Universities as research partners in publicly supported entrepreneurial firms.

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Audretsch, D. B., Leyden, D. P., & Link, A. N. (January 01, 2012). Universities as research partners in publicly supported entrepreneurial firms. *Economics of Innovation and New Technology, 21(5-6),* 529-545.

Abstract:

Partnerships between universities and industrial firms can play a key role in enhancing competitiveness because they provide a conduit for the spillover of knowledge from the academic organization where knowledge is created to the firm where it is transformed into innovative activity. We set forth in this paper a model of industry/university participation, and we test the model empirically, using research project data on entrepreneurial firms that were funded through the US Department of Energy's Small Business Innovation Research (SBIR) program. We find that larger firms are more likely to be involved in a research partnership with a university, in general, as are firms with founders who have an academic background. We find the latter result holds across disaggregated types of university partnerships, as well. We find no empirical evidence that the size of the SBIR award influences the likelihood of a research partnership.

Keywords: research partnerships | innovative behavior | entrepreneurship | industry/university relationships | economics | innovation

Article:

1. Introduction

The issue of competitiveness has emerged as one of the great policy concerns confronting the USA. The inability of the country to be competitive in traditional manufacturing industries as well as emerging high technology industries has been linked to higher rates of unemployment and lower rates of economic growth.1 A key issue in enhancing American competitiveness is to generate more innovative activity from investments in science and technology. Partnerships between universities and industrial firms can play a key role because they provide a conduit for the spillover of knowledge from the academic organization where knowledge is created to the firm where it is transformed into innovative activity, which ultimately enhances the competitiveness of the firm, industry, and country.† 2

The Council on Competitiveness (1996, 3–4) emphasized more than a decade and a half ago the importance of industry/university relationships in the USA:

> [P]articipants in the U.S. R&D enterprise will have to continue experimenting with different types of partnerships to respond to the economic constraints, competitive pressures and technological demands that are forcing adjustments across the board. … [and in response] industry is increasingly relying on partnerships with universities …

A number of academic studies support this claim as well.3 For example, Link (1996) showed that university participation in formal research joint ventures (RJVs) has increased steadily since the mid-1980s, Cohen et al. (1998) documented that the number of industry/university R&D centers increased by more than 60% during the 1980s, and a related survey of US science faculty by Morgan (1998) revealed that many desire even more partnership relationships with industry. Mowery and Teece (1996, 111) argue that such growth in strategic alliances in R&D is indicative of a ‘broad restructuring of the US national R&D system’. The findings of these studies are consistent with the view that partnerships between industry and universities are conducive to knowledge spillovers that promote innovative activity and ultimately enhance competitiveness.

According to Hall, Link, and Scott (2000, 2003), little is known about the types of roles that universities play in such research partnerships or about the economic consequences associated with those roles.4 What research there is on the topic of universities as research partners falls broadly into either examinations of industry motivations or university motivations for engaging in an industry/university research relationship.5

Hall, Link, and Scott (2000, 2003) noted that the literature has identified two broad industry motivations for engaging in an industry/university research relationship. The first is access to complementary research activity and research results.6 Rosenberg and Nelson (1994, 340) emphasized: ‘What university research most often does today is to stimulate and enhance the power of R&D done in industry, as contrasted with providing a substitute for it’. Pavitt (1998), based on his review of this literature, was more specific in this regard. He concluded that academic research augments the capacity of businesses to solve complex problems. The second industry motivation is access to key university personnel.7 A third motivation might be that through a university relationship, the firm can expand its boundaries while at the same time eliminating market transactions for research services. Following Coase (1937, 388), it might be the case that university-based research services are an example of the ‘entrepreneur-co-ordinator’ who, through the partnership, is able to direct research without the complications of a market with exchange transactions.

University motivations for partnering with industry seem to be financially based. Administration-based financial pressures for faculty to engage in applied commercial research with industry are growing.8 Zeckhauser (1996, 12746), for example, was subtle when he referred to the supposed importance of industry-supported research to universities as he describes how such relationships might develop: ‘Information gifts [to industry] may be a part of [a university's] commercial courtship ritual’. Along those same lines, Cohen et al. (1997, 177) argued that:9 ‘University administrators appear to be interested chiefly in the revenue generated by relationships with industry’. They are also of the opinion that faculty, who are fundamental to making such relationships work: ‘… desire support, per se, because it contributes to their personal incomes [and] eminence … primarily through foundation research that provides the building blocks for other research and therefore tends to be widely cited’.

However, several drawbacks to university involvement with industry have been identified, such as the diversion of faculty time and effort from teaching, the conflict between industrial trade secrecy and traditional academic openness, and the distorting effect of industry funding on the university budget allocation process (in particular, the tension induced when the distribution of resources is vastly unequal across departments and schools).

Empirical research related to universities as research partners, as recently summarized by Link and Wessner (2011), does so by drawing on the industrial organization paradigm developed by Bain (1949). Defining ‘conduct’ as partnering with a university and ‘structure’ as those firms or universities or environmental characteristics that bring about partnering, then the structure → conduct literature can be summarized as follows. Partnering (i.e. conduct) is more likely in the following independent situations (i.e. structure): the firm is engaged in exploratory internal R&D (Bercovitz and Feldman 2007); the firm is mature and large (Fontana, Geuna, and Matt 2006; Stuart, Ozdemir, and Ding 2007); there is a lack of intellectual property issues between the firm and the university (Hall 2004; Hall, Link, and Scott 2001); and university faculty are male, with tenure, and are part of a university research center (Link, Siegel, and Bozeman 2007; Boardman and Corley 2008). Defining performance in terms of the economic consequences of partnering with a university, then the conduct → performance literature can be summarized as follows: there will be two-way flows of knowledge through publication and conferences, and through the formation of RJVs (Cohen, Nelson, and Walsh 2002; Link 2005; Link and Scott 2005; Hertzfeld, Link, and Vonortas 2006); firm R&D will be more successful (Link and Rees 1990; Hall, Link, and Scott 2000, 2003; Kodama 2008); and university research parks – literally a university-based manifestation – will grow as will attendant industries (Link and Scott 2007; Bozeman, Hardin, and Link 2008).

The remainder of this paper is outlined as follows. In Section 2, we set forth a model of industry/university participation. In Section 3, we test this model by developing a reduced form equation of the probability that a firm will partner with a university on a specific research project. Our data for this empirical test comes from projects funded by the US Department of Energy's (DOE's) Small Business Innovation Research (SBIR) program. Finally, in Section 4, we conclude the paper with summary remarks.

