Opening the ivory tower's door: An analysis of the determinants of the formation of U.S. university spin-off companies.

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Abstract:

This paper presents findings from an analysis of the determinants of the formation of university spin-off companies within the university's research park. We find that university spin-off companies are a greater proportion of the companies in older parks and in parks that are associated with richer university research environments. We also find that university spin-off companies are a larger proportion of companies in parks that are geographically closer to their university and in parks that have a biotechnology focus.

Keywords: university spin-offs | research park | biotechnology | research policy

Article:

1. Introduction

Since the passage of the Bayh–Dole Act in 1980 in the United States, technology transfer activities at universities have taken center stage. The extant literature has focused on patenting activities as a general trend and as a university-specific response to the Act (Nelson, 2001, Hall, 2005 and Mowery and Sampat, 2005), and on the establishment and operations of university technology transfer offices (Siegel et al., 2003). One technology transfer activity that has received little attention, either in the United States or in other industrialized countries, is the formation of university spin-off companies on university research parks.2 This is surprising because technology transfer has become a dominant strategy in U.S. universities over the past 25 years.3 To emphasize further the economic importance of technology transfer associated with new firms located in parks, the Science Park Administration Act of 2004, S.2737, decrees that high technology clustering "… is in the best interest of the Nation …" (U.S. Congress, 2004).

In the United States, the preponderance of related research has been case-based, focusing almost exclusively on spin-off activity in high technology cluster areas such as Silicon Valley, Route

128 around Boston, and Research Triangle Park (Kennedy, 2000, Lee et al., 2000, Link, 1995, Link, 2002, Link and Scott, 2003a, Roberts, 1991 and Saxenian, 1994).4 This paper departs from the case-based approach and investigates, in a systematic yet exploratory manner, characteristics associated with university differences in the formation of spin-off companies, specifically university-based companies that locate in the university's research park.

Our specific focus on university research parks is important because they contribute critically to the U.S. national innovation system. Parks enhance knowledge spillovers between universities and tenant firms, and parks enhance regional economic growth and make markets more competitive (Link, 2002).

In Section 2, we posit a model of the determinants of the formation of university spin-off companies. The data used to estimate the model are described and the estimates are presented in Section 3. The paper concludes with summary observations in Section 4 along with a call for future work on this previously neglected topic.

Spin-off companies are found to be concentrated more in older parks and in parks that are associated with richer university research environments. We also find that spin-off companies are concentrated more in parks that are geographically closer to their university and in parks that have a biotechnology focus.

2. A Model of spin-off company formation in university research parks

We proffer the following definition of a university research park:5

> A university research park is a cluster of technology-based organizations that locate on or near a university campus in order to benefit from the university's knowledge base and ongoing research. The university not only transfers knowledge but expects to develop knowledge more effectively given the association with the tenants in the research park.

Generally, if the park is on or adjacent to a university campus, the university owns the park land and either oversees, or at least advises on, aspects of the activities that take place in the park as well as on the strategic direction of the park's growth. When the park is located off campus, it is often the case that the park land is owned by a private venture – and sold or leased to tenants – but the university has typically contributed financial capital to its formation and/or intellectual capital to its operation; therefore, there are elements of an administrative relationship between the university and such research parks.

Universities are motivated to develop a research park by the possibility of financial gain associated with technology transfer, the opportunity to have faculty and students interact at the applied level with technology-based organizations, and by their responsibility of contributing to a regional-based economic development effort. Research organizations are motivated to locate in a research park to gain access to faculty, students, and research equipment, and to foster research synergies.

Based on the definition above, the population of 81 currently active research parks, as defined in the National Science Foundation database on university research parks, through 2002 is shown in Fig. 1.6 Notable in the figure are the following parks: Stanford Research Park (established in 1951), Cornell Business & Technology Park (established in 1952), and the Research Triangle Park of North Carolina (established in 1959). Also notable in the figure is the increase in park formation that began in the late-1970s and accelerated in the early 1980s in response to the increase in real R&D performed in industry in the late 1970s and to several public policies designed to stimulate R&D and thus possibly park formations – the Bayh–Dole Act of 1980, the R&E tax credit in 1981 and its subsequent renewal, and the National Cooperative Research Act of 1984.

