1.045	20	6
Company 7	30.342	30	1	ANTIIDIOTYPE INDUCTION	HYBRIDOMA	24	0.574	14	0
Company 8	3.421	3	0	Increasing the potency of MHC class	VACCINE	8	2.811	22	5
Company 9	6.201	6	0	Efficient generation of human T cells from a	NATURE BIOTECHNOLOGY	18	12.822	231	0
Company 10	10.7	11	1	DIRECTED EVOLUTION OF A	PROCEEDINGS OF THE NATIONAL	131	10.7	1402	241
Company 11	28.956	29	1	Chlamydia pneumoniae infection	ANNALS OF NEUROLOGY	102	8.603	878	0
Company 12	10.7	11	1	ADENOSINE AGONISTS INHIBIT	FASEB JOURNAL	0	7.252	0	6
Company 13	4.357	4	0	Large porous particles for pulmonary drug	SCIENCE	119	28.956	3446	34
Company 14	1.266	1	0	Noise-mediated enhancements and	PHYSICAL REVIEW E	33	2.397	79	5
Company 15	7.252	7	0	NATURE GENETICS, 14 (3): 292-299 NOV	NATURE GENETICS	201	26.711	5369	15

Preliminary analysis using this patent-paper pair has demonstrated its validity as a measure of science quality, as it shows a robust correlation with whether the corresponding firm received first round venture funding. I utilized this measure to control the variation on idea/technology quality among sample start-up firms.

2.5. Statistical Analysis

Contingency tables with Chi square statistic or Fishers' exact test were used to determine if there were significant associations between any two of the eight categorical independent variables (founder/co-founder, SAB member, BOD member, join as FTE, Consultant, Co-research, Jr. Inventor as founder/co-founder and Jr. inventor FTE).

Independent variables that were highly associated or correlated were considered in different models to avoid collinearity.

Univariate analyses were also conducted between independent variables, control variables and dependent variables, namely successful first round VC funding and strategic alliance formation. All of the eight independent variables mentioned in Section 2.2 were compared one at a time between companies who successfully received first round VC funding and companies who did not, by means of contingency tables with Fisher's exact test or Chi-squared statistics, to identify if there was a difference in the proportions of those involvement characteristics between firms received external funding or not; Comparisons for those same independent variables between firms successfully formed strategic alliances and those who didn't were analyzed in a similar fashion to detect whether there was a difference in the proportions regarding those eight involvement characteristics between firms formed alliance or not. Details are shown in Section 3.2.

Multiple logistic regression analyses were then used to determine which factors was significantly associated with the likelihood of receiving first round VC funding or forming strategic alliance. In order to build multiple logistic regression models, a step-forward approach was used, with the level to enter set at a 2-sided $P < 0.05$ and the level to leave at a 2-sided $P > 0.2$. After there were no more variables remaining to enter the model, a step-backward approach was used to eliminate variables until only those significant at the 2-sided $P < 0.05$ level remained. All possible 2-way interactions of significant variables were tested by introducing one interaction into the model at a time. A 2-sided $P < 0.05$ indicates statistical significance. All of the analyses were performed with the use of Statistical Analyses Software release 8.2 (SAS, Cary, NC).

3. Results

3.1 Descriptive Statistics

Based on faculty's responses to the questionnaire, table 3.11 lists some of the key statistics about their involvement in the ventures formed to commercialize their invention. "Act as a SAB member" seems to be the most common role for faculty inventors to get involved in the spin-off venture, 40 out of 60 venture had at least one of their faculty inventors sat on their SAB (67%). Other common roles held by faculty inventors include consultant (66%) and co-founder (60%), but there was none faculty joined the firm to work full time. Among the 60 firms, there were 47 firms had a least one of the faculty inventors took at least one of following five roles: being co-founder of the firm, acted as SAB member, BOD member, consultant or conducted co-research with the firm.

Table 3.11: Frequency Table

	Number of firms with valid response (N)	Positive answer (N)	%
■ Inventors' Singular Involvement			
Faculty inventor as (co)founder	60	36	60%
Faculty inventor as SAB Member	60	40	67%
Faculty inventor as BOD Member	59	18	31%
Faculty inventor join as FTE	60	0	0%
Faculty inventor as consultant	59	39	66%
Faculty inventor conduct co-research	59	14	24%
Jr. inventor as (co)founder	48	14	29%
Jr. inventor joined as FTE	46	10	22%
Faculty inventor involved in at least one of above 6	60	47	78%
■ Inventors' Multiple Involvement			
Faculty as (co)founder + SAB + BOD + Consultant + co-research	60	2	3%
Faculty as (co)founder + SAB + BOD + Consultant	60	15	25%
Faculty as (co)founder + SAB	60	33	55%
Faculty as (co)founder + consultant	60	30	50%
Faculty as (co)founder + SAB + Consultant	60	27	45%
Faculty as SAB + BOD	60	17	28%
■ Firm Performance			
Received 1st round VC funding*	60	40	67%
Formed strategic alliance	60	31	52%
Exited through IPO or M&A	60	30	50%

* Average days to first round VC funding is 599 days. Average size of first round VC funding is $3 million.
** Average days to first major strategic alliance is 1647 days.