2. Model of the industry/university participation

When firms initiate a research partnership with a university, or when a university initiates a research partnership with a firm, each is acting entrepreneurially as it systematically and purposely attempts to identify, or explore, and capture a new source of supply – knowledge. For the firm, this new source of supply is knowledge that the university has (or can generate), but that the firm cannot acquire easily (i.e. at low cost) on its own; for the university, this new source of supply is finances that the firm has, but that the university cannot easily (i.e. at low cost) acquire on its own. Each uses, or exploits, systematically and purposely this new source of supply to create jointly, among other things, a new method of production, be it a good or service/ intellectual output. That new method of production can lead to a new market or organization of industry.10

The degree to which a firm will engage with a university in an innovation process is a two-step decision process in which the firm first decides whether to establish a relationship, and second what level of involvement it will have assuming it has already decided to establish a relationship.

Consider the second decision first. The value of working with a university is twofold. It increases the probability that the innovation process will be successful, and it increases the value of any innovation that might result. Letting the level of involvement with the university be represented by Q, where Q might be thought of empirically as R&D inputs, the probability that the innovation process results in a marketable product can be represented by the concave function p(Q) and the revenues (net of production costs) associated with the production and sale of the resulting innovation can be represented by the concave function R(q) where q indicates the quality/marketability of the innovation.11 The quality q of the innovation is itself assumed to be a concave function q(Q) of the level Q of involvement with the university. Thus, expected net revenues from the production and sale of the resulting innovation will be:

$$R^e = p(Q) \cdot R(q(Q)),$$

and expected marginal net revenues associated with the production and sale of the innovation will be

$$\mathrm{MR}^e = p'(Q) \cdot R(q(Q)) + p(Q) \cdot R'(q(Q)) \cdot q'(Q).$$

There are, of course, costs to engaging in the R&D process itself, both in terms of the physical and intellectual effort required as well as in terms of the costs of raising the funds to be able to make such effort.12 Assuming that these costs include both fixed and variable components, we can represent the cost function by the function:

$$c = c(Q) \quad \ni \quad c(0) > 0, c'(Q) > 0, \text{ and } c''(Q) > 0.$$

The optimal level of university involvement, assuming the firm wishes to maximize the expected profits from engaging in an R&D process, will be some Q* that maximizes the expected profits associated with the R&D process:

$$\pi^{e}(Q) = p(Q) \cdot R(q(Q)) - c(Q),$$

that is, Q* will be that level of Q that equates expected marginal revenue, MR e , to the marginal cost, MC, of the R&D process:

$$p'(Q) \cdot R(q(Q)) + p(Q) \cdot R'(q(Q)) \cdot q'(Q) = c'(Q).$$

Figure 1 provides a graphical illustration of the determination of the optimal level of involvement with the university.

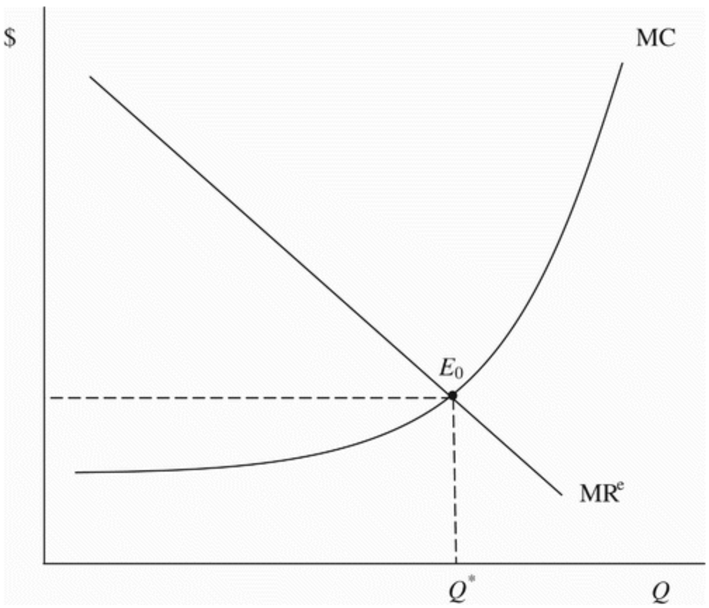

Figure 1. Determining the level of involvement with a university.

Of course, the above analysis is based on the assumption that the firm in fact chooses to work with the university. Unlike the decision as to how large *Q* should be, the decision whether to engage with the university is a discrete one in which the firm chooses from among three possibilities: partner with a university, perform the R&D in-house, or not engage in R&D. Following Coase's (1937) analysis on the boundaries of a firm, the decision to partner with a university requires that the expected profits associated with that partnership, $\pi^{e}(Q^{*})$, be at least as great as the expected profits associated with performing the R&D in-house, $\pi^{e}_{\text{in-house}}$. Thus, a necessary condition for partnering with a university is that:

$$\pi^{e}(Q^{*}) \geq \max\{\pi^{e}_{\text{in-house}}, 0\}.$$

level of expected profits associated with a university partnership, $\pi^e(Q^*)$, will depend on the nature of the partnership. To better understand the factors that will affect the value of a university partnership, note that those expected profits can be defined as the area between the MR^e curve and the MC curve in Figure 1 (minus, of course, the fixed costs associated with the R&D process), that is

$$\pi^e(Q) = \int (p'(Q) \cdot R(q(Q)) + p(Q) \cdot R'(q(Q)) \cdot q'(Q) - c'(Q)) \cdot dQ - c(0). \qquad (7)$$

Thus, the level of these profits will depend on the degree to which the following factors are part of a university partnership:13

- *University provision of human and/or physical capital that the firm otherwise would not have access to*. To the extent, this is true, the partnership will relax a resource constraint of the firm, thus resulting in the MC curve being further to the right (and perhaps vertically lower) that it would be otherwise. This results in a higher level of engagement, Q^*, a higher level of expected profits, $\pi^e(Q^*)$, and therefore a greater probability that a university partnership will meet the necessary condition described in Equation 6.

- *The presence of the partnership reduces the cost of raising capital to fund the R&D process*. This cost in large part will be determined by the degree to which the firm can fund the R&D project internally versus externally, by the perceived riskiness of the R&D process by financial markets, and by the perceived market value of the resulting innovation. A lower cost of raising capital will mean that the MC curve is vertically lower. To the extent that this occurs, the level of engagement Q^* with the university will be higher, the level of expected profits $\pi^e(Q^*)$ will be greater, and therefore there will be a greater probability that a university partnership will meet the necessary condition described in Equation (6).