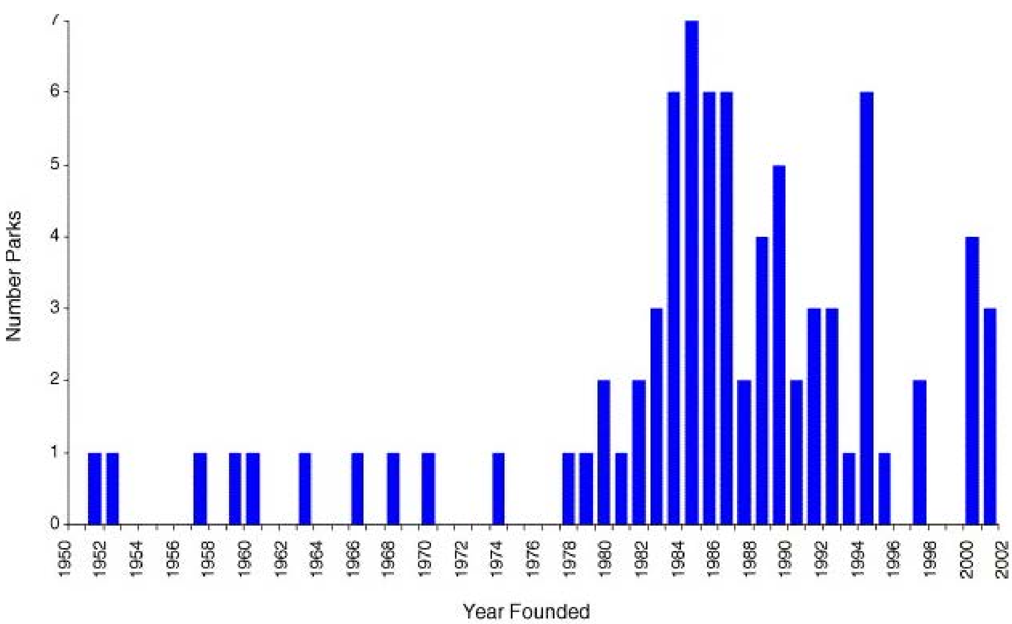

Fig. 1. Population of university research parks, by year founded (1951–2002) (n = 81).

Danilov (1971) attributes the relatively long period from about 1960 to the early 1970s, during which the research park formation movement seemingly stalled, to a number of park efforts that failed as well as to the restraints on corporate R&D growth that coincided with a lackluster economy.

We view the formation of university spin-off companies as an output of university research related activity and an outcome of the university's purposive technology transfer efforts.7 Our hypothesis is that there are two relevant sets of inputs to spin-off formations: the research environment of the university and the characteristics of the research park to which the spin-off companies locate:

Spin-offs= *f*(university research environment, research part characteristics)

We offer two hypotheses about relationship (1). First, we hypothesize that the more research intensive the university, the greater the probability that faculty will innovate, and the more innovative the faculty, the greater the probability that technologies will develop around which a spin-off company could be based. Regarding the research environment of the university, DiGregorio and Shane (2003) emphasize that intellectually eminent universities generate more start-up companies.8 To the extent that the university's research environment relates to its broader social network – especially an industrial social network – the research of Lockett et al. (2003) also supports our first hypothesis.

Radosevich (1995) and Franklin et al. (2001) argue that an entrepreneurial environment is conducive for the formation of spin-off companies. To the extent that universities with older research parks have, over time, developed such an environment where entrepreneurial-like perception of opportunities is part of the park's culture,9 then we hypothesize that the formation of university spin-off companies into the university's park will occur more often in older parks than in newer ones.

3. The dataset and the empirical findings

As part of the dataset on university research parks that we have developed for the National Science Foundation (Link and Scott, 2003b), information was collected on the percentage of current (in year 2002) park organizations that were university spin-off companies. This information was collected through interview surveys for 51 of the 81 U.S. research parks in the United States (Fig. 1). Thus, with reference to Eq. (1), this information forms the dependent variable in our analysis.

We approximate the research environment of the university qualitatively. Each of the 51 universities in our dataset is classified as being one of the top 100 universities in terms of the level of R&D spending from all sources, or not. We approximate the age of the park as the number of years since its formation. We control for other university and park characteristics, such as: the distance, in miles, between the university and its research park; if the university is a private or a state university; if the research park is operated by the university or by a foundation or private contractor; the technology focus of the park if it has one; and the region of the country of the university and its park.

Thus, for estimation purposes, Eq. (1) becomes:

spin-offs= *f*(RD100, age, mileage, prostate, oper, techit, techbio, region)

Each of the variables is described in Table 1.