In addition, only two ventures have faculty inventor took all five roles in the venture – faculty inventor became co-founder, SAB member, BOD member, and consultant and conducted joint research with the firm simultaneously. The most common multiple involvement for faculty inventor is co-founding the firm and sitting on its SAB – 33 out of 60 firms had faculty inventor took these two roles simultaneously.

Among the 60 firms that sent valid responses back, forty (40) or 67% of them received first round venture capital funding; Thirty one (31) or 52% formed strategic alliance with established biopharmaceutical corporations.

Table 3.12 and table 3.13 break down the total number of firms by faculty inventor's role as co-founder and junior inventor's involvement (acted as co-founder or joined the firm as FTE). 44 out of 60 ventures (73%) had no junior inventor's involvement in the spin-off firms and 24 ventures (40%) weren't co-founded by faculty inventor. Firm co-founded by faculty inventor with no involvement from junior inventor is the most common way of forming a spin-off venture in the study cohort (24 out of 60 ventures). This type of ventures has the highest rate of receiving venture capital funding (79%) and forming strategic alliances with established biopharmaceutical corporations (67%).

Table 3.12: Founding Involvement - Faculty vs. Junior Inventors

	N (% received VC funding)	
	Jr. inventor <u>NOT</u> involved as a co-founder or FTE (0)	Jr. inventor involved as a co-founder or FTE (1)
Faculty inventor NOT act as founder(0)	20 (55%)	4 (25%)
Faculty inventor act as a (co)founder (1)	24 (79%)	12 (75%)

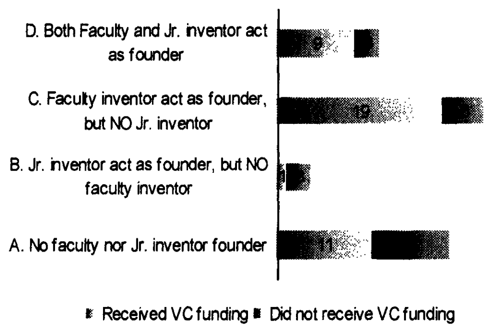
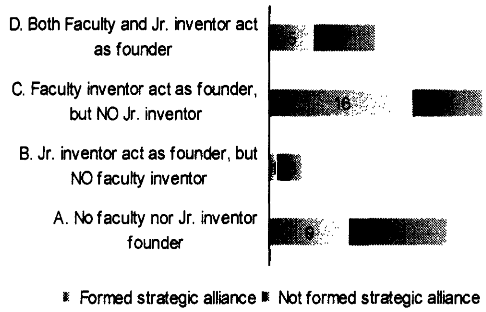


Table 3.13: Founding Involvement - Faculty vs. Junior Inventors

	N (% formed alliances)	
	Jr. inventor NOT involved as a co-founder or FTE (0)	Jr. inventor involved as a co-founder or FTE (1)
Faculty inventor NOT act as founder(0)	20 (45%)	4 (25%)
Faculty inventor act as a (co)founder (1)	24 (67%)	12 (42%)



In general, faculty inventor's involvement as co-founder increases the rate of receiving VC funding increases from 55% to 79% when junior inventors are not involved. When junior inventor did get involved, rate of receiving VC funding also increases from 25% to 75%. Similarly, faculty inventor's involvement as co-founder increases the percentage of forming strategic alliances from 45% to 67% when junior inventor wasn't involved. The percentage increases from 25% to 42% when junior inventor did get involved.

On the other hand, the involvement of junior inventor decreases the percentage of receiving VC funding from 55% to 25% when faculty was not a co-founder. When faculty did get involved as a co-founder, the drop on the rate of receiving VC funding is slight, from 79% to 75%. When looking at forming strategic alliance as an outcome, again, involvement of junior inventor would decrease the success rate from 45% to 25% if faculty was not involved as co-founder. The success rate would drop from 67% to 42% if they are co-founder of the venture.

In summary, involvement of faculty inventor as co-founder helps increase the likelihood of receiving VC funding and successfully forming strategic alliance; while junior inventor's involvement decreases the chance of receiving VC funding and forming alliances with established corporations.

Table 3.14 and table 3.15 illustrate the number of firms by faculty's role as SAB member and by junior inventor's involvement. Faculty inventor served as SAB member but no junior inventor's participation seems to be the most common form in this particular comparison (27 out of 60 ventures). This type of ventures has the largest portion received VC funding (78%) and formed strategic alliances (63%).

A pattern similar to faculty inventor's involvement as a co-founder can be observed here. When junior inventors are not involved, faculty inventor's involvement as SAB member increases the percentage of firms that received VC funding from 53% to 78%. If junior inventor did get involved in the venture, faculty's participation as SAB member also increases the percentage from 33% to 69%. Similarly, faculty inventor's involvement as SAB member increases the percentage of forming strategic alliances from 47% to 63% when junior inventor wasn't involved. The percentage increases from 33% to 38% when junior inventor did get involved.

