High Risk Venturing:
An Empirical Investigation of
University Technology Licensing to
Start-Ups and Young Private Firms

IHELG Monograph
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- Conferences
- Bibliographical and document service
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Introduction

A promising young drug company, Seragen, Inc... was developing a new class of drugs that scientists believed might someday be a “magic bullet” in the fight against cancer... Seragen was not just the purveyor of a magic bullet against disease; it was the cure for Boston University’s chronic financial needs, the wonder drug that would propel the university’s modest investment into Ivy League ranks and, maybe, win a Nobel Prize for one of its faculty members... The university poured tens of millions into the company... but will not reap much of the benefit... Out of money and delisted from the NASDAQ stock market, Seragen was acquired by... a San Diego company whose shares promptly tumbled when the deal was announced... To the university, that represented a 90 percent loss on its investment... For just the $50 million that the school put into Seragen as of 1989, it could have $175 million today had it instead put the money into a mutual fund. (Barboza, 1998: 1,13).

While extreme in scale and scope, the experience of Boston University and its colorful president, John Silber, nevertheless reflects a growing trend among institutions of higher education, particularly large research universities, to pursue uncharacteristically risky paths in the ongoing quest to generate new sources of revenue (Bourke & Weissman, 1990; Jennings, 1992). As federal and state funding for higher education has contracted and expectations for the use of scarce resources risen, colleges and universities have increasingly felt the pressure to at least maintain, if not expand, a base from which to supply its labor intensive enterprise (Winston, 1998).

One mechanism for expanding resources, as demonstrated in the Boston University case, is through the use of university start-up companies established for the purpose of developing marketable products around a faculty invention or intellectual property. Rather than following the more traditional licensing route whereby a technology is licensed to a large, public firm, a relatively inefficient means of capturing the full value of a patented or copyrighted idea, universities are participating as equity partners and venture capitalists in quasi-independent start-ups or small private firms in the hopes of realizing enormous financial gain. In essence, these institutions hope to create the next Xerox or Polaroid Corporation, companies built on university born inventions (Matkin, 1990).

Unfortunately, as the Boston University example captures, the potential for lucrative returns is highly speculative and contingent upon a start-up success rate that is notoriously low. Research on start-up firm failure, depending on how it is measured, suggests that at best fewer than 50 percent survive past the first five years and less than two of ten reach the ten year milestone (Slaughter & Leslie, 1997). Nevertheless, universities are increasingly willing to venture into this unfamiliar and speculative terrain believing that the few blockbuster successes they envision will occur can more than offset the many that will languish or fail.
Purpose of Study

Considering higher education’s enthusiasm for engaging in this uncharacteristically risky behavior, it is particularly worrisome that it is doing so despite an enormous knowledge gap in the literature to inform this kind of entrepreneurial practice. Specifically, there has been little systematic study of the start-up phenomenon or the licensing of technology to small private companies that ultimately go public, a crowning achievement for a university seeking a highly visible demonstration of its commitment to economic development and of course, potentially reaping the financial benefits of greatly appreciated stock that it may hold. Hence, the purpose of this study is to address this knowledge gap by investigating a particular set of resource factors that may explain differential performance among institutions engaged in technology transfer. In other words, are there internal and external resources to universities that explain higher or lower performance in terms of start-up formation and licensing to private companies that go public?

Theoretical Framework

Although it has not previously been brought to bear on higher education phenomenon, the resource-based view of the firm is a useful lens for conceptualizing technology transfer performance differences among universities based on the competitive environment that institutions of higher education confront. Widely utilized within the strategic management literature, the resource-based view of the firm suggests that particular idiosyncratic resources, those that are difficult or costly to copy, can provide an organization a competitive advantage in the marketplace when appropriately exploited (Barney, 1991). Firms that possess particular resource attributes may outperform other competing firms in an industry. These resources could be any number of assets, capabilities, organizational processes, organizational attributes, information, knowledge, etc. that the organization possesses.

Given that institutions of higher education also differ in terms of the resources they possess and some are difficult, if not impossible, to imitate or copy such as the quality of faculty and the presence of particular internal and external support structures, it is reasonable to conclude that there may be those that provide distinct advantages to an institution’s technology transfer program. For example, previous research suggests that expert knowledge and scientific capabilities (Deeds, DeCarolis, & Coombs, 1997; Finkle, 1998) as well as access to important personnel, information, and support structures (Flynn, 1993; Mansfield & Lee, 1996) are important sources of competitive advantage. Furthermore, access to university research, the creation of new products and processes by high-technology industries (Mansfield & Lee, 1996) have been shown to be significant predictors of performance. Hence, in a higher education context, such resources as the quality of one’s faculty, the presence of particular programs and infrastructures, the amount of R&D support, and location related factors might represent critical resources of this type for a university and hence predictors of technology transfer performance.

Methodology

The sample of 108 of the 126 Carnegie Research I and II universities in this country was drawn from annual licensing surveys of the Association of University Technology Managers (AUTM), the national association of professionals responsible for technology transfer at
institutions of higher education. Drawing from this pool of universities is appropriate considering the wide variation in technology transfer activity of these schools and because the bulk of university commercialization effort in this country is centered on this subset of institutions. The universities in the sample are also geographically spread across the country such that no obvious representativeness biases were created by missing data on the 18 institutions not included in the dataset.

Data on these 108 institutions was obtained from the AUTM annual licensing surveys between 1991 and 1998 as well as other sources such as the National Science Foundation, the National Academy of Sciences, the U.S. Patent Office Database, the Securities and Exchange Commission’s (SEC) on-line database of companies that made an initial public offering (IPO), web pages of technology transfer offices of institutions in the sample, the Venture Capital Yearbook, and Peterson’s Guide to Colleges and Universities. Using multi-source data was important both as a means of collecting information that was only available in a given source and for triangulation purposes since in some cases information on certain variables could be found in more than one of these sources.