- *Engagement with the university results in a transfer of knowledge* (*such as an increase in the absorptive capacity of the firm*) *and/or skills to the firm.* To the extent this is present in university partnership, the MR^e curve and/or the MC curve will be further to the right than they otherwise would be. This results in a greater level of engagement Q^* with the university, an increase in expected profits $\pi^e(Q^*)$, and therefore a greater probability that a university partnership will meet the necessary condition described in Equation (6).

- *University partnership results in a reduced ability by the firm to appropriate the benefits of the R&D process*. Such a characteristic of a university partnership may be due to the more open research environment that universities operate in. To the extent this factor is present, the MR^e curve would be further to the left than it otherwise would be. That results in a lower level of engagement Q^*, lower expected profits $\pi^e(Q^*)$, and therefore a diminished likelihood that the necessary condition in Equation (6) is met.

Figure 2 summarizes this choice problem by illustrating two cases, the first of which (defined by the expected profit function $\pi_1^e(Q))$ is associated with the firm deciding to engage with the university, the second of which (defined by the expected profit function $\pi_2^e(Q))$ results in the firm deciding not to engage with the university.

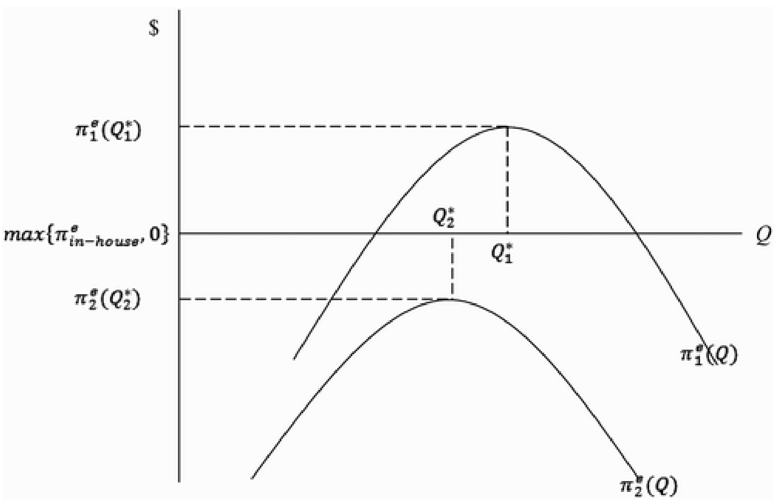

Figure 2. The decision to engage with a university.

Finally, note that these results are based on the assumption that the firm seeks to maximize the profits associated with the R&D process. However, experiments by Fehr, Herz, and Wilkening (2010) based on a theoretical principal-agent model by Aghion and Tirole (1997) find that principals tend to value control in the decision-making process independent of the level of profit and therefore are willing to pay a premium (in the form of foregone profits) to preserve that control. In the context of this paper, this suggests that firms may insist on a higher, strictly positive threshold of profitability before deciding to partner with a university. To the extent this is true, the condition for partnering with a university would become:

$$\pi^e(Q^*) \geq \max\{\pi^e_{\text{in-house}}, 0\} + \rho,$$

where ρ represents the value that firm places on maintaining control of the R&D process rather than delegating its authority to a university. As Fehr, Herz, and Wilkening (2010) note, the likelihood that the principal will delegate authority to an agent will increase, the greater the principal perceives that its interests coincide with the interests of the agent or the more the agent has expertise/knowledge that the principal does not have. In the context of this paper, that suggests that the presence of specialized university knowledge and/or a greater comfort level on the part of the firm with engaging with a university, the smaller will be ρ, and therefore the greater the likelihood that the firm decides to partner with the university.

3. Statistical analysis

Our empirical model focuses on identifying those factors that play a role in the discrete choice problem of whether to partner with a university. We define our empirical model to be

$$\mathrm{Univ} = \mathrm{f}(\mathbf{X}, \mathbf{Z}),$$

where Univ is a dichotomous representation of whether a firm partners with a university on a particular research project, X is a vector of project characteristics, and Z is a vector of firm characteristics. Following the theoretical discussion above, we seek variables for X and Z that are associated with changes in the firm's expected marginal revenue, its marginal cost, and/or its expectation that its interests coincide with those of a university.

3.2 SBIR database

The SBIR program was created in 1982 under the US Small Business Innovation Development Act of 1982 with the following stated objectives: to stimulate technological innovation, to use small business to meet Federal research and development needs, to foster and encourage participation by minority and disadvantaged persons in technological innovation, and to increase private sector commercialization of innovations derived from Federal research and development (R&D).14 The 1992 reauthorization of the program broadened the above objectives to emphasize the participation of woman owned and controlled businesses.

Each government agency with an extramural research budget is required to set aside a portion (currently equal to 2.5%) of that budget to award to small (500 or fewer employees) US businesses (at least 51% owned by US citizens or lawfully admitted permanent resident aliens) in response to requests for proposals on defined topics. The structure of the SBIR program is defined by three phases: Phase I has awards to assist businesses as they assess the feasibility of an idea's scientific and commercial potential in response to the funding agency's objectives; currently these are 6-month awards for up to $100,000. Phase II has awards to assist businesses further their research with an expectation that the resulting technology will be commercialized; currently these are two-year awards for up to $1,000,000. There are no agency awards in Phase III; it is the period of time when the funded businesses are to move their technology from the laboratory into the market place. The business is expected to find private-sector funding (e.g. from venture capitalists) during this period.

Eleven agencies currently participate in the SBIR program, with the Department of Defense (DoD) accounting for nearly 58% of all awards, followed by Health and Human Services' National Institutes of Health (NIH) with about 19%, and DOE with about 6% (along with the National Aeronautics and Space administration and the National Science Foundation with similar percentages). Currently, about $2 billion is allocated per year to Phase I and Phase II awards, with nearly 98% account for the contribution by these five agencies.

As part of the SBIR program's reauthorization in 2000, the US Congress charged the National Research Council (NRC) within the National Academies to make recommendations for improvements in the program. Among those evaluatory activities that the NRC undertook was an extensive and balanced survey in 2005 based on a population of 11,214 projects completed from Phase II awards during the 1992–2001 time period. DOE Phase II projects in this database are studied herein.