Table 3.14: Involvement - Faculty as SAB member vs. Jr. Inventors

	N (% received VC funding)	
	Jr. inventor NOT involved in as co-founder or FTE (0)	Jr. inventor involved as co-founder or FTE (0)
Faculty inventor NOT involved as a SAB member (0)	17 (53%)	3 (33%)
Faculty inventor involved as a SAB member (1)	27 (78%)	13 (69%)

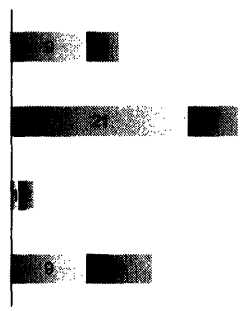
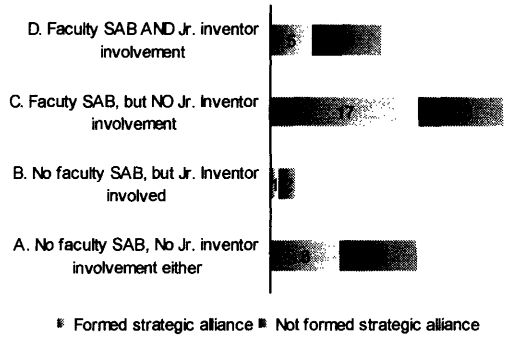


Table 3.15: Involvement - Faculty as SAB member vs. Jr. Invento

	N (% formed alliances)	
	Jr. inventor NOT involved as a co-founder or FTE (0)	Jr. inventor involved as a co-founder or FTE (1)
Faculty inventor NOT on SAB (0)	17 (47%)	3 (33%)
Faculty inventor on SAB (1)	27 (63%)	13 (38%)



On the other hand, the involvement of a junior inventor decreases the percentage of receiving VC funding from 53% to 3% when the faculty inventor was not an SAB member. When faculty did get involved as a SAB member, the drop on the rate of receiving VC funding is smaller, from 78% to 69%. When looking at forming strategic alliance as an outcome, involvement of junior inventor decreases the success rate from 47% to 33% if faculty was not involved as SAB member. The success rate would drop from 63% to 38% if faculty inventor sits on the SAB of the venture.

To sum up, involvement of faculty inventor as SAB member helps increase the likelihood of receiving VC funding and successfully forming strategic alliance; while junior inventor's involvement decreases the chance of receiving VC funding and forming alliances with established corporations.

When compare overall faculty inventor's involvement vs. junior inventor's involvement, any form of faculty inventor's involvement (co-founder, SAB member, BOD member, consultant, co-researcher) with no junior inventor's participation remain the most common form (34 out of 60 ventures). 74% of these ventures received VC funding and 59% of them successfully formed strategic alliances with established biopharmaceutical corporations. Results are summarized in table 3.16 and 3.17.

Table 3.16: Overall involvement - Faculty vs. Junior Inventor

	N (% received VC funding)	
	Jr. inventor NOT involved as a co-founder or FTE (0)	Jr. inventor involved as a co-founder or FTE (1)
Faculty inventor NOT involved in any form (0)	10 (50%)	3 (33%)
Faculty inventor involved in some form (1)	34 (74%)	13 (69%)

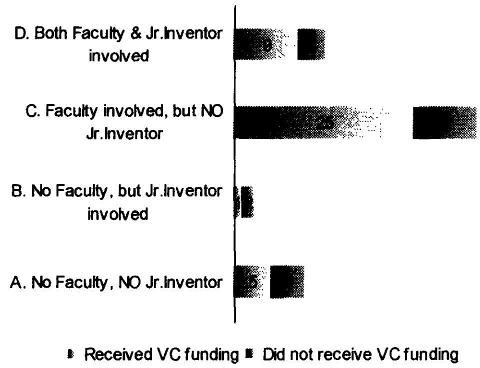
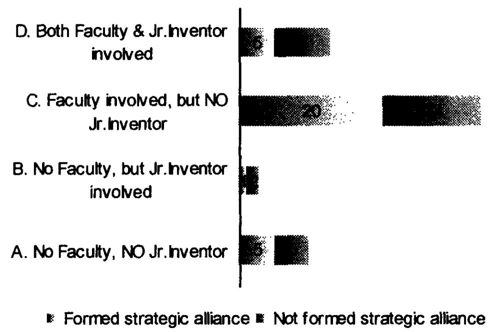


Table 3.17: Overall involvement - Faculty vs. Junior Inventor

	N (% formed alliances)	
	Jr. inventor NOT involved as a co-founder or FTE (0)	Jr. inventor involved as a co-founder or FTE (1)
Faculty inventor NOT involved in any form (0)	10 (50%)	3 (33%)
Faculty inventor involved in some form (1)	34 (59%)	13 (38%)



General observations here are similar to previous results. Faculty inventor's any involvement (co-founder, SAB member, BOD member, consultant or co-researcher) increases the likelihood of receiving VC funding (50% to 74% when junior inventor not involved, or 33% to 69% when they were involved) and forming strategic alliance (50% to 59% when junior inventor not involved or 33% to 38% when they were involved). The involvement of junior inventors decreases the likelihood of receiving VC funding (50% to 33% if faculty inventor not involved or 74% to 69% if they were involved) and forming of alliances (50% to 33% if faculty inventor not involved or 59% to 38% if they were involved).