Dependent Variables

Two dependent variables were investigated as they represent important and widely accepted benchmarks of performance within the university technology field – start-up companies formed and companies that made a public offering to which a university had licensed a technology. As it regards the former performance measure, it is a continuous variable representing the average annual number of university start-ups formed between 1996-1998 and obtained from the AUTM licensing surveys. Start-up companies are emerging as an increasingly common mechanism for commercializing a technology. Whereas universities have traditionally followed a conservative approach to technology transfer, licensing a technology to an established large public firm in return for an up-front fee and steady licensing royalties as a percentage of sales, in recent years, institutions are increasingly opting for forming their own company around the technology or licensing it to a small but hungry private firm. The theory behind this practice is that many technologies that emerge from universities are not sufficiently developed to the point that a large company would even be interested in licensing it or when the technology is reasonably well developed, it still requires considerable development by the licensing firm to transform it into a product that a customer would buy. Hence, the valuation of a given technology is directly related to how much further work is needed to develop it into a saleable product. By capturing more of the value of a technology, and by association assuming the risk involved in developing a technology that might in the end not be commercializable, a university can command a more lucrative licensing deal if not be an active partner in producing and selling products. The catch, obviously, is that many of these ventures will languish if not fail.

The other dependent continuous variable, the total number of licenses a university held with private companies that subsequently went public between 1996 and 2000 as reported in the SEC Database, is another major achievement milestone for a university. Economic development has become a mantra for institutions of higher education seeking to demonstrate their contribution to the betterment of society. One highly visible way of demonstrating their value in this regard is being associated with a company that makes a public offering. A number of high
profile public offerings have been touted by universities and the popular press as evidence of their contributions to economic growth such as Google Incorporated, the internet search engine firm started by two Stanford students, CuSee Me Networks, a firm built largely from the innovative virtual conferencing software at Cornell University, and any number of medical device firms spun out of universities in recent years among other examples of start-up companies that went public. Although the prestige and legitimacy provided by being associated with a company that goes public is important, the financial returns to doing so can also be extremely lucrative should the university own stock in the firm. Because young firms are often idea and enthusiasm rich but cash and capital poor, generally the only asset they can offer is equity. As such, an increasing number of universities are accepting stock in lieu of up-front fees and/or licensing royalties in the hopes that a public offering will see the value of the stock appreciate substantially. Even if a few of the firms in which they hold stock make a public offering, the returns can dwarf the losses on the many other firms that do not do well or fail before going public. Hence, this measure of university technology transfer performance has become a crowning achievement for a university engaged in technology commercialization.

Independent Variables

As was proposed via the lens of the resource-based view of the firm, institutions of higher education would be expected to have particular idiosyncratic resource sets that may offer performance advantages in technology transfer. Building from previous research, a series of internal resource factors to universities were identified as possible sources of advantage.

Industry R&D Revenue

Industry sponsored R&D at universities, although considerably smaller in overall terms compared to federal sources, nonetheless is the fastest growing source of R&D funding for university research (National Science Board, 1998). Furthermore, even though industrial support may be quite small by comparison, its overwhelming emphasis on supporting applied versus basic research and for generating targeted outcomes suggests that it might stimulate considerable technology transfer activity. Previous research on university-industry relations, for instance, indicates that institutions with closer ties to industry do generate greater numbers of spin-offs and exhibit more entrepreneurial activity such as faculty consulting with industry, faculty involvement in new firms, and faculty and university equity participation in start-up firms (Cohen, Florida, Randazzese, & Walsh, 1998; Roberts & Malone, 1996).

Considering this research base, it is likely that industry R&D represents a critical resource to universities as would be predicted by the resource-based view of the firm and should be predictive of the two outcome variables of interest. This continuous variable was operationalized as the average annual industry R&D revenues realized by an institution over the three year period 1993-1995 and obtained from the National Science Foundation's annual surveys of research and development expenditures at universities and colleges.

Quality of Science and Engineering Faculty

A critical resource for the development of sophisticated and cutting-edge technologies is access to persons with expert knowledge and talent. One source of this expertise includes
university scientists who specialize in particular areas of research. However, judging by the fact that institutions do not tend to make radical jumps in published rankings of institutional quality, even over a multi-year period, attracting and retaining a high quality faculty requires considerable time, effort, and financial investment. Hence, it is likely a source of competitive advantage.

Previous research on the value of university researchers provides evidence of this fact. Specifically, a significant relationship between the reputation of university scientists and various measures of firm performance has been identified. Deeds, DeCarolis, and Coombs (1998), for example, found that university scientist talent was a significant predictor of initial public offering (IPO) performance of biotechnology companies. Zucker, Darby, and Armstrong (1998) found a direct and significant relationship between the reputation of university scientists and the number of products in development or on the market as well as the size of the company measured in number of employees. Finkle (1998) found that biotechnology companies in which the CEO was a former university professor performed better than firms where the CEO was not a former professor.

Given this previous evidence and the fact that most start-up companies and licensed technologies that emerge from universities do so from research activity in the science and engineering disciplines (Association of University Technology Managers, 1998), the quality reputation of an institution’s science and engineering faculty should predict the number of start-ups formed and IPO companies to whom a university had licensed a technology, an outcome in alignment with the tenets of the resource-based view of the firm.

Data for this continuous variable was obtained from the National Research Council’s (NRC) 1995 report on university research quality. The NRC surveyed university faculty about their opinions on the quality of research produced at 207 institutions of higher education including the ones in this study sample. The NRC data has been used in previous research exploring the impact of university R&D and the nexus between industry and higher education and is believed to be a legitimate rating publication based on its attention to methodological rigor and comprehensiveness (Mansfield, 1995; Mansfield & Lee, 1996). The NRC reports rankings across five broad disciplinary areas, the arts and humanities, social and behavioral sciences, biological sciences, physical sciences, and engineering. Since the latter three areas are most relevant to this study, an overall average ranking was calculated from ratings of those three fields.