Although not the largest agency participating in the SBIR program, there are some compelling reasons for focusing on DOE for this study. First, businesses that are funded through DoD and are successful in completing Phase II have a captive audience for much of their resulting technology, namely DoD (Nelson 1982; Link and Scott 2009). In 2005, the year of the NRC survey, nearly 40% of the technology developed by businesses through DoD Phase II awards was sold to that agency. Thus, the behavior of those businesses, especially their behavior toward partnering with universities is not guided entirely by market pressures. Second, NIH is comprised of 27 research institutes and centers, but there is a great amount of heterogeneity among Phase II award recipients because of heterogeneity of the Institute's focus (Link and Ruhm 2009). In our opinion, businesses funded by Phase II awards from DOE are more likely to have market-based incentives for creating new technologies and commercializing them, and thus relying strategically on universities as a source of technical knowledge and technology (National Research Council 2008). See Table 1 for descriptive statistics on the DOE sample of Phase II awards.

Table 1. Descriptive statistics on the NRC survey of DOE Phase II awards, 1992–2001.

Data reduction	Number of Phase II projects
Completed Phase II projects	808
Phase II survey sample size	439
Phase II random survey sample sizea	436
Response to the random survey (percent)	154 (35.3%)
Projects uses herein based on responses to all survey questions	92

a The NRC surveyed a number of non-randomly chosen projects (n=3) so as to be able to emphasize pre-selected success examples (National Research Council 2008).

3.3 Specification of the model

The variables used to estimate versions of Equation (8) are defined in Table 2, and descriptive statistics are presented in Table 3.

Table 2. Definition of variables.

Variable	Definition
Dependent variable	
Univ	=1 if in executing the Phase II research project there was involvement by a university
UnivFaculty	=1 if faculty member(s) or adjunct member(s) worked on the Phase II research project as a consultant
UnivGA	=1 if graduate student(s) worked on the Phase II research project
UnivEqupt	=1 if university facilities and/or equipment were used on the Phase II research project
UnivSub	=1 if a university was a subcontractor on the Phase II research project
UnivLicense	=1 if the technology for the Phase II project was licensed from a university
UnivDevelop	=1 if the technology for the Phase II project was developed at a university by a participant in the Phase II research project
Independent project variable	
Award	Phase II award amount ($1000)
FemalePI	=1 if the PI on the Phase II project was a female
Software	=1 if the actual/expected commercialized output is software
Hardware	=1 if the actual/expected commercialized output is hardware
ProcessTech	=1 if the actual/expected commercialized output is a process technology
ServiceCapab	=1 if the actual/expected commercialized output is service capability
Tool	=1 if the actual/expected commercialized output is a research tool

EducMat	=1 if the actual/expected commercialized output is educational material
Other	=1 if the actual/expected commercialized output is other than listed above
Independent firm variable	
Bus	=1 if a founder of the firm has a business background
Acad	=1 if a founder of the firm has an academic background
Emp	Employment in the firm at the time of the Phase II award
FemaleOwn	=1 if the firm is owned by a female

Table 3. Descriptive statistics on the variables (n=92).

Variable	Mean	Std. Dev.	Range
Dependent variable			
Univ	0.348	0.479	0/1
UnivFaculty	0.185	0.390	0/1
UnivGA	0.217	0.415	0/1
UnivEqupt	0.120	0.326	0/1
UnivSub	0.130	0.339	0/1
UnivLicense	0.022	0.147	0/1
UnivDevelop	0.054	0.228	0/1
Independent project variable			
Award	688.60	96.96	387.29–750.00
FemalePI			
Software	0.217	0.415	0/1
Hardware	0.565	0.498	0/1
ProcessTech	0.337	0.475	0/1
ServiceCapab	0.207	0.407	0/1

Tool	0.130	0.339	0/1
EducMat	0.043	0.205	0/1
Other	0.076	0.267	0/1
Independent firm variable			
Bus	0.446	0.450	0/1
Acad	0.587	0.495	0/1
Emp	23.84	38.69	0–200
FemaleOwn	0.043	0.205	0/1

We consider seven dependent variables in the estimation of Equation (8), although our focal dependent variable is Univ (Table 2). This variable measures dichotomously whether an SBIR award-recipient firm partnered with a university in any manner while executing its funded Phase II research project. In our sample of 92 funded and completed Phase II projects (Table 1), nearly 35% had a university relationship (Table 3).

The remaining six non-mutually independent university variables measure dichotomously the type of university relationship and allow us indirectly to obtain a fuller indication of the motivations for partnering with a university, particularly with regard to whether universities provide specialized inputs that are not readily or otherwise available to the firm.15 Most commonly (Table 3), firms are involved with a university through the use of graduate students (UnivGA); nearly 22% of the Phase II research projects employed graduate students. The less frequent relationships are when the Phase II research relies on a technology developed at the university by a participant in the Phase II project – this occurs only about 5% of the time – or a technology licensed from the university – this occurs about 2% of the time.

The dependent variables reflect the propensity for the university to be involved in SBIR Phase II research projects in a variety of ways. Alvarez, Barney, and Young (2010), Eckhardt and Shane (2010), and Sarasvathy et al. (2010) stress the roles that the recognition of entrepreneurial opportunity plays in the decision by individuals to undertake entrepreneurial activity. There are three categories of available variables that influence either the existence of entrepreneurial opportunities or the ability of the firms to recognize that such entrepreneurial opportunities are associated with university–firm partnerships.

The first category of independent variables reflects characteristics specific to SBIR Phase II award project. Regarding project characteristics, the level of Phase II funding (Award) will affect the firm's decision to partner in two ways. First, the greater the level of Phase II funding the greater will be the firm's access to human and/or physical capital. Second, the greater the level of Phase II funding, the lower the cost of raising capital to fund the R&D process will be. The difficulty in predicting the result of these effects is that they argue for increased profits for the firm whether it partners with the university or not. Thus, in terms of Figure 2, both the π e (Q) curve and the line will shift up, and thus the likelihood of partnering with the university could increase or decrease, depending on the relative degree to which π e (Q) and line increase. It should be noted, however, that if the firm chooses to partner with the university, the larger the level of Phase II funding, the greater will be the level of involvement with the university Q* due to the large level of funding shifting the firm's marginal cost curve down and to the right.

A second independent variable indicates whether the PI on the Phase II project is female. The relative propensity of females to engage in entrepreneurial activity, and the recentness of that activity, has been extensively documented (Acs and Audretsch 2010). Thus, we would expect a negative coefficient between female principle investigators (FemalePI), and possibly female owners (FemaleOwn) – a firm variable discussed below – and the dependent variables.16 However, to the extent to which women entrepreneurs are less protective of the ability to control (Fehr, Herz, and Wilkening 2010), the likelihood of partnering with a university could increase.