3.2 Statistical Analysis Results

Aforementioned descriptive analysis shows the general effects of faculty inventor's involvement (co-founder, SAB or any other role) and junior inventor's involvement on the likelihood of venture receiving VC funding and forming strategic alliances. In this section, I conduct statistical analysis to confirm the findings by testing their significant level. Associations among all dependent, independent and control variables (first round VC funding, strategic alliances, founder/co-founder, SAB member, BOD member, join as FTE, consultant, co-research, Jr. inventor co-founder, Jr. inventor FTE, Jr. inventor's involvement, idea quality and first round VC capital accessibility) in this study are provided in Table 3.2. Findings are summarized as follows:

Table 3.2.1: Association among all variables

Variables	1 (N)	2 (N)	3 (N)	4 (N)	5 (N)	6 (N)	7 (N)	8 (N)	9 (N)	10 (N)	11 (N)	12 (N)
Dependent Variables												
1 First round VC funding			**0.0253* (60)**	**0.0528** (60)**	0.5501 (60)	NA	0.5659 (60)	0.2591 (59)	0.1009 (60)	0.2656 (48)	0.1848 (46)	0.6797 (60)
2 Strategic Alliances			0.2057 (60)	0.4650 (60)	0.6931 (60)		0.9352 (60)	0.9421 (59)	0.6531 (60)			0.1854 (60)
Independent Variables												
3 Faculty inventor as co-founder				<0.0001 (60)	0.0004 (60)	NA	0.0003 (60)	0.0213 (59)	NA	0.7972 (48)	0.8423 (46)	0.1527 (60)
4 SAB Member					0.0028 (60)	NA	0.0006 (60)	0.6297 (59)	NA	0.2616 (48)	0.7196 (46)	0.1485 (60)
5 BOD Member						NA	0.0017 (60)	0.1312 (59)	NA	0.0130 (48)	0.1285 (46)	0.0116 (60)
6 Faculty as FTE							NA	NA	NA	NA	NA	
7 Consultant								0.0022 (59)	NA	0.6534 (48)	0.2534 (46)	0.7134 (60)
8 Co-research									NA	0.0270 (47)	0.0325 (45)	0.0896 (59)
9 Any faculty's involvement										0.9480 (48)	0.4740 (46)	1.0000 (60)
10 Jr. inventor founder as co-founder											<0.0001 (46)	
11 Jr. inventor as FTE												
12 Jr. inventor involvement												
Controls												
13 Idea Quality	0.3627 (23)		0.9069 (23)	0.3627 (23)	0.4719 (23)	NA	0.3627 (23)	0.9309 (23)	0.4820 (23)	0.7636 (19)	0.7098 (18)	
14 1st round VC funding accessibility	**0.0224* (60)**											

- Whether faculty inventor found the firm or not is significantly associated with first round VC funding (p=0.0253), suggesting that further multivariate regression model should be built to further understand its significance.
- Whether a faculty inventor sits on the SAB is a "border line" issue (p=0.0528); further multivariate regression models could be built to find if other factors would influence its significance.
- None of the independent variables are found to be significantly associated with dependent variable "strategic alliances".
- The variable "Founder inventor as co-founder" was strongly associated with SAB membership, BOD membership, consultant status and co-research status.

- Similarly, whether a faculty inventor sat on the SAB was strongly associated with his/her BOD membership, consultant status and whether a faculty inventor joined the venture as a full time employee.
- Whether a faculty inventor was a member of BOD was strongly associated with whether he/she was a consultant for the company and whether a junior inventor was a co-founded or had any involvement with the firm.
- Whether a faculty inventor did consulting work for the company was significantly associated with whether he/she conducted joint research with the firm;
- Whether a faculty inventor conducted joint researched with the firm was also strongly correlated with whether a junior inventor was co-founder of the company or joined the venture as a full time employee;
- Whether a junior inventor involved in the founding of the company was strongly associated with whether he/she joined the company full time.
- A limited number of samples for idea quality (23) affects its legality being used as a control variable.
- First round VC funding accessibility is significantly associated with dependent variable "first round VC funding" and can be used as a control variable.

Given many independent variables are strongly associated with each other, "faculty inventor as a co-founder" and "SAB" will have to be studied in separate models (Table 3.2.2 and Table 3.2.3) to avoid collinearity which, if not, would consequently result in instability of the estimates. In addition, since faculty related independent factors are not strongly associated with junior inventor's involvement, they can be adjusted for each other in the multivariate regression models.

Table 3.2.2 presents the results from multiple logistic regression models studying the adjusted effect of selected independent variables (Faculty as co-founders and SAB) and control variables (first round VC funding accessibility) on companies' likelihood of receiving first round VC funding.

Table 3.2.2: Multiple regression models on whether ventures received VC funds*

	Model 1					Model 2				
	Estimate	Std. Error	Wald ChiSq	Pr>ChiSq	OR (95% CI)	Estimate	Std. Error	Wald ChiSq	Pr>ChiSq	OR (95% CI)
Independent Variables (0 vs.1)										
Faculty inventor as co-founder	-0.6870	0.2994	5.2662	**0.0217**	0.253 (0.078-0.818)	-1.0513	0.3781	7.7291	**0.0054**	0.122 (0.028-0.538)
SAB Member										
BOD Member										
Faculty as FTE										
Consultant										
Co-research										
Jr. inventor's involvement (co-founder+FTE)	0.2951	0.3318	0.7906	0.3739	1.804 (0.491-6.626)	0.3757	0.3795	0.9801	0.3222	2.120 (0.478-9.385)
Control Variables (0 vs.1)										
1st round VC funding accessibility						21.6264	8.0867	7.1519	0.0075	>999.999(322.687, >999.999)
Idea Quality										
Intercept	0.4887	0.3223	2.3002	0.1294		-5.6284	2.2729	6.1320	0.0133	