Number of Equity Positions

In general, universities are inherently conservative and risk adverse, at least as it regards activity that may jeopardize their external image and reputation. One manifestation of this behavior in the area of technology transfer as mentioned earlier is a proclivity to seek up-front and/or regular royalty payments when negotiating technology transfer licensing deals. However, start-ups or young companies are often capital poor and unable or unwilling to agree to such payments. Thus, some deals inevitably fall apart or are not pursued.
Some universities have shown a willingness to accept stock in lieu of front-loaded royalty payments as a cost-effective way for a firm to obtain a technology license and hence make it more likely that a deal will be arranged (Manak, 1996). Additionally, a willingness to accept equity in lieu of royalty sends a signal to business and industry that a university is willing to share in the risk and assume some responsibility for the long-term success of the enterprise (Bray & Lee, 2000). However, other institutions have firm policies against its practice, generally based on conflict of interest concerns. As such, a policy that encourages the practice of accepting equity could be considered a strategic resource for technology transfer and hence an organizational source of competitive advantage according to the resource-based view of the firm.

In light of this research, the number of equity positions held should be a predictor of the number of start-ups formed and IPO companies to whom a university had licensed a technology. Rather than use a dichotomous measure that simply captured the presence of a policy allowing the acceptance of equity in a licensing deal, a variable that measured actual equity deal activity was selected as being more representative of an institution’s true willingness to structure this kind of agreement. This data was reported in the 1995 AUTM licensing survey for the year 1995 as well as in the aggregate for prior years (AUTM has been surveying institutions since 1991). Hence, the figure included in this study is the sum of the prior year’s figure and 1995.

University Patents

While patenting is no guarantee that a university developed technology has future marketability or that it will even get developed into a product, it does represent a primary tool for safeguarding its future potential. Obtaining patents also signals important outsiders that an institution is serious about commercialization and recognizes the needs of for-profit firms since the university was willing to invest the necessary time, effort, and expense into obtaining patents. As a result, established firms may be more interested in obtaining the technology. In the context of start-ups, venture capitalists and persons with management expertise may also be attracted to the possibilities of a patented technology and seek to invest or become involved in its development (Bell & McNamara, 1991).

Previous research on patenting indicates that patents can be a valuable organizational resource for competitive advantage and predictive of firm performance. Deeds, Decarolis, and Coombs (1999), for example, found some evidence that the number of firm patents predicted firm performance in the biotechnology industry at the time of an IPO. Zahra and Bogner (1999) also found support for the impact of patent activity on firm performance in the software industry. In a recent study of university-based start-ups, Shane (1999) found that patents with greater domestic and international patent class coverage as well as subsequent patent citations were highly predictive of a technology being developed via the formation of a start-up firm.

Based on the results of the aforementioned research it seems reasonable to conclude that the number of patents in a university’s portfolio should predict both measures of technology transfer performance. The university patents variable is continuous and operationalized in this study as the average annual number of patents issued to a university over the period 1993-1995. This information was obtained primarily from the AUTM licensing surveys. In the few cases where the data was not available in the AUTM surveys, the information was collected from the
U.S. Patent Office database that is available on-line and searchable using the institution’s name as a patent assignee.

Private Versus Public Status

Private and public universities differ in ways such as how they are funded, how they must meet legal and fiduciary requirements, and how they are accountable to their various stakeholders (Stadtman, 1992). As such, they may differ in ways that they approach (or are required to approach) technology transfer activity. For example, public higher education may be prevented from engaging in certain kinds of entrepreneurial activity that private institutions are not and/or private universities may have greater flexibility in how technology transfer programs are structured and managed. Thursby and Kemp (1999), for example, found that private universities were able to more effectively leverage their intellectual capital into commercial licenses than public institutions. Historically, some of the most well known institutions with a culture supportive of entrepreneurial activity are also private schools (Louis, Blumenthal, Gluck, & Stoto, 1989; Matkin, 1990). Finally, as evidenced by the Boston University Seragen case, private institutions may have greater latitude to invest endowment income into high-risk ventures such as start-up companies.

As an organizational resource within the resource-based theory of the firm framework, then, private institutions should enjoy a competitive advantage and thus should have greater numbers of start-up companies and licenses with newly public companies. In this study, an institution’s private or public status is a dichotomous variable and coded a one if a private institution and a two if otherwise. This information was obtained from the 1995 edition of Peterson’s Guide to College’s and Universities.

Venture Capital Munificence

Venture funding is a valuable resource to many of the specific types of companies that come out of universities based on their capital intensive nature and in the case of biotechnology firms, their generally long time frame to profitability (Lerner, 1994). Specifically, university start-ups benefit from the financial capital provided but often also from the management or advisory expertise provided by venture capitalists. Since a venture capital investor has an intrinsic desire to see the company succeed, they are generally eager to provide guidance to the firm on the path toward profitability or at least to help the company grow to the point where a larger firm might be interested in acquiring it or to take the company public (MacMillan, Zemann, & Subbanarasimha, 1987).

Research on university start-up companies has affirmed the important role venture capital plays in the ultimate success of a new university venture (Cawood, 1991; Roberts, 1991) and how regional differences in venture capital availability may influence a university’s level of success with at least start-ups (Roberts & Malone, 1996).

Hence, within a resource-based view of the firm framework, the venture capital available in the region where a university is located should predict the number of start-ups formed and licenses with newly public companies. This continuous variable was operationalized as the average annual venture capital disbursements by state for the years 1993-1995 and drawn from
the *Venture Capital Yearbook*. While Venture Economics, the publisher of the *Venture Capital Yearbooks*, does not have data on all venture backed financing deals in a given year, it is one of the most comprehensive of any studies of the industry and represents the vast majority of independent private fund investment. Hence, its data are reasonable proxies for the true level of venture capital investment and the relative differences by state.

*Control Variables*

Two other resource variables were included as controls since they have often been shown to be important in firm performance research, the size and age of the firm (Beatty & Zajac, 1994; Deeds, DeCarolis, & Coombs, 1997). In this case, the size and age of the technology transfer office (TTO) was used. These continuous variables were both obtained from the AUTM licensing surveys.

The size of the TTO came from the 1995 AUTM survey and represents the number of professional staff FTEs (full time equivalents) in the office at that time. Universities with greater numbers of professional staff to handle technology transfer would be expected to outperform institutions less well endowed with this human capital resource. The age of the TTO, operationalized as the number of years that the office had at least .5 FTE of dedicated professional staff, was obtained from the 1998 licensing survey. Institutions with older TTOs would be expected to have developed superior skill sets for managing the commercialization enterprise and hence also predicted to enjoy higher performance levels.