The second category of project-specific independent variables reflects the relevant technology. Entrepreneurial opportunities are not assumed to be homogeneous across different technologies. Rather, Scherer (1983) observed that the propensity to innovate any given technology is, in fact, influenced by the commercial opportunities associated with that technology. Differences in entrepreneurial opportunities across technologies are accounted for by using a series of dichotomous variables, reflecting whether the funded research has or is expected to generate commercialized output that is software, hardware, or a process technology. Similarly, entrepreneurial opportunities may vary across the expected/actual commercialized outputs of service capabilities, research tools, educational material, and other outputs, so dichotomous variables are included. These controls are of particular interest for the potential light that they shed on financial market views of the riskiness and profitability of one line of research versus another. If, for example, financial markets view more tangible innovations (software, hardware, and research tools) as less risky and/or more profitable than intangible innovations (process technology, service capabilities, and educational products), we would expect the former group to be associated with a higher likelihood of university partnering.

The third category of independent variables reflects characteristics specific to the firm, and in particular, to its owner. These variables indicate the ability of the firm to identify and act on entrepreneurial opportunities. A growing literature has identified the background and career trajectory of the founder as having a large influence on firm strategy and performance. The ability of the firm to recognize and act on entrepreneurial opportunities is enhanced when the founder has a business background. Similarly, a founder with an academic background might be expected to increase the propensity for the firm to partner with the university because the ability of the founder and firm to identify entrepreneurial opportunities emanating from research undertaken at the university is presumably higher. Link and Ruhm (2011) have argued that the background of an entrepreneur influences his/her firm's behavior. Background establishes blueprints that tend to become a stable element of the structure of the firm, and the structure of the firm guides its strategy, including partnering or not with a university. Viewed in the light of Fehr, Herz, and Wilkening (2010), a possible explanation as to why such entrepreneurial background is important is that it is connected to the degree to which the entrepreneur values control and on the degree to which the entrepreneur sees his/her interests as similar to that of a university. In the SBIR database, this dimension of the entrepreneur is quantified in terms of having either a business background (Bus) or an academic background (Acad),17 with a business background perhaps indicating a stronger desire for control and an academic background perhaps indicating a closer perceived alignment between the entrepreneur and a university. Additionally, a business background might be associated with the perception that the enterprise is less risky. To the extent these conjectures are true, a business background would have an ambiguous effect on the likelihood of partnering with a university, while an academic background would be associated with a greater likelihood of partnering with a university.

Regarding other firm characteristics, we control for firm size by the level of employment (Emp) at the time of the Phase II award. On the one hand, larger firms may be less likely to partner with a university, holding constant the scope of the Phase II project, because they have a breadth of internal resources to draw upon to meet any uncertainties associated with the research. On the other hand, larger firms may be more likely to partner with a university, ceteris paribus, if associated with its size is specialization of its employees. Moreover, to the extent that a larger firm is viewed as a less risky venture, that too would result in the level of employment being positively associated with the likelihood of university partnering.

3.4 Econometric findings

The probit results from the estimation of Equation (8) are in Table 4.18 With respect to our focal dependent variable, Univ, the results in column (8) show that larger firms, measured in terms of number of employees at the time of the Phase II award (Emp) are more likely to be involved with a university. This finding is not inconsistent with our prior findings that larger firms have less fungible human capital or view that larger firms may be considered less risky. There is no statistical evidence that this size relationship is nonlinear. The results also show that entrepreneurs with an academic background (Acad) are, as conjectured, more likely to partner with a university than those with some other background.

Table 4. Probit regression results (n=92) (std. errors).

Variables	(1) Univ	(2) $Univ_{Faculty}$	(3) $Univ_{GA}$	(4) $Univ_{Equpt}$	(5) $Univ_{Sub}$	(6) $Univ_{License}$	(7) $Univ_{Develop}$
Award	−0.001	−0.0008	0.002	−0.002	−0.003	−0.004	−0.004
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)***	(0.060)	(0.004)
FemalePI	0.192	–	−0.085	–	0.196	–	0.962
	(0.715)		(0.716)		(0.862)		(0.847)
Software	1.376	0.551	0.646	0.042	0.762	–	0.389
	(0.532)*	(0.482)	(0.475)*****	(0.581)	(0.517)***		(0.790)
Hardware	0.602	0.522	0.603	0.341	0.389	–	−0.039
	(0.412)****	(0.438)	(0.391)****	(0.447)	(0.469)		(0.646)
ProcessTech	0.412	0.047	0.417	0.065	0.364	–	0.131
	(0.341)	(0.368)	(0.347)	(0.457)	(0.450)		(0.652)
ServiceCapab	−0.115	−0.452	−0.109	−0.204	0.296	–	0.815
	(0.413)	(0.473)	(0.433)	(0.610)	(0.523)		(0.730)
Tool	0.858	0.573	0.292	0.813	0.940	7.374	–
	(0.435)**	(0.441)	(0.470)	(0.497)	(0.451)**	(1.269)*	
EducMat	−1.378	–	–	–	–	–	–
	(0.937)****						
Other	0.209	0.120	–	–	–	–	0.774

Table 4. Probit regression results (n=92) (std. errors).

Variables	**(1) Univ**	**(2) Univ$_{Faculty}$**	**(3) Univ$_{GA}$**	**(4) Univ$_{Equpt}$**	**(5) Univ$_{Sub}$**	**(6) Univ$_{License}$**	**(7) Univ$_{Develop}$**
	(0.674)	(0.759)					(0.868)
Emp	0.007	0.005	0.004	0.008	0.009	−0.075	0.003
	(0.004)***	(0.005)	(0.004)	(0.005)****	(0.005)***	(1.142)	(0.007)
Bus	−0.118	−0.223	0.460	0.691	−0.098	–	–
	(0.309)	(0.339)	(0.319)****	(0.413)***	(0.413)		
Acad	0.749	0.219	0.250	0.853	0.532	10.841	5.744
	(0.342)**	(0.011)**	(0.351)	(0.489)***	(0.348)****	(1.269)*	(1.230)*
FemaleOwn	0.576	0.706	0.438	1.092	1.236	–	–
	(0.800)	(0.767)	(0.723)	(0.770)*****	(0.815)****		
Intercept	−0.920	−1.004	−3.234	−1.040	−0.220	−18.011	−4.680
	(1.178)	(1.218)	(1.434)**	(1.430)	(1.318)	(14.19)	(1.23)*
Log Likelihood	−50.45	−41.81	−43.76	−28.41	−31.74	−3.53	−13.92
Pseudo R^2	0.283	0.231	0.187	0.302	0.329	0.635	0.559

Note: Variables that predict perfectly are omitted and noted by '–'.