	Model 3					Model 4				
	Estimate	Std. Error	Wald ChiSq	Pr>ChiSq	OR (95% CI)	Estimate	Std. Error	Wald ChiSq	Pr>ChiSq	OR (95% CI)
Independent Variables (0 vs.1)										
Faculty inventor as co-founder										
SAB Member	-0.6045	0.3004	4.0491	**0.0442**	0.299(0.092-0.969)	-0.7762	0.3403	5.2021	**0.0226**	0.0212 (0.056-0.804)
BOD Member										
Faculty as FTE										
Consultant										
Co-research										
Jr. inventor's involvement (co-founder+FTE)	0.2678	0.3256	0.6766	0.4108	1.709 (0.477-6.122)	0.2942	0.3518	0.6994	0.403	1.801 (0.454-7.152)
Control Variables (0 vs.1)										
1st round VC funding accessibility						16.7424	6.8213	6.0243	0.0141	>999.999 (29.164, >999.999)
Idea Quality										
Intercept	0.4159	0.3287	1.6009	0.2058		-4.3371	1.9243	5.0796	0.0242	

* Note: After testing, no significant interactions were found between each pair of these independent variables, therefore, interactions results are not shown in these tables.

As shown in Model 1, when a faculty inventor was NOT acting as a co-founder, the chance of getting first round VC funding for start-up ventures was only 25.3% (OR [95% CI]: 0.253 (0.078-0.818)) of those with the faculty inventor as a co-founder. On the one hand, this association remained statistically significant (p=0.0217), even after adjusting for a junior inventor's involvement. On the other hand, junior inventor's involvement was not associated with first round VC funding results (p=0.3739).

Model 2 was built based on Model 1 with an additional factor – the effect of first round VC funding availability in the capital market: when the faculty inventor is NOT acting as a co-founder, the start-up venture's chance of getting first round VC funding is only 12.2% (OR [95% CI]: 0.122 (0.028-0.538)) of those ventures with the faculty inventor as co-founder. This adjusted association was even more statistically significant (p=0.0054) after controlling for VC market's ups and downs. The junior inventor's involvement was not associated with whether the venture was funded (p=0.3222).

As shown in Model 3 of Table 3.2.2,, when faculty NOT sitting on the SAB, the chance of getting first round VC funding for start-up ventures was only 30% (OR [95% CI]: 0.299(0.092-0.969)) of those with faculty inventor as a SAB member. This association remained statistically significant (p=0.0442), after adjusting for a junior inventor's involvement. On the other hand, a junior inventor's involvement was not associated with first round VC funding results (p=0.4108).

Model 4 takes Model 3's results and further controls for first round VC funding availability in the capital market: when the faculty inventor was NOT acting as a SAB member, the start-up venture's chance of getting first round VC funding was only 21.2% (OR [95% CI]: 0.212 (0.056-0.804)) of those ventures with the faculty inventor on the SAB. This adjusted association was even more statistically significant (p=0.0226) after controlling for the VC market's ups and downs. A junior inventor's involvement was still not strongly associated (p=0.403).

Table 3.2.3 presents the results from multiple logistic regression models studying the adjusted effect of selected independent variables (faculty inventors as co-founders and SAB member) and control variables (first round VC funding accessibility) on companies' likelihood of forming strategic alliances with established biopharmaceutical corporations.

Table 3.2.3: Multiple regression models on whether ventures formed strategic alliances*

	Model 1					Model 2				
	Estimate	Std. Error	Wald ChiSq	Pr>ChiSq	OR (95% CI)	Estimate	Std. Error	Wald ChiSq	Pr>ChiSq	OR (95% CI)
Independent Variables (0 vs.1)										
Faculty inventor as co-founder	-0.4347	0.2817	2.3807	0.1228	0.419 (0.139-1.265)	-0.5392	0.303	3.1679	0.0751	0.34 (0.104-1.115)
SAB Member										
BOD Member										
Faculty as FTE										
Consultant										
Co-research										
Jr. inventor's involvement (co-founder+FTE)	0.4982	0.3150	2.5007	0.1138	2.708 (0.788-9.311)	0.4833	0.3248	2.2148	0.1367	2.629 (0.736-9.390)
Control Variables (0 vs.1)										
1st round VC funding accessibility						8.2873	4.7178	3.0857	0.079	>999.999(0.383, >999.999)
Idea Quality										
Intercept	-0.2515	0.3180	0.6255	0.4290		-2.6743	1.4074	3.6106	0.0574	

	Model 3					Model 4				
	Estimate	Std. Error	Wald ChiSq	Pr>ChiSq	OR (95% CI)	Estimate	Std. Error	Wald ChiSq	Pr>ChiSq	OR (95% CI)
Independent Variables (0 vs.1)										
Faculty inventor as co-founder										
SAB Member	-0.2878	0.2867	1.0074	0.3155	0.562 (0.183-1.730)	-0.3365	0.2986	1.2701	0.2597	0.51 (0.158-1.644)
BOD Member										
Faculty as FTE										
Consultant										
Co-research										
Jr. inventor's involvement (co-founder+FTE)	0.4558	0.3094	2.1697	0.1408	2.488 (0.740-8.370)	0.4221	0.3149	1.7969	0.1801	2.326 (0.677-7.991)
Control Variables (0 vs.1)										
1st round VC funding accessibility						7.1646	4.3415	2.7234	0.0989	>999.999 (0.261->999.999
Idea Quality										
Intercept	-0.2422	0.3269	0.5492	0.4587		-2.3295	1.2977	3.2225	0.0726	

* Note: After testing, no significant interactions were found between each pair of these independent variables, therefore, interactions results are not shown in these tables.