*Results*

The data were analyzed using ordinary least squares regression. Table 1 presents the descriptive results including a correlation matrix. The average number of start-up companies formed was 2.2 per year while the average number of IPO companies to whom a university had licensed a technology was 2.6. The average university had $9.6 million in industry sponsored research, a faculty quality rating of 3.0 (on a 1-5 scale), 4.3 equity positions, and 13.8 patents.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>s.d.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Start-ups formed</td>
<td>2.20</td>
<td>2.57</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. IPOs</td>
<td>2.59</td>
<td>3.35</td>
<td>.71</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Industry R&amp;D</td>
<td>9.57 mil</td>
<td>9.03 mil</td>
<td>.56</td>
<td>.53</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Faculty quality</td>
<td>3.01</td>
<td>.71</td>
<td>.58</td>
<td>.63</td>
<td>.41</td>
<td>.100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Equity positions</td>
<td>4.27</td>
<td>6.30</td>
<td>.51</td>
<td>.48</td>
<td>.38</td>
<td>.33</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Patents</td>
<td>13.82</td>
<td>13.51</td>
<td>.72</td>
<td>.78</td>
<td>.59</td>
<td>.62</td>
<td>.44</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Private/public</td>
<td>.28</td>
<td>.45</td>
<td>.15</td>
<td>.34</td>
<td>.08</td>
<td>.35</td>
<td>.13</td>
<td>.21</td>
<td>.04</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Venture capital</td>
<td>332.39 mil</td>
<td>630.18 mil</td>
<td>.33</td>
<td>.26</td>
<td>-.01</td>
<td>.36</td>
<td>-.01</td>
<td>.21</td>
<td>.04</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. TTO size</td>
<td>2.38</td>
<td>2.29</td>
<td>.61</td>
<td>.61</td>
<td>.41</td>
<td>.56</td>
<td>.38</td>
<td>.61</td>
<td>.03</td>
<td>.41</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>10. TTO age</td>
<td>16.56</td>
<td>11.94</td>
<td>.42</td>
<td>.39</td>
<td>.23</td>
<td>.30</td>
<td>.26</td>
<td>.59</td>
<td>.06</td>
<td>.18</td>
<td>.44</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Correlations above |.29| are significant at p<.01; those above |.20| are significant at p<.05. N's vary from 100-108 because of missing data.
Because a few of the bivariate correlations among independent variables were somewhat high, although still below the rule of thumb threshold of .8 (Lewis-Beck, 1980), a more thorough investigation for collinearity was conducted. Variance inflation factors were computed for each variable (not shown), all of which were under 3.3, well below the concern level of ten that previous researchers indicate is suggestive of collinearity problems (Von Eye & Schuster, 1998). Finally, a series of regression model pairs were run in which each independent variable with a correlation above .4 was included and then subsequently excluded from the models to see if the regression coefficient results were substantively effected. No differences were found, indicating the absence of excessive collinearity.

Table 2 presents the results of the regression analyses. Two regression models were run, one with the start-ups formed as the dependent variable and the other with the IPO companies to whom a university had licensed a technology as the dependent variable. For each model, a partial and full model was executed so as to control for the size and age of the technology transfer office.

Table 2
Results of Regression Analyses

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1: Start-Ups Formed</th>
<th></th>
<th>Model 2: IPOs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N=100</td>
<td>Partial</td>
<td>Full Model</td>
<td>N=102</td>
</tr>
<tr>
<td>TTO Size</td>
<td>.54***</td>
<td>.18*</td>
<td>.56***</td>
<td>.19*</td>
</tr>
<tr>
<td>TTO Age</td>
<td>.18*</td>
<td>.00</td>
<td>.14</td>
<td>-.09</td>
</tr>
<tr>
<td>Industry R&amp;D</td>
<td></td>
<td>.18*</td>
<td></td>
<td>.10</td>
</tr>
<tr>
<td>Faculty Quality</td>
<td></td>
<td>.11</td>
<td></td>
<td>.03</td>
</tr>
<tr>
<td>Equity Positions</td>
<td></td>
<td>.21**</td>
<td></td>
<td>.13*</td>
</tr>
<tr>
<td>Patents</td>
<td></td>
<td>.30**</td>
<td></td>
<td>.54***</td>
</tr>
<tr>
<td>Private/Public Status</td>
<td></td>
<td>-.04</td>
<td></td>
<td>.21***</td>
</tr>
<tr>
<td>Venture Capital</td>
<td></td>
<td>.22***</td>
<td></td>
<td>.04</td>
</tr>
<tr>
<td>F-Value</td>
<td>34.06***</td>
<td>20.67***</td>
<td>33.50***</td>
<td>29.43***</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>.40</td>
<td>.64</td>
<td>.40</td>
<td>.69</td>
</tr>
</tbody>
</table>

* p < .05
** p < .01
*** p < .001

It is evident from the regression results that the two models explained a significant amount of the variation in each of the dependent variables and that the inclusion of the independent variables significantly (p=.001) improved the model fit in each case. The full model involving start-ups formed explained 64 percent of the variance while the model involving IPOs explained 69 percent of the variance, a finding indicative of good model fits. Additionally, since the F-statistic was highly significant between the partial and full models in both regression equations, the use of the full models for drawing inferential conclusions was appropriate.
As it relates to the control variables, the size of the technology transfer office was highly significant in both partial models and significant in the full models. However, the age of the technology transfer office was only significant in the start-ups formed partial model. Hence, the results indicate that the number of professional staff is a significant predictor of these measures of technology transfer performance but that institutions with older offices don’t appear to enjoy performance advantages.