*Significant at 0.01-level or better.

**Significant at 0.05-level.

***Significant at 0.10-level.

****Significant at 0.15-level.

*****Significant at 0.20-level.

We find no evidence that either the size of the SBIR award (Award) or gender (FemalePI or FemaleOwn) influence the likelihood of a research partnership, although our theoretical arguments were not conclusive for such a relationship. The exception (columns (4) and (5)) is that female-owned firms are more likely to enter a university research relationship to gain access to technical capital (i.e. equipment) or research capital (i.e. subcontract). This finding, although not predicted from our theoretical arguments might reflect the still infant research nature of firms owned by female entrepreneurs.

Finally, we find that the expected outputs of software, hardware, and research tools are positively associated with greater university partnering, while the expected outputs of service capability and education products have a negative association. This is not inconsistent with financial markets perceptions of the value of these different lines of research.

In our opinion, the most striking finding when the nature of the university partnership is disaggregated (columns (2)–(7)) is that the background of the entrepreneur is statistically significant in every specification. In particular, having an academic background is significantly and positively correlated with every dimension of the relationship (except that the positive coefficient in the graduate student equation in column (3) is not significant), thus suggesting a general willingness to exploit a variety of relationships with a university that finds its origins in a perception by the entrepreneur that his/her interests and the interests of the university are similar. For entrepreneurs with a business background, however, that flexibility is not present except for the use of graduate students and university equipment (columns (3) and (4)), thus suggesting less of a perceived alignment between the entrepreneur's interests and a university's interests and a greater premium placed on control.

4. Discussion of the findings and conclusions

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1. Introduction

2. Model of the industry/university...

3. Statistical analysis

4. Discussion of the findings and conclusions

One of the major economic challenges confronting the USA is a lack of competitiveness in many industries. Policies to enhance US competitiveness, particularly in knowledge-based industries focus on increasing the spillover of knowledge from universities to the private sector. However, to actualize such knowledge spillovers, public policy needs to identify and promote conduits of knowledge spillovers from the university to private firms.

This paper has focused on a particular conduit of knowledge spillovers, namely partnerships between firms awarded a Phase II SBIR grant and universities. The propensity for an SBIR Phase II Award firm to partner with a university is linked to three types of factors – those involving the underlying technology, those involving the anticipated outputs, and those involving the firm and in particular the background of the founder. The empirical evidence provided in this paper suggests that all three of these factors influence the propensity of the firms to partner with a university. The likelihood of a firm entering into a partnership with a university is apparently greater for certain technologies, such as software and hardware, than for other technologies, such as process technologies.

Similarly, the likelihood of a firm–university partnership existing is greater for certain anticipated outputs than for others. If the anticipated output is a research tool, the likelihood of the firm partnering with a university is greater. However, other anticipated outcomes, such as the commercialized output being a service capability, are not statistically linked to the existence of a university–firm partnership.

The background of the founder of the firm is also linked to the likelihood of a firm–university partnership existing. If the founder has an academic background, there is a greater likelihood of the firm partnering with a university. Still, those founders with a business background do exhibit a greater propensity to partner with the university in more limited and specific ways, such as having a graduate student working on the Phase II research project, or using university facilities.

Taken together, the results from the analyses presented in this paper suggest that partnerships between firms and a university may flourish as entrepreneurs from the universities become more prevalent. It may be that facilitating entrepreneurship from university scientists and researchers not only has a direct benefit in terms of increased entrepreneurial activity, but also may enhance the subsequent spillovers of knowledge from the university to private firms, ultimately fuelling innovation, growth, and competitiveness.

Notes

†This paper was prepared for presentation at the Workshop on Academic Entrepreneurship, Economic Competitiveness, Basque Institute of Competitiveness, San Sebastian, Spain, 8–9 September 2011.

Link and Tassey (1987) were among the first to emphasize this trend from an economic policy perspective.

See Hagedoorn, Link, and Vonortas (2000) for review of the literature on research partnerships.

An earlier version of this literature review is in Link and Wessner (2011).

Hall's (2004) subsequent emphasis on industry/university research partnerships in the USA is on intellectual property. See also the role of intellectual property protection mechanisms in research partnerships, as discussed by Hertzfeld, Link, and Vonortas (2006).

Schacht (2009) provides an excellent review of public policies to promote industry/university relationships. Her starting point is (p. 4): ‘The promotion of cooperative efforts among academia and industry is aimed at increasing the potential for the commercialization of technology’. To wit, legislation in the USA to promote such partnerships traces at least to public policy responses to the productivity slowdown in the early and late 1970s. Specifically, such initiatives included the Bayh–Dole Act of 1980 (P.L. 96-517), Economic Recovery Tax Act of 1981 (P.L. 97-34), and the Tax Reform Act of 1986 (P.L. 99-514).

Cohen et al. (1998) provide a selective review of this literature, emphasizing the studies that have documented that university research enhances firms’ sales, R&D productivity, and patenting activity. See, Blumenthal et al. (1986); Jaffe (1989); Adams (1990); Berman (1990); Feller (1990); Mansfield (1991, 1992); Van de Ven (1993); Bonaccorsi and Piccaluga (1994); Klevorick et al. (1994); Zucker, Darby, and Armstrong (1994); Henderson, Jaffe, and Trajtenberg (1995); Mansfield and Lee (1996); Zeckhauser (1996); Campbell (1997); and Baldwin and Link (1998). Cockburn and Henderson (1997) show that it was important for innovative pharmaceutical firms to maintain ties to universities. Hall, Link, and Scott (2000, 2003) suggest that perhaps such research ties with universities increase the ‘absorptive capacity’, in the sense of Cohen and Leventhal (1990), of innovative firms.

See Leyden and Link (1992) and Burnham (1997). Link (1995) documented that one reason for the growth of Research Triangle Park in North Carolina was the desire of industrial research firms to locate near the triangle universities (University of North Carolina in Chapel Hill, North Carolina State University in Raleigh, and Duke University in Durham).

See Berman (1990), Feller (1990), and Henderson, Jaffe, and Trajtenberg (1995), and Siegel, Waldman, and Link (1999, 2003).

Siegel, Waldman, and Link (1999, 2003) document that university administrators consider licensing and royalty revenues from industry as an important output from university technology transfer offices.

Bercovitz and Feldman (2007), building on the conceptual advances of Pisano (1991) and Chesbrough (2003), refer to exploration and exploitation in the context of upstream university research alliances.

By concave, we mean that that first derivative of the function is positive and the second derivative is negative.