Table 1. Description of variables ($n = 51$)

Name	Description	Mean	Range
Spin-offs	Percentage of park organizations that are university spin-off companies in year 2002	9.58	0–40
RD100	=1 if the university is a top 100 university in terms of R&D spending in 1999 (latest year of data available from the National Science Foundation)	0.61	0–1
Age	Age of the park in years from the date it was founded	16.80	0–50
Mileage	Miles from the university to the park	4.31	0–35
Prstate	=1 if university is private; 0 if university is state	0.18	0–1
Oper	=1 if the park is operated by the university; 0 if the park is operated by a foundation or private contractor	0.31	0–1
Techit	=1 if IT is the advertised dominant technology of park tenants; 0 otherwise	0.25	0–1
Techbio	=1 if bioscience is the advertised dominant technology of park tenants; 0 otherwise	0.27	0–1
Region [a]	*s* = 1 if the park is in the south, 0 otherwise; mw = 1 if the park is in the midwest, 0 otherwise; *w* = 1 if the park is in the west, 0 otherwise	*s* = 0.33; mw = 0.24;*w* = 0.22	0–1

a Following the U.S. Bureau of the Census classification, the northeast includes: Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, and New Jersey. The south includes: Delaware, Maryland, West Virginia, Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Alabama, Mississippi, Florida, Louisiana, Arkansas, Oklahoma, Texas, and the District of Columbia. The midwest includes: North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, and Ohio. And the West includes: Alaska, Washington, Oregon, California, Montana, Idaho, Nevada, Wyoming, Utah, Arizona, Colorado, New Mexico, and Hawaii.

As noted in Table 1, spin-offs is a truncated variable between 0 and 100 although the dataset only contains multiple observations at 0, thus Tobit is the appropriate econometric procedure.10

The Tobit estimates corresponding to three variations of Eq. (2) are in Table 2.11 The results in column (1) are the full specification, while those in columns (2) and (3) delete insignificant variables. All three specifications are overall significant; our discussion focuses on the parsimonious specification in column (3) with comparisons to the other specifications.

Table 2. Tobit Estimates from Eq. (2), *n* = 51 (standard errors in parentheses)

Variables	(1)	(2)	(3)
RD100	3.56^{*} (1.82)	3.78^{**} (1.78)	3.49^{*} (1.80)
Mileage	0.65 (0.65)	–	–
Mileage^2	-0.10^{*} (0.05)	-0.055^{***} (0.017)	-0.057^{***} (0.017)
Prstate	3.50 (3.17)	2.39 (2.21)	–
Oper	1.47 (1.88)	2.00 (1.86)	2.58 (1.79)
Age	0.76^{***} (0.09)	0.76^{***} (0.09)	0.80^{***} (0.08)
Techit	2.40 (2.15)	1.66 (2.11)	–
Techbio	4.82^{**} (2.17)	4.46^{**} (2.07)	3.86^{**} (1.92)
South	1.15 (3.19)	–	–
Midwest	−0.74 (3.22)	–	–
West	1.93 (3.34)	–	–
Constant	-9.34^{**} (3.78)	-7.58^{***} (2.24)	-7.22^{***} (2.17)

Variables	(1)	(2)	(3)
Tobin's sigma	5.27 (0.58)	5.38 (0.59)	5.49 (0.61)
Pseudo R^2	0.229	0.223	0.216
χ^2 (d.f.)	77.28 (11)***	75.17 (7)***	73.11 (5)***
log likelihood	−130.28	−131.34	−132.37

Note: There are 10 left-censored observations at spin-offs = 0 and 41 uncensored observations.

* Denotes significance at the 0.10 level.

** Denotes significance at the 0.05 level.

*** denotes significance at the 0.01 level. Tobin's sigma is the ancillary parameter σ for the Tobit model (Greene, 2003, pp. 764–766).

The research environment of the university is significant, as hypothesized. More research-oriented universities, as measured by RD100, have within their research parks a greater proportion of tenants that are university spin-off companies. In alternative regressions, we dropped RD100 and included variables that alternatively distinguished research orientation by dividing the sample into top 10 R&D universities versus all others, and top 50 R&D universities and all others. These alternative R&D environment variables were never significant.12

Also, as hypothesized, older parks do have a greater percentage of tenants that are university spin-off companies. The variable age is highly significant.

Our findings also indicate that distance matters. Those universities with research parks closer to their campus (i.e., mileage decreases) have a greater percentage of university spin-off companies, and this effect is non-linear. The empirical results suggest that technology also matters. The percentage of university spin-off companies is greater in research parks that have a biotechnology focus than in parks with either an information technology focus or in parks with no specific technology focus.

Finally, the above findings do not differ significantly across the different regions.

4. Summary observations and policy implications

Because this study is the first effort to quantify university spin-off formations into a university research park, our findings should be interpreted cautiously. However, our results are important not only because of their general descriptive interest, but also because they validate our conceptual arguments and signal university and research park characteristics associated with an aspect of technology transfer, namely technology that is transferred from the university as manifested in the form of companies rather than simply in the form of licensing fees to be paid to the university.