As shown in Table 2 above, four of the independent variables were positively significant in Model One involving start-ups and three were significant in Model 2 involving IPO firms. Specifically, for Model One, the level of industry R&D, the number of equity positions, the number of patents, and the level of venture capital in a state were significant or strongly significant predictors of start-up performance. For Model 2, the number of equity positions and patents held as well as an institution’s status as public or private were positive or strongly positive predictors of IPO performance. These results indicate the importance of these resources for success with a high risk technology transfer program such as would be manifested in a start-up company and licensing to young private firms strategy. Of equal note, however, the findings of no significance for faculty quality in either model suggests that universities with more highly reputable faculty in the disciplines most likely to be engaged in technology transfer do not necessarily enjoy performance advantages over their counterparts with less highly respected faculty. Furthermore, universal performance advantages across both forms of high-risk venturing are not enjoyed by private institutions, schools with greater revenues from industry, and schools in venture capital poor states.

Discussion

As mentioned earlier, the purpose of this study was to investigate the effects of particular internal and external resource factors on the performance of universities in terms of start-up company formation and licenses held with companies that make an initial public offering. The results indicate a set of resources that are predictive of these measures of high-risk technology transfer performance. The first of these, industry R&D revenues, was positively predictive of start-up formation. Mansfield’s (1995) work on the sources of funding for higher education R&D sheds some light on why this result might be expected. In his study of 66 firms in seven major industries as well as of 200 academic researchers, he found that university-based researchers generally received government funding on their projects when they were at an early stage of development. As a project matured, however, industrial support began to grow in importance as a research idea began to evolve into a bona fide product. Additionally, faculty became more involved as industry consultants. Thus, it may be that when faculty increase their linkages with industry, either as consultants or contracted researchers on a specific commercially oriented project, they develop a stronger entrepreneurial perspective. One manifestation of this perspective may be a keen interest in forming a start-up company for the commercialization of their research.

A second significant resource, in this case for both start-up formation and IPO companies to whom a university had licensed a technology, was the number of equity positions held. This findings indicates that a willingness to accept equity in lieu of front loaded royalty payments or as a means of reducing the reliance on royalty payments can be an important factor in whether or
not a licensing deal is consummated, at least with small, often cash-starved companies (Bray & Lee, 2000). As mentioned earlier, start-ups or young companies, particularly in the fields most likely to be seeking technologies emerging from universities, are generally facing fairly long product development horizons before profitability. Even at the time of a public offering, these types of companies may still be in the research and development phase and are often short on cash (something that a public offering hopefully would alleviate). Hence, insisting on up-front payments on licenses with this kind of firm is often not a viable strategy for a university seeking a deal unless the marketability of the technology is obviously very strong or it is already close to being ready for sale. Nevertheless, the more traditional licensing deals are usually less risky and thus often appealing to the generally financially conservative higher education industry.

What this study indicates, however, is that universities that do demonstrate a greater willingness to assume the risk of an equity deal are more highly engaged with forming start-ups and clearly rewarded with more companies that go public. By extension, then, the possibility then exists that the value of the stock held by the university may appreciate significantly and for the first time the institution can choose to sell the stock on the open market, a situation that would not be possible in the context of a traditional license.

Of all the resources investigated in this study, the number of patents held was the most predictive of the two measures of technology transfer. This result provides strong evidence for the importance of patenting as an aid to the commercialization process. Clearly, universities that held more patents outperformed institutions with fewer patents in terms of the number of start-ups formed and IPO companies to whom a university had licensed a technology. While not a surprising result considering previous research (Shane, 1999; Zahra and Bogner, 1999), it does reinforce the fact that the quantity of an institution’s patent holdings does directly influence the opportunities for commercialization. Hence, institutions that increase their patenting of technologies are likely to be rewarded with more licensing deals with industry. Based on Shane’s findings (1999), however, patents with more broad-based protections are likely to be the most appealing to high technology start-up firms, the ones often interested in early stage technologies from universities.

A fourth significant resource, in this case as it involves IPO firms to whom a university had licensed a technology, was an institution’s private or public status. Specifically, private universities outperformed public institutions on this measure of technology transfer performance. A possible explanation for this result is that public institutions may be more conservative in their technology transfer programs than private institutions and hence less likely to pursue licenses with untested pre-IPO firms. Instead, public institutions may seek to license their technologies to established public companies that are generally more willing to agree to traditional licenses with up-front royalty payments. This proclivity to conservative technology transfer behavior may be due to a greater sense of societal responsibility. More specifically, public institutions may be less willing to risk tarnishing their reputations as good stewards of public funds due to their heavier reliance on public funding sources. Additionally, public institutions may more often than private schools be prevented by policy or regulation from engaging in particular kinds of technology transfer activity. Since universities are extremely concerned with maintaining, indeed advancing, their reputations for excellence (Bowen, 1980),
the potential threat to their reputations may be a powerful force driving their greater reluctance to become involved in the more risky forms of technology transfer.

The final significant resource involved the venture munificence variable. Universities located in states with more robust venture capital resources were much more likely to outperform institutions in states where venture capital was less abundant. This finding suggests that venture capital resources play an important role in creating an environment supportive of university start-up formation. Considering that the types of firms likely to be formed around a university developed technology are in industries where venture capital funding is often important (Roberts & Malone, 1996), this finding is particularly noteworthy to universities considering ramping up their start-up strategy. Specifically, if adequate capitalization is not available in the area, it might not be wise to pursue this route for commercialization unless the university secures financial resources from other sources such as through the creation of its own venture fund, something that a growing number of universities have initiated.

Limitations

While this study provides new insights into the experience of universities with their technology transfer programs, it is not without its limitations. A first potential shortcoming of the study centers on the operationalizations of particular variables. For example, the faculty quality measure was calculated from data provided by the National Academy of Sciences from 1993. While their data set is one of the most respected in academia as being methodologically sound and a reasonable approximation to the true differences in faculty quality among institutions, it is nonetheless ratings of academics by academics as opposed to ratings based on other objective measures such as citation counts. It is also slightly more dated than would have been preferred.

A second shortcoming to the study focuses on the methodological design itself. More specifically, the research employed a cross-sectional design and hence, it is only able to report on aspects of university technology transfer during a limited point in time. While this concern was alleviated somewhat by the choice of computing a three-year average for many of the variables, it nonetheless does not fully capture how performance has changed over a period of years. Time considerations are a potentially important issue considering the time horizons involved in developing a technology, licensing it, and seeing it produce an income stream.