In Model 1, when a faculty inventor was NOT acting as a co-founder, the chance of forming strategic alliances for start-up ventures was 42% (OR [95% CI]: 0.419 (0.139-1.265)) of those with faculty inventor as a co-founder. On the one hand, this association was NOT statistically significant (p=0.1228), even after adjusting for a junior inventor's involvement. On the other hand, junior inventor's involvement was not associated with first round VC funding results (p=0.1138).

Model 2 was built based on Model 1 with an additional factor, the effect of first round VC funding availability in the capital market. When the faculty inventor was NOT acting as a co-founder, the start-up venture's chance of forming strategic alliances was 34% (OR [95% CI]: 0.34 (0.104-1.115)) of those ventures with faculty inventor as co-founder. This adjusted association was NOT statistically significant (p=0.0751) after controlling for VC market's ups and downs. A junior inventor's involvement was not associated with whether the venture was funded (p=0.1367).

As shown in Model 3 of Table 3.2.3,, when the faculty inventor was NOT sitting on the SAB, the chance of forming strategic alliances for start-up ventures was 56.2% (OR [95% CI]: 0.562 (0.183-1.730)) of those with faculty inventor as a SAB member. This association was NOT statistically significant (p=0.3155), after adjusting for a junior inventor's involvement. But a junior inventor's involvement was not associated with first round VC funding results (p=0.1408).

Model 4 takes Model 3's results and further controls for first round VC funding availability in the capital market: when the faculty inventor was NOT acting as a SAB member, the start-up venture's chance of forming strategic alliances is 51% (OR [95% CI]: 0.51 (0.158-1.644)) of those ventures with faculty inventor on the SAB. This adjusted association was even more statistically significant (p=0.2597) after controlling for VC market's ups and downs. A junior inventor's involvement is still not strongly associated (p=0.1801).

4. Discussion

4.1. Summary of findings

This study has examined some factors that might influence the initial performance of university spin-off firms. Particular emphasis was placed on whether faculty's involvement in the new ventures matters and how faculty's various roles affect the first round VC funding decisions and venture's capability in forming strategic alliances with established Biopharmaceutical corporations, taking account into the capital market conditions and the quality of the invention itself. Despite the obvious self-report limitations of this study and the problems of bias introduced by the survey methodology itself, there are several interesting results. A summary of findings can be found in Table 4.1.

Table 4.1: Summary of findings

Hypothesis	Finding		Hypothesis rejection
	Direction of Impact	Significance level	
1.1: Faculty inventor as co-founder is significantly associated with 1st round VC funding results	Positive	Significant	Can NOT be rejected
1.2: Faculty inventor as co-founder is significantly associated with venture's capability of forming strategic alliances	Positive	Insignificant	Rejected
2.1: Faculty inventor sitting on the SAB is significantly associated with 1st round VC funding results	Positive	Significant	Can NOT be rejected
2.2: Faculty inventor sitting on the SAB is significantly associated with venture's capability of forming strategic alliances	Positive	Insignificant	Rejected
3: Any faculty inventor's involvement is significantly associated with receiving 1st round VC funding and the forming of strategic alliances	Positive	Insignificant	Rejected
4: Any junior inventor's involvement is significantly associated with receiving 1st round VC funding and the forming of strategic alliances	Negative	Insignificant	Rejected

Analyzing a cohort of new biomedical firms founded to exploit MIT-assigned inventions during the 1978-2003 period, the study shows that when considered as stand-alone factors, faculty as co-founders or SAB members of the spin-off venture had positive impacts on and significant association with a venture's chances of receiving first round VC funding. This positive impact and significant association remained after adjusting for a junior inventor's involvement and after controlling for first round VC market's condition. Therefore, hypothesis 1.1 and 2.1 cannot be rejected.

Similarly, when considered as stand-alone factors, although faculty inventors acting as co-founders or SAB members had a positive impact on a venture's capability to form strategic alliances, their associations were NOT significant. These associations remained insignificant, even after being adjusted for a junior inventor's involvement and the VC capital market's condition. Therefore, hypothesis 1.2 and 2.2 are rejected.

When considering any faculty inventor's involvement as one factor (any one role, whether as co-founder, SAB member, BOD member, consultant, or co-researcher), I find that it is neither significantly associated with receiving first round VC funding nor significantly associated with forming strategic alliances. Therefore, hypothesis 3 is rejected.

Similarly, when considering any junior inventor's involvement as one independent variable (either with the junior inventor acting as a co-founder or joining the firm as a full time employee), this is not significantly associated with receiving first round VC funding or forming strategic alliances. Therefore, hypothesis 4 is rejected.