Interpreting our dependent variable as a signal of technology transfer embodied in companies raises the possibility that our model may omit at least one important explanatory variable, namely a variable capturing differences among universities' administrative incentives to appropriate technology returns simply with licensing fees as opposed to appropriating the technology returns through a start-up company in which the university could have an interest. Describing such different incentive structures is certainly one area for future research.13

Further, our analysis did not consider characteristics of spin-off companies other than whether each was an information technology or biotechnology company. Describing spin-off company characteristics is a second area for future research. In addition to descriptions of the technologies, company ownership characteristics (e.g., is the spin-off company owned and managed by a faculty member or by a venture capitalist?) are possibly important. Also, are there important and systematic performance differences for university spin-off companies, and are those differences related to the company's location within or outside a research park?

These caveats aside, our finding that the percentage of university spin-off companies is relatively greater in research parks that have a biotechnology focus has important policy implications—regional economic development policy implications in particular. As noted by Link (2005), and others, the success of biotechnology clusters within several regions of the United States, and other industrialized nations, has led economic development planners in other regions to focus on biotechnology as a strategic technology for stimulating growth in their region. Of course, fundamental to such an imitative policy strategy being successful is a clear understanding of how established clusters were developed, the research capabilities of the university(ies) or institute(s) in the planning regions, and the ability of such university(ies) or institute(s) in the planning regions to emulate what others have done.

What others have done is spin-off dedicated biotechnology firms into juxtaposed areas or parks in order to take critical advantage of the tacit knowledge that resides in the university(ies) or institute(s) scientists. Thus, understanding characteristics of university research parks conducive for spin-off formations is a critical first step, or planning guideline, especially relevant to a regional biotechnology growth strategy or policy. Perhaps the findings in this paper will provide the seeds for such an understanding.

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2 A second area that has received little attention, and however, is beyond the scope of this paper, is the impact of university spin-off companies on both the revenue growth of the university and the economic growth of the region.

3 Deuker (1997) makes a case that the development of biomedical technologies was the genesis of technology transfer activity in U.S. universities.

4 See also the excellent reviews of the literature in Clarysse et al. (2005), Degroof and Roberts (2004), and Johansson et al. (in press).

5 This is the definition that will be used by the National Science Board in its forthcoming Science and Engineering Indicators, 2006. This section draws directly from Link and Scott (in press); therein is a more detailed explanation of the development of this definition.

6 The genesis for the construction of this database came from recommendations at the National Science Foundation-sponsored Research Park Indicators Workshop, convened at the University of North Carolina at Greensboro in November 2002. Based on the findings from the workshop, the National Science Foundation set forth an initiative for Link to develop a national database on university research parks.

7 Not all university spin-off companies are the result of the purposive activity of the university. It is also the case that faculty may establish a spin-off company because they cannot reach an intellectual property (IP) agreement with university administrators. As Hall et al. (2001) and Hertzfeld et al. (2003) have shown, IP issues associated with university research can be pronounced.

8 Shane and Stuart (2002) argue that the overall resource environment of a university is important for the survival of start-ups, regardless of their location (See also Lerner, 2005).

9 See Hébert and Link (1998) for a discussion of the perception characteristic of an entrepreneur.

10 Tobit analysis allows us to model the need for an appropriate environment before any spin-offs at all appear. Without the appropriate circumstances, the dependent variable is 0; with the right environment, then the spin-offs' share exceeds 0, with the share being a function of the explanatory variables. Greene (2003, pp. 764–766) provides a general discussion of the Tobit model and its use with limited dependent variables such as our variable for the percentage of tenants that are university spin-off companies. Also, we do not have information for all parks on the number of tenants in the park. Thus, Eq. (2) is specified as a share equation because information on the number of spin-offs was not available.

11 Selection from the population of 81 universities with research parks into our sample of 51 university research parks was not considered empirically. Either we were told by park directors that information on spin-offs was not available because it had not been collected, or we were unable to identify a park individual who could provide the requested information. Those variables – information was available or not, and an individual was available or not – of course predict response perfectly and cannot be used to explain the differences in the probability of response with the sample of 51 respondents. Our paper leaves for future research the specification of an underlying model of the determinants of response (factors that make it more or less likely that the information or a responding individual would be available) and the determination of whether the error in the probit model of response is correlated with the error in the Tobit model of the percentage of spin-off companies.

12 These results are available on request from the authors. Also, we do not have consistent information on the level of R&D performed at universities. Selected data on this innovation measure are available from the National Science Foundation for those universities in the top 100, but for the other universities their websites generally report contradictory numbers. Thus, we chose to control for research environment of each university dichotomously.

13 It was suggested that Eq. (2) should control for the physical opportunity of parks to house spin-off companies and for the relative incentive of parks to encourage or even invite spin-off companies to locate. This is a reasonable issue, but unfortunately our data do not allow us to test these ideas. We have no measures of acres available or tenant space that is vacant. Controlling for park size per se will not address this point.