A third limitation of the research is that it does not address any of the cost effectiveness issues that are obviously of additional interest. For example, the study showed that staff size was directly related to performance in both models. However, it may be that direct and indirect costs of hiring additional staff may not supercede the benefits provided by the additional personnel. The study also does not address any productivity issues associated with technology transfer such as the number of IPO firms per licensing deal or the number of patents per license.

Finally, even though the three models explained a sizable portion of the variance in performance, there is still an unexplained portion in the models. Furthermore, some useful additional data could have been obtained via an institutional survey. Some examples include more direct measures of faculty attitudes toward technology transfer or additional information on
key policies such as how technology transfer activity figures into tenure and promotion or if faculty can take leaves of absence to work on commercial projects.

Implications

For university leadership and those charged with managing the technology transfer enterprise, this study offers a number of useful insights. First, locational advantages appear to be limited to start-up formation. Universities in venture capital poor states do not appear to suffer from underperformance as it regards having licenses with firms that go public. This result should bolster the confidence of universities in states with lower levels of venture capital to pursue licenses with young but hungry companies that aspire to become a publicly traded firm. However, technology transfer professionals should be aware of the linkage between start-up formation and venture capital munificence such they would be wise to exercise caution when attempting to advance a start-up strategy for commercialization unless they are able to offer their own in-house venture funds or attract out of state venture capital.

Second, the finding of no significance with the faculty quality variable suggests that an institution is not de facto provided performance advantages simply based on the quality of their science and engineering faculty. What is likely to be more important are such factors as the nature of the patent portfolio and the potential commercializability of technologies. In sum, the very best faculties may not in fact be the best sources for technology licensing opportunities.

Third, a willingness to accept equity in lieu of a tradition license has demonstrated value for both forming start-ups and being rewarded with an affiliation with a company that goes public. Thus, technology transfer practitioners would be wise to consider the utility of a start-up strategy for commercialization as well as an investment strategy using equity deals with young companies seeking to eventually go public.

Lastly, and in some ways most importantly, this study offers additional insights into the ways in which universities are changing in this country. Economic development as a mission goal is no longer the exclusive domain of land-grant institutions. Today, it is embraced by a growing cadre of research universities apparently unfazed by the tremendous financial and legitimacy risks associated with high risk venturing or the potential for high profile failure. Etzkowitz (1998) referred to this fundamental mission expansion as a second academic revolution. Like the first academic revolution during the latter half of the 19th Century where universities shifted from a focus on cultural preservation to the creation of new knowledge, higher education has now broadened its mission to include the translation of research into bona fide products and new enterprises for the practical benefit of society (Etzkowitz, Webster, & Healey, 1998). Given that this is generally unfamiliar territory for the majority of institutions and few appear to enjoy substantial financial benefit from it, university leaders and policy makers alike would be wise to consider the degree to which this expanded mission is appropriate for all research universities.

Opportunities for Future Research

Based on the research findings from this study, a number of useful streams of future research are evident. First, a content analysis of the IPO prospectuses searched for this study
would reveal valuable information on such issues as the nature of equity positions by universities and the kinds of licensing arrangements executed with universities. Furthermore, in many instances, the faculty inventors of a technology were also discussed in some detail. The study of these persons' relationships to the firm and/or a qualitative investigation of the faculty inventors themselves would add significantly to the literature.

A second useful area of inquiry would involve the post-IPO performance of firms that hold university licenses. For example, are there any aspects of universities that may predict year one stock performance? Intuition would suggest that over time, institutional effects diminish, but no study has actually sought to empirically test this proposition.

Finally, it would be particularly revealing to investigate other measures of technology transfer performance such as the number of licenses executed and licensing income realized. The latter of these variables would be particularly insightful since licensing income is at least a rough proxy for the ultimate success of a product in the marketplace based on the fact that royalty payments to universities are generally calculated as a percentage of sales.

Conclusion

This study has explored the predictive effects of a set of resource factors on university technology transfer performance as measured by start-up formation and IPO companies to whom a university had licensed a technology. Using the theoretical lens of the resource-based view of the firm, the research has shown that the size of the technology transfer office, level of industry R&D revenues, number of equity positions and patents held, institutional private or public status, and state venture capital munificence are significant predictors of one or both of the selected measures of technology transfer performance. Since the current environment for university technology transfer is aggressively advancing, this study offers useful insights into the planning and execution of technology transfer activities that informs its responsible practice. Furthermore, the study suggests useful future streams of research using the unique database created as well as investigations using new or re-operationalized variables.
References


units. For example, blockbuster licenses such as Taxol at Florida State University, Cisplatin at Michigan State University, and the Vitamin D technologies at the University of Wisconsin all came out of chemistry departments. If licensing is as strong in non-medical or non-engineering disciplines as anecdotal evidence suggests, it might negate any potential performance advantages in either of these units. It is also likely that not all medical or engineering schools are the same and as such, measures of unit quality might actually reveal significant results.

**Human Capital Resources**

The finding regarding the quality of science and engineering faculty suggests the central importance of this resource for achieving high levels of performance in technology transfer. In fact, this variable was the only one significant across all three measures of performance. This result is consistent with Mansfield & Lee’s (1996) research on the contribution of universities to industrial innovation from the perspective of industry. Specifically, they found that institutions with more reputable faculties (also measured using National Academy of Sciences ratings) were more likely to be cited by industry as having contributed significantly to industrial innovation. Hence, it is perhaps not surprising to find that one benefit of being highly cited by industry is their interest in licensing technologies that in turn generate royalties. Furthermore, institutions with strong faculty reputations are probably able to negotiate more lucrative licensing deals than those universities that are not as highly regarded.