4.2. Discussion

Previous empirical studies (Jesen and Thursby, 2001; Wright et al. 2004) have suggested that a faculty inventor's involvement was important to university technology transfer, as well as to the growth of university spin-off firms. In general, my finding that there is a positive impact on attracting first round VC funding and forming strategic alliances resulting from a faculty inventor's involvement in university spin-off firms supports these empirical studies.

When a faculty inventor sees the commercial potential of his/her invention, he/she usually wants be part of the core founding team that explores the best way to productize the technology. Whether or not the original inventor helps found the university spin-off firm may indicate how confident and committed the faculty inventor is to his/her invention, thus sending a strong signal to potential investors. On the one hand, when venture capitalists make their first round funding decision, uncertainty and information asymmetries often force them to rely on such signaling effects as the faculty inventor's enthusiasm and commitment to the invention. On the other hand, when large corporations make strategic alliance decisions, it is normally much later than the first round VC funding decision (in my study, the average number of days to first round VC funding was 599, while it took an average of 1647 days to form first strategic alliances). Therefore, large corporations require a great deal of data to evaluate a deal. This explains why a faculty inventor acting as co-founder is significantly associated with a new venture's ability to secure first round VC funding (finding 1.1) but not to form strategic alliances with large corporations (finding 1.2).

When a faculty inventor becomes a member of SAB, while the inventor may provide high level directional advice on the technology area upon which the new venture should focus, he/she may not have much technical expertise on how to bridge the knowledge gap. This type of "big picture" advice could be very useful in the early stages when first round VC funding decisions are about to be made. When large corporations consider signing a co-market, co-promotion, collaboration, or distribution alliance agreement, the university spin-off venture should be in a stage where a compound, large molecule or device prototype is ready. At this stage, the value an SAB member brings to the venture is considerably more limited than in the earlier stages, and my study shows that acting as a SAB member is significantly associated with first round VC funding results (finding 2.1) but not with forming strategic alliances (fining 2.2).

Although finding 3 confirms that a faculty inventor's involvement helps with first round VC funding and forming strategic alliances, it does not support this association statistically. There are two possible reasons for this. The first is error due to limited sample size and incomplete information on various variables of each firm. There are only 22 firms with full information covering all of the independent and control variables, thus leading to limited statistical power on univariate analysis and multiple logistic regression analyses. Another possibility is that there is no significant association between any faculty inventor's involvement and the receiving of first round VC funding, thereby reflecting the dilemma that many venture capitalists are facing: on the one hand, they hope a faculty inventor brings as much tacit knowledge as possible to the firm by actively being involved in the firm's early stage operation, especially in R&D and technology development; on the other hand, they are worried about the firm becoming too research-oriented, which, in turn, may lead to lower market and commercial sensitivity.

Interestingly, my study finds that a junior inventor's involvement has a negative impact on a firm's ability to receive VC funding or form strategic alliances. Unfortunately, there is a scarcity of literature in this area. Having a junior inventor but not a faculty inventor involved in the commercialization of an invention is a "negative" signal to both venture capitalist and strategic partners – it shows that the faculty inventor is not passionate about nor committed to the invention, if he/she wants to send a junior inventor over to "explore" the situation. In another scenario, where both faculty inventors and junior inventors are involved, potential investors might think the venture's culture is dominated by the academic researchers, and that it will be hard to bring outsiders in, thereby deterring them from investing in or partnering with the venture. Clearly, further study needs to be conducted in this area to better explain the reason behind a junior inventor's negative impact on VC funding and partnering.

4.3. Limitations

While this study provides important new insights into faculty inventors' roles in university spin-off new ventures, and analyzes faculty and junior inventors' involvement as a factor for performance, it is not without its limitations. One major shortcoming is the limited source of study population. The study is based on data from 96 biomedical spin-offs with their core inventions and technologies licensed from only one institution – MIT. Therefore, there is likely a limited representative issue here. In addition, previous studies have found that the presence of a medical school is related to productivity measures of university licensing in biomedical technology domain (Thursby and Kemp, 2000). Thus, given the geographic proximity of Harvard Medical School (HMS), its affiliated teaching hospitals, not to mention the reputation of MIT, technology spinning out of the institute may relatively easily obtain VC funding. Moreover, as mentioned in the previous chapter, the university and its Technology Licensing Office (TLO) are fundamental to the birth and growth of university spin-off firms (Kassicieh et al., 1996; Link et al., in press; Siegel et al., in press). MIT's TLO is well-known and trusted in the biomedical investment and technology partnering community, and its policies and procedures may be favorable to spin-off companies. Furthermore, MIT's self-enforcing entrepreneurial environment may have some impact on the growth and performance of those spin-off firms. Given these factors, the study's findings should be interpreted with caution; because of possible selection bias, some conclusions may not be generalized to include all university spin-offs.

Another limitation may reside in the methodology itself. Surveys were sent to 110 faculty inventors, and 31 valid responses were received. There might be a difference between those faculty inventors who responded and those who did not. For example, those with good experiences with university spin-offs might be more willing to provide information, and the 31 valid responses may not be a fair, representative, and even distribution of all biomedical spin-offs from MIT. In addition, during raw data processing, a firm was coded as "1" if there was at least one faculty inventor involved as founder/co-founder, SAB member, BOD member, consultant, or co-researcher. In another words, a firm with multiple faculty inventors involved would be treated in the same fashion as it would if only one faculty inventor were involved. But empirical evidence suggests that multiple inventors' involvement in a single firm might have a more positive impact on firm's performance.