David, Hall, and Toole (2000) provide an insightful description of the R&D process from an investment perspective.

David, Hall, and Toole (2000) provide a more complete treatment of the variety of factors that affect the level of R&D activity.

For a more detailed discussion of the economic role of the SBIR program, see National Research Council (2008) and Link and Scott (2010).

These six types of involvement are defined by the availability of data from the NRC survey and not by our perception of importance.

The gender of the Phase II research project's PI (FemalePI) and the gender of the firm's owner (FemaleOwn) are also considered because of the SBIR program's emphasis on woman entrepreneurs.

Subsumed in the intercept are those entrepreneurs whose background is other than business or academics.

To test empirically for selection bias, we estimated the probability of response to the NRC survey as a function of the age of the project and the number of employees in the firm at the time of the survey (2005). We conjecture that older award recipients would be less likely to respond to the survey because of a loss of institutional memory, and the larger the firm the more likely it would respond because of available resources, ceteris paribus. While this was statistically the case, we could not reject the null hypothesis that the model of response and the model of university partnership are independent from one another (i.e. the correlation of the errors in the two models is not significantly different from zero).

References

Acs, Z. and Audretsch, D. B. 2010. Handbook of entrepreneurship research, New York: Springer.

Adams, J. D. 1990. Fundamental stocks of knowledge and productivity growth. Journal of Political Economy, 98: 673–702.

Aghion, P. and Tirole, J. 1997. Formal and real authority in organizations. Journal of Political Economy, 105: 1–29.

Alvarez, S. A., Barney, J. B. and Young, S. L. 2010. “Debates in entrepreneurship: Opportunity formation and implications for the field of entrepreneurship”. In Handbook of entrepreneurship research, Edited by: Acs, Z. J. and Audretsch, D. B. 23–46. New York: Springer.

Bain, J. S. 1949. “Price and production policies”. In A survey of contemporary economics, Edited by: Ellis, H. S. 129–73. Philadelphia, PA: The Blakiston Company.

Baldwin, W. L. and Link, A. N. 1998. Universities as research joint venture partners: Does size of venture matter?. International Journal of Technology Management, 15: 895–913.

Bercovitz, J. E.L. and Feldman, M. P. 2007. Fishing upstream: Firm innovation strategy and university research alliances. Research Policy, 36: 930–48.

Berman, E. M. 1990. The economic impact of industry-funded university R&D. Research Policy, 19: 349–55.

Blumenthal, D., Gluck, M. E., Lewis, K. S., Stoto, M. A. and Wise, D. 1986. University industry research relationships in biotechnology: Implications for the university. Science, 232: 1361–6.

Boardman, P. C. and Corley, E. A. 2008. University research centers and the composition of research collaborations. Research Policy, 37: 900–13.

Bonaccorsi, A. and Piccaluga, A. 1994. A theoretical framework for the evaluation of university–industry relationships. R&D Management, 24: 229–47.

Bozeman, B., Hardin, J. and Link, A. N. 2008. Barriers to the diffusion of nanotechnology. Economics of Innovation and New Technology, 17: 751–3.

Burnham, J. B. 1997. Evaluating industry/university research linkages. Research-Technology Management, 40: 52–5.

Campbell, T. I.D. 1997. Public policy for the 21st century: Addressing potential conflicts in university–industry collaboration. The Review of Higher Education, 20: 357–79.

Chesbrough, H. 2003. Open innovation: The new imperative for creating and profiting from technology, Boston: Harvard Business School Publishing.

Coase, R. H. 1937. The nature of the firm. Economica, 4: 386–405.

Cockburn, I. and Henderson, R. 1997. "Public–private interaction and the productivity of pharmaceutical research". NBER working paper 6018, National Bureau of Economic Research, Cambridge MA. http://www.nber.org/papers/w6018.pdf.

Cohen, W. M., Florida, R., Randazzese, L. and Walsh, J. 1998. "Industry and the academy: Uneasy partners in the cause of technological advance". In Challenges to research university, Edited by: Noll, R. 171–200. Washington, DC: Brookings Institution Press.

Cohen, W. M. and Leventhal, D. A. 1990. "The implications of spillovers for R&D and technology advance". In Advanced in applied micro-economics, Edited by: Link, A. N. and Smith, V. K. 29–46. Greenwich, CT: JAI Press.

Cohen, W. M., Nelson, R. R. and Walsh, J. P. 2002. Links and impacts: The influence of public research on industrial R&D. Management Science, 48: 1–23.

Council on Competitiveness. 1996. Endless frontiers, limited resources: US R&D policy for competitiveness, Washington, DC: Council on Competitiveness.

David, P. A., Hall, B. H. and Toole, A. A. 2000. Is public R&D a complement or a substitute for private R&D? A review of the econometric evidence. Research Policy, 29: 497–529.

Eckhardt, J. T. and Shane, S. 2010. "An update to the individual-opportunity nexus". In Handbook of entrepreneurship research, Edited by: Acs, Z. J. and Audretsch, D. B. 47–76. New York: Springer.

Fehr, E., Herz, H. and Wilkening, T. 2010. The lure of authority: Motivation and incentive effects of power. Working paper, Department of Economics, University of Zurich.

Feller, I. 1990. Universities as engines of R&D-based economic growth: They think they can. Research Policy, 19: 349–55.

Fontana, R., Geuna, A. and Matt, M. 2006. Factors affecting university–industry R&D projects: The importance of searching, screening and signaling. Research Policy, 35: 309–23.

Hagedoorn, J., Link, A. N. and Vonortas, N. S. 2000. Research partnerships. Research Policy, 29: 567–86.

Hall, B. H. 2004. "University–industry research partnerships in the United States". In Rethinking science systems and innovation policies, Edited by: Contzen, J. P., Gibson, D. and Heitor, M. V. 1–31. West Lafayette, IN: Purdue University Press.

Hall, B.H., A.N. Link, and J.T. Scott. 2000. Universities as research partners. NBER working paper 7643, National Bureau of Economic Research, Cambridge MA. http://www.nber.org/papers/w7643.pdf.

Hall, B. H., Link, A. N. and Scott, J. T. 2001. Barriers inhibiting industry from partnering with universities: Evidence from the Advanced Technology Program. Journal of Technology Transfer, 26: 87–98.

Hall, B. H., Link, A. N. and Scott, J. T. 2003. Universities as research partners. Review of Economics and Statistics, 85: 485–91.

Henderson, R., A.B. Jaffe, and M. Trajtenberg. 1995. Universities as a source of commercial technology: A detailed analysis of university patenting 1965–1988. NBER working paper no. 5068, National Bureau of Economic Research, Cambridge MA. http://www.nber.org/papers/w5068.pdf.

