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The effect of informal industry contacts on the time university scientists allocate to collaborative research with industry

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Abstract We ask whether informal interactions between university and industry scientists result in collaborative research. Using data from a national survey of tenured and tenure-track scientists and engineers in U.S. research extensive universities, we demonstrate that university scientists' informal interactions with private sector companies increase both the likelihood and intensity of collaborative research with industry.

Keywords Technology transfer · University-industry relations · Informal interactions

JEL Classifications O31 · O32

1 Introduction

Informal interactions and networking between university scientists and engineers[1] and private companies constitute a significant and frequent component of the process of university-industry technology and knowledge transfer[2] (Cohen, Florida, Randazzese, & Walsh, 1998). However, little is known about what this type of interaction actually means. While there are many policy relevant questions to ask about informal

[1] Hereafter use the shorthand ''scientists'' to mean ''scientists and engineers'' except in those cases where it is necessary to make the distinction.

[2] Hereafter use the shorthand ''technology transfer'' to mean ''technology and knowledge transfer'' except in those cases where it is necessary to make the distinction.

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university-industry interaction and the productivity of these interactions,[3] we start at the beginning by assessing whether informal interaction between university scientists and private companies leads to joint research across the sectors.

Very few studies link informal ties to the innovation process (Powell & Grodal, 2006). That there is little direct study of the outcomes of informal interaction between university scientists and private companies is a function of two related phenomena. First, most studies assessing the process of technology transfer consider informal channels of technology transfer as complements to more formalized channels such as joint ventures and other contractual forms of university-industry interaction (Cohen, Nelson, & Walsh, 2002). While informal linkages are typically nominated as important, there is little analysis explaining whether or in what ways these interactions are important, as well as whether such interactions trigger other types of interactions, such as collaborative research. This secondary focus in the literature is probably due to difficulty accompanying the study of informal interaction and networking. Unlike formal university-industry interactions, the less formal channels of technology transfer are difficult to gauge. Conceptual problems inherent in defining the boundaries of social networks exist, and in many cases the difficulty of this task is exacerbated by the general lack of institutional sanction (or even acknowledgement) of informal networks.

Once the decision to study informal university-industry interactions is made, the next step is to pinpoint what aspects of these interactions are informal per se and what aspects of designated informal interactions actually matter. For instance, how much weight should be attributed to a conversation (or an e-mail exchange or an exchange of research documentation) between a university scientist and a product manager at a private firm? Are some informal interactions less formal than others? When do informal interactions become formal? And so on. We make no attempt to answer all of these questions. The point is that there is much left to understand about informal relationships between university scientists and private companies and that this paper constitutes but a first step towards such understanding.

Using data from a national survey of scientists and engineers from 13 disciplines employed in the 150 research extensive universities in the U.S. (Carnegie Foundation for the Advancement of Teaching, 2004), we estimate whether informal interactions (defined below) between university scientists and private companies result in increased probability and higher intensity of collaborative research between university and industry scientists. We ask whether university scientists who engage in networking behaviors with private companies (e.g., information exchange related to research) are more likely to engage in collaborative research with industry scientists and devote a greater proportion of their research time to inter-sector research. We find that university scientists who engage in what we designate as informal interactions with private companies spend a higher percentage of their research-related work time to collaborative research with industry.

This paper is organized as follows. Section 2 presents our sample and survey methodologies. In Sect. 3 we discuss our hypothesis and clarify key concepts, particularly what we mean by informal interaction between university scientists and

[3] Questions that would be useful to answer for policy makers, university administrators, and private firms include: What role exactly do these informal encounters play? Do they lead to more formal collaborations between university and industry? Do they lead to joint work on discrete outputs such as patents or prototypes?

private companies. In this section we draw on prior studies to support our hypothesis. Section 4 includes the results of our econometric model and discussion thereof and the last section includes concluding remarks and mention of potential future research.

2 Data

The data for this project were collected under the auspices of the 2005 Research Value Mapping Survey of Academic Researchers (RVM 2005).[4] The survey targeted tenured and tenure-track university scientists employed in doctorate granting research extensive institutions (Carnegie Foundation for the Advancement of Teaching, 2004), though for alternate research purposes some EPSCoR university and HBCU[5] faculty were included. The sample was stratified by academic discipline, academic rank, and gender, resulting in a sample of 5,916 individuals. The survey was executed in accordance with Dillman's (2000) ''tailored design method'' and was terminated with an overall response rate of 37%. After removing from our sample sociologists (to compare engineers to a reference group of non-engineering, ''hard'' scientists) and also faculty employed at EPSCoR universities and HBCUs (to compare faculty working at Carnegie research extensive universities only), we employ in this study a final N of 1,643 university researchers. Table 1 presents descriptive statistics for the variables used in our model (developed in the next section). Since the sample for this study was stratified, in Table 2 we report both sample proportions and estimated population proportions. To obtain population estimates, we weighted the sample observations by discipline, gender, and academic rank. The population proportions for these variables to construct the sampling weights were readily available in the population data used to draw the sample for this study.

3 Variables and hypotheses

We focus on estimating the effect of informal relationships between university and industry scientists on the intensity of university scientists' collaborative research with private firms. Implicit in this research design is the expectation that informal interactions are an antecedent to more formal interactions such as collaborative research, but not merely a correlate. Such reasoning is partially supported by existing studies of scientific collaboration in that that these studies acknowledge that collaboration is fundamentally the outcome of social networking (e.g., Melin, 2000). Scientists are aware of the importance of informal relationships and often acknowledge that informal relations underlie formal ties (Powell & Grodal, 2006). However the extent and role of informal ties across organizations or contexts remains an under-researched phenomenon (Powell & Grodal, 2006).

[4] The project is funded by the