It may also be that institution’s with less reputable faculties focus their licensing efforts more regionally and thus reduce their chances for negotiating a license with a large, wealthy, multinational firm. This was another phenomenon that Mansfield and Lee (1996) found. Namely, when industrial firms cited schools with less reputable faculties as being important contributors to industrial innovation, these schools were generally within 100 miles of the firms.
Finally, if schools with lower faculty reputations are more locally focused, their licensing portfolio is probably more heavily weighed with smaller, less mature companies, the ones unlikely to be in a position to offer a university a highly lucrative licensing deal. Regardless the reason for the differential performance, it is evident that the quality of an institution’s faculty is a critical resource associated with patenting, licensing, and licensing income, and as the resource-based view of the firm would predict, those institutions with stronger faculty reputations outperform those with less reputable faculties.

As it regards the size and age of the TTO, two human capital oriented control variables in the study, they also were positively predictive of performance, the former with licenses and licensing income and the latter with patents and licenses. These results are also consistent with prior research on organizational performance (Deeds, DeCarolis, & Coombs, 1999) and indicative of the importance of strong skill sets and sufficient staff to manage the complex and time intensive tasks associated with technology transfer practice.

Organizational Resource

The one organizational resource investigated for this study was the private or public status of a university. In this case, the status of an institution does not appear to make a difference in terms of technology transfer performance on any of these outcomes. Hence, the perception of private schools as somehow being more effective at technology transfer, ceteris paribus, is unfounded. If at one time private universities did enjoy performance advantages, the recent increased emphasis by states for university participation in economic development may have afforded public institutions greater flexibility to engage in commercial activity (Wilson & Szygenda, 1990) and hence increased their own performance to match that of their private counterparts.
External Environment Effects

The final area of investigation in this study involved the external environment effects on technology transfer performance, namely the entrepreneurial climate and venture capitalization of a state as well as the level of state support for higher education. The environmental variable results indicated a strongly negative relationship between venture capitalization and the number of licenses and licensing income for a university and a slightly negative relationship for number of licenses and the entrepreneurial climate variable. Furthermore, there was a strongly negative relationship between state support for higher education and licensing income for public institutions and a strongly positive one for private schools.

As it regards the venture capitalization variable, this result was puzzling since it implies that schools in venture rich states underperform in relation to their counterparts in venture poor states. Upon surface observation, this result seems counter to what the data might suggest considering that the top three performers in terms of licensing income (Columbia, UC-San Francisco, and Stanford) came from states with high levels of venture capital (California and New York). However, in looking at the data as a whole, there were a number of schools from states with high venture capitalization that are low performers in terms of licensing income.

While a visual examination of the data appears to affirm the accuracy of the regression result, it does not explain why this relationship might exist. One likely explanation for this association is that states with lower levels of venture capital also have fewer smaller companies or an overall environment that is not particularly supportive of the type of firms that might develop out of universities. Hence, in these states, technology transfer activity is de facto forced to emphasize a licensing strategy with large established firms, the very types of companies that are likely to generate the greatest amount of licensing income in the short term. Thus, the
linkage between venture capital munificence and licensing income may be more indirect with small companies in a state being an intervening variable.

A second related explanation for this finding is that there may in fact be a positive relationship between a state’s venture capital munificence but only with the in-state portion of its licensing income, an investigation that was beyond the scope of this study. However, when out of state income is considered as well, the relationship may have been reversed. Research by Mansfield & Lee (1996) provides support for this explanation, particularly at institutions that have what they coined, faculty stars. Specifically, as mentioned earlier, they found that while the majority of university-industry linkages were within 100 miles of each other, universities with better faculty reputations (measured using the same National Academy of Sciences data used in this study) were more likely to have a national reach. Additionally, based on general observation of annual reports of technology transfer offices for this study, it appears that the licenses that generate the largest amounts of income are often with large companies located outside of that institution’s state. Hence, it may be that the benefits of venture capital munificence are being accrued by institutions in less venture capital robust states who seek licenses with companies in states like California, Massachusetts, and New York where the opportunities for investment are greater. In the event that is true, schools located in states flush with venture capital may face particularly strong competition for licensing opportunities from the very best of the out of state schools.

In the case of the entrepreneurship climate variable, it was mildly significant (p=.058) in the positive direction in model two involving the number of licenses performance variable. Considering that this environmental measure is more broadly reflective of the climate for all kinds of young businesses, not just those needing venture capital, it would be expected to
possibly have a different predictive effect on performance than the venture capital variable. Based on the result involving the entrepreneurship climate variable, then, it appears that universities with stronger overall climates for entrepreneurship (and hence the greatest likelihood for licensing opportunities with smaller firms), enjoy a small performance advantage over institutions located in states with weaker external environments of this kind.

The final finding of significance associated with the issues of location involved the state appropriations variable and licensing income. It was most interesting to find strong significance in the negative direction for public universities but strongly positive significance for private institutions, a result supportive of a resource-dependence theory explanation for the phenomenon.

Taking the public school result first, it appears that the incentive to seek alternative revenue sources when state funding is lower is considerable. These institutions may have sought to pursue the most promising licensing opportunities with shorter-term payoff than public schools with less threatened traditional resource streams and been rewarded with higher levels of income realized. Considering the legitimacy now afforded to institutions that support an economic development agenda, it may also be that public institutions with less state support may be seeking to leverage their involvement in technology transfer as a means of increasing their perceived level of excellence or relevance in the eyes of state legislators and taxpayers with the ultimate hoped for reward being increased state support.

In the case of private universities, they may be affected by support of public universities but in the opposite direction. Specifically, when resources are greater for public higher education, the overall economic health of the state is often made stronger, a finding with support in the literature (Paulsen, 1996). Thus, when the state’s economy and workforce productivity is
enhanced, private schools may benefit in the form of more lucrative opportunities for technology transfer. Additionally, in states where support of higher education is high, demand for private post-secondary education may be lower, increasing the pressure on the most critical resource to privates, tuition income. Recent research by Hu and Hossler (2000) is suggestive of a tuition-demand linkage such as this. With concern over tuition income heightened, then, private institutions may feel the need to develop new and risky income sources such as could be pursued through technology transfer. Similarly, in states with low levels of support for public higher education, student demand for private education may be higher, reducing pressure on the critical resource of tuition income. Hence, in this situation, private institutions would not feel as strong a need to advance their technology transfer programs.