Hertzfeld, H. R., Link, A. N. and Vonortas, N. S. 2006. Intellectual property protection mechanisms in research partnerships. Research Policy, 35: 825–38.

Jaffe, A. B. 1989. Real effects of academic research. American Economic Review, 79: 957–78.

Klevorick, A. K., Levin, R. C., Nelson, R. R. and Winter, S. G. 1994. On the sources and significance of interindustry differences in technological opportunities. Research Policy, 24: 195–206.

Kodama, T. 2008. The role of intermediation and absorptive capacity in facilitating university–industry linkages: An empirical study of TAMA in Japan. Research Policy, 37: 1224–40.

Leyden, D. P. and Link, A. N. 1992. Government's role in innovation, Norwell, MA: Kluwer Academic Publishers.

Link, A. N. 1995. A generosity of spirit: The early history of Research Triangle Park, Chapel Hill, NC: University of North Carolina Press for the Research Triangle Park Foundation.

Link, A. N. 1996. Research joint ventures: Patterns from Federal Register filings. Review of Industrial Organization, 11: 617–28.

Link, A. N. 2005. “Research joint ventures in the United States: A descriptive analysis”. In Essays in honor of Edwin Mansfield: The economics of R&D, innovation, and technological change, Edited by: Link, A. N. and Scherer, F. M. 187–95. Norwell, MA: Springer.

Link, A. N. and Rees, J. 1990. Firm size, university based research, and the returns to R&D. Small Business Economics, 2: 25–31.

Link, A. N. and Ruhm, C. J. 2009. Bringing science to market: Commercializing from NIH SBIR awards. Economics of Innovation and New Technology, 18: 381–402.

Link, A. N. and Ruhm, C. J. 2011. Public knowledge, private knowledge: The intellectual capital of the entrepreneur. Small Business Economics, 36: 1–14.

Link, A. N. and Scott, J. T. 2005. Universities as partners in US research joint ventures. Research Policy, 34: 385–93.

Link, A. N. and Scott, J. T. 2007. The economics of university research parks. Oxford Review of Economic Policy, 23: 661–74.

Link, A. N. and Scott, J. T. 2009. Private investor participation and commercialization rates for government-sponsored research and development: Would a prediction market improve the performance of the SBIR program?. Economica, 76: 264–81.

Link, A. N. and Scott, J. T. 2010. Government as entrepreneur: Evaluating the commercialization success of SBIR projects. Research Policy, 39: 589–601.

Link, A. N., Siegel, D. S. and Bozeman, B. 2007. An empirical analysis of the propensity of academics to engage in informal technology transfer. Industrial and Corporate Change, 16: 641–55.

Link, A. N. and Tassey, G. 1987. Strategies for technology-based competition: Meeting the new global challenge, Lexington, MA: D.C. Heath.

Link, A. N. and Wessner, C. W. 2011. “Universities as research partners: Entrepreneurial explorations and exploitations”. In Handbook of research in innovation and entrepreneurship, Edited by: Audretsch, D. B. 290–9. London: Edward Elgar.

Mansfield, E. 1991. Academic research and industrial innovation. Research Policy, 20: 1–12.

Mansfield, E. 1992. Academic research and industrial innovation: A further note. Research Policy, 21: 295–6.

Mansfield, E. and Lee, J. 1996. The modern university: Contributor to industrial innovation and recipient of industrial R&D support. Research Policy, 25: 1047–58.

Morgan, R. P. 1998. “University research contributions to industry: The faculty view”. In Trends in industrial innovation: Industry perspectives & policy implications, Edited by: Blair, P. D. and Frosch, R. A. 98–116. Research Triangle Park, NC: Sigma Xi, The Scientific Research Society.

Mowery, D. C. and Teece, D. J. 1996. “Strategic alliances and industrial research”. In Engines of innovation: US industrial research at the end of an era, Edited by: Rosenbloom, R. S. and Spencer, W. J. 111–30. Boston: Harvard Business School Publishing.

56. National Research Council. 2008. An assessment of small business innovation research program at the Department of Energy, Edited by: Wessner, C. W. Washington, DC: National Academics Press.

Nelson, R. R. 1982. “Government stimulus of technological progress: Lessons from American history”. In Government and technical progress, Edited by: Nelson, R. R. 451–82. New York: Pergamon.

Pavitt, K. 1998. The social shaping of the national science base. Research Policy, 27: 793–805.

Pisano, G. 1991. The governance of innovation: Vertical integration and collaborative arrangements in the biotechnology industry. Research Policy, 20: 237–49.

Rosenberg, N. and Nelson, R. R. 1994. American universities and technical advance in industry. Research Policy, 23: 323–48. [CrossRef], [Web of Science ®]

61. Sarasvathy, S. D., Dew, N., Velamuri, S. R. and Venkataramanin, S. 2010. “Three views of entrepreneurial opportunity”. In Handbook of entrepreneurship research, Edited by: Acs, Z. J. and Audretsch, D. B. 77–98. New York: Springer.

Schacht, W. 2009. Industrial competitiveness and technological advancement: Debate over government policy, Washington, DC: Congressional Research Service, US Congress.

Scherer, F. M. 1983. The propensity to patent. International Journal of Industrial Organization, 1: 107–28.

Siegel, D.S., D. Waldman, and A.N. Link. 1999. Assessing the impact of organizational practices on the productivity of university technology transfer offices: An exploratory study. NBER working paper no. 7256, National Bureau of Economic Research, Cambridge MA. http://www.nber.org/papers/w7256.pdf.

Siegel, D. S., Waldman, D. and Link, A. N. 2003. Assessing the impact of organizational practices on the productivity of university technology transfer offices: An exploratory study. Research Policy, 32: 27–48.

Stuart, T. E., Ozdemir, S. Z. and Ding, W. W. 2007. Vertical alliance networks: The case of university-biotechnology-pharmaceutical alliance chains. Research Policy, 36: 477–98.

Van de Ven, A. H. 1993. A community perspective on the emergence of innovations. Journal of Engineering Technology Management, 10: 23–51.

Zeckhauser, R. The challenge of contracting for technological information. Proceedings of the National Academy of Scienc, Vol. 93, pp.12743–8.

Zucker, L.G., M. Darby, and J. Armstrong. 1994. Intellectual capital and the firm: The technology of geographically localized knowledge spillovers. NBER working paper no. 4946, National Bureau of Economic Research, Cambridge MA. http://www.nber.org/papers/w4946.pdf.