Furthermore, due to limited information on idea quality (only 23 spin-off firms have idea quality scores), I was not able to use this variable as an effect control for other independent variables. For instance, a faculty inventor's significant association with first round VC funding results could be merely an indirect result of idea quality, which was represented via the faculty inventor's involvement in the study. In addition, there might be other potentially confounding issues not included in my analysis. For example, market complexity, market growth rate and market acceptance toward a start-up's product and services could influence the probability of receiving VC funding (Heirman et al. 2004); Besides, research-based start-ups that develop early stage innovative and broad technologies (platform technologies) are more likely to raise venture capital (Shane, 2005), while those focusing on a concrete product opportunity are typically financed with debt rather than VC. Product/technology stage could be another related factor influencing VC's decisions.

Lastly, but certainly not least, certain other uncontrolled issues may have an impact on the results. For example, inventions from one of the most prolific inventors at MIT were licensed to 24 university spin-offs. Although this academic was just one of the co-inventors or co-founders of most of the 24 spin-offs, some of his personal choices (i.e. preferring to do research at MIT rather than to co-research with the start-up) may have had an impact on this relatively small scale study with only 59 valid samples.

Given the aforementioned limitations, therefore, results from this study should be interpreted with caution.

4.4. Future Research

Overall, the study of the role faculty play in biomedical start-up ventures could benefit all parties involved: the faculty themselves, the spin-off firms, the university licensing offices and venture investors in the long run.

In future work, a broadened sample set, covering larger number of spin-offs firms at more universities from different geographic locations would provide much more statistical power in analysis, and as a result, would yield a better perspective on how a faculty inventor's involvement might influence performance. With a larger sample size, research could be extended to include more finely-segmented variables. For example, technologies could be broken down to platform vs. product-oriented technology, BioPharma pathway vs. devices, and so on. These detailed categories would better reflect the overall situation, and therefore, would filter out potential confounders in VC's decision making.

Future research may consider alternative research methods, i.e. using continuous variables rather than binary categorical ones to retain accurate information for more robust statistical power. And employing other study designs, i.e. case control, might improve the statistical analysis quality.

It would also be interesting to take a more in-depth look at why junior inventors' involvement as founders/co-founders or full-time employees decreased the probability of receiving first round VC funding or forming strategic alliances.

5. Conclusion

Since the passage of Bayh-Dole Act in 1980 and the Federal Technology Transfer Act in 1985, university technology transfer has grown dramatically. An increasing number of these transferred technologies have been licensed to university spin-off firms to further commercialize the inventions, especially in the biomedical science area. The present study of faculty inventors' involvement in 60 biomedical ventures formed to pursue technology spinning out of MIT helps shed some light on this issue.

In general, the study finds that a faculty inventor's involvement had a positive impact on the likelihood of receiving first round VC funding and forming strategic alliances, although this was not statistically significant. In contrast, a junior inventor's involvement had a negative impact on the chances of receiving first round VC funding and forming strategic alliances, but no significant association has been found here either.

More specifically, the faculty inventor acting as a co-founder was significantly associated with the likelihood of receiving first round VC funding. This significance level remained, after adjusting for a junior inventor's involvement and was further strengthened after controlling for first-round venture capital market condition. However, the faculty inventor's role as a co-founder was not found to be significantly associated with venture's capability of forming strategic alliances with established biopharmaceutical corporations, even when adjusted for other non-correlated variables and controls.

Similarly, the faculty inventor's role as a scientific advisory board inventor was on the border line when examined as a stand-alone factor. After adjusting for the junior inventor's involvement, it was significantly associated with the likelihood of receiving first round VC funding but not with its capability of forming strategic alliances. Further, when controlled for first-round venture capital resource richness, the faculty inventor's role as an SAB member was even more significantly associated with likelihood of being funded by venture capital firms, even though still not significant in its capability to form strategic alliance.

The descriptive evidence and statistical analysis in this study replicated and supported previous empirical studies (Jesen and Thursby, 2001; Wright et al. 2004) which suggested that faculty's involvement was important to university technology transfer as well as the growth and performance of university spin-off ventures.

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Appendix I: Questionnaire sent to faculty inventors

Company name: __________ Date: _______, Time: ______ Venue: ________

Interviewee: Prof.________

FOUNDING:

1. Would you consider yourself a founder or co-founder of the company? (Yes/No):

2. Did any of the following junior inventors serve as co-founders of the company? (Yes/No)

- A

- B

- C

Were there any other co-founders (if so who)?

After the founding of the company we are interested in the on-going role of the inventors with the company:

3. Were you a member of the Scientific Advisory Board? (Yes/No):

4. Were you a member of the Board of Directors? (Yes/No):

5. Did you take any managerial position within the company for a period of time (e.g. CEO, CSO etc.) - for example as a leave of absence or sabbatical? (Yes/No):

If yes, what role?

6. Did any of the following junior inventors join the company as full-time employee? (Yes/No)

- A

- B

- C

7. Did you act as a consultant to the company? (Yes/No)

8. Did you do any joint research with the company after it was incorporated? (Yes/No):

End of survey. Thank you very much!