Policy and Practice Implications

This study has a number of important implications for policy makers and institutions. First, the study reveals useful insights about location related factors that impact performance. In general, schools located in states with an overall weak entrepreneurial climate are not necessarily disadvantaged, or are only at a mild disadvantage. What appears to be much more important is the venture capital munificence of a state. Specifically, universities considering ramping up their technology transfer efforts in venture robust states should be especially cognizant of the competition they will likely face from other schools seeking licenses with their state's young high technology firms. Furthermore, universities in relatively venture capital poor states need to recognize that expanding their technology transfer programs will likely require taking a more regional or national scope or seeking to develop their own venture capital programs, something that a number of institutions and their states have been doing in recent years.
A second important result with policy and practice implications involves the level of state appropriations. As the data revealed, state appropriations are strongly associated with technology transfer activity. However, it would be unwise for state policy makers to simply conclude that reducing support for higher education is the appropriate course of action for stimulating technology transfer at public institutions. Instead, policy makers might be wise to consider a realignment of incentive structures in order to better ensure that universities pursue in-state opportunities for technology transfer in ways that stimulates overall economic growth. One way this might be achieved is through incentive budgeting. Specifically, states might make available to institutions a separate pool of monies that are allocated on the basis of achieving particular economic development goals. Thus, universities might see new opportunities to benefit from state support rather than worry that it is a critical source of base income that could be threatened.

A third finding with particularly strong implications involved the results with the federal and industry R&D variables. As the study showed, federal and industry R&D investment is clearly positively associated with patenting, but there appears to be a disconnect in the linkage beyond that point. Intuitively, it would seem that the explanatory impact of federal and industry R&D on a technology further down the commercialization path would become progressively weaker (i.e., many other factors impact the marketplace potential of an end product or even the appeal of a new but underdeveloped technology to an outside firm). Yet, the R&D related results nonetheless suggest that if one important goal of academic R&D investment is the production of new products or processes for societal benefit, it would be useful to investigate ways to better ensure that the handoff or partnering with industry does occur. For example, funding agencies might place greater emphasis in granting criteria on plans for partnering with industry in the
latter stages of a technology's development and/or make clear that funds for latter stages of
development could be made available.

Finally, the results of this study highlight the changing nature of higher education's
mission. Whereas the economic development role for America's research universities had
historically centered on the land-grant institutions, today, it has been widely adopted across the
spectrum of research institutions. Etzkowitz (1998) referred to this fundamental mission
expansion as a second academic revolution. Like the first academic revolution during the latter
half of the 19th Century where universities shifted from a focus on cultural preservation to the
creation of new knowledge, higher education has now broadened its mission to include the
translation of research into bona fide products and new enterprises for the practical benefit of
society (Etzkowitz, Webster, & Healey, 1998). As this study has shown, universities are heavily
engaged in commercial activity in ways that have brought them in much closer association with
industry. Given that this is generally unfamiliar territory for the majority of institutions and few
appear to enjoy substantial financial benefit from it, university leaders and policy makers alike
would be wise to consider the degree to which this expanded mission is appropriate for all
research universities.

Study Limitations

One limitation of the study involves the operationalization of several variables. For
example, the faculty quality measure was calculated from data published by the National
Academy of Sciences in 1993. While their data set is one of the most respected in academia as
being methodologically sound and a reasonable approximation to the true differences in faculty
quality among institutions, it is nonetheless ratings of academics by academics as opposed to
ratings based on other objective measures such as citation counts. The entrepreneurial climate
variable also may not have adequately captured differences within a state. For instance, Stanford University’s experience near Silicon Valley is probably different than UCLA in Los Angeles. Unfortunately, the sample size precluded statistical analyses any more focused than at the state level.

A second limitation centers on the cross-sectional design of the study. Measuring performance at a point in time, albeit addressed somewhat by calculating three-year averages, does not capture change over a period of years. Considering the long time frames often involved in commercializing research, a longitudinal study design would have provided additional insights on the phenomenon.

Finally, the study does not address any of the cost-effectiveness issues that are of obvious additional importance. For example, there is no guidance as to the direct and indirect costs of adding additional technology transfer office staff even though the data revealed a direct and positive relationship between staff size and performance on two of the outcome measures.

Opportunities for Future Research

A number of useful opportunities for future research emerged from this study. First, a qualitative study focused on technology transfer practitioners or faculty actively involved in patenting and licensing, for instance, might reveal excellent insights into the explanation of findings reported here. A second area of research would be to test different operationalizations of some of the variables. For example, the state measures of venture capital and entrepreneurial climate might be improved by substituting a regional one since technology transfer certainly occurs across state lines.

Given the strongly contrasting results between private and public institutions as it relates to the level of state appropriations, further investigation of this dynamic would also be
informative. Exploring R&D and commercialization incentive structure differences would be an appropriate place to begin. Additionally, it would be useful to broaden the measures of performance to include university start-up formation or affiliations with firms that go public, two additional measures of performance not addressed in this study. Finally, it would be important to explore other factor sets not investigated. These might include measures of the institutional culture, a potential source of motivation for faculty entrepreneurial activity (Roberts, 1991). Other potential variables might be specific policies governing faculty involvement in technology transfer such as the equity policy, policy on leaves of absence for commercial activity, and tenure policies that may explicitly recognize commercial involvement as an important and appropriate function for faculty.

Conclusion

This research represents the first national study of its kind exploring specific factors that may explain differential performance with technology transfer. The results suggest that both theoretical lenses, the resource-based-view of the firm and resource dependence theory, are useful ones for understanding the ways in which particular internal and external resources impact technology transfer activity. Considering the increasing expectations for higher education to serve specific economic development needs, this study provides a useful window into what institutional resources or capabilities may contribute to higher levels of performance. While it does not specifically address the normative question of whether or not higher education should be engaged in entrepreneurial activity, the study does offer informed guidance to institutions and policy makers that are clearly pursuing active engagement with academic commercialization activities. Hence, this study has sought to advance our knowledge in this area and to provide key stakeholders with useful insights on important considerations to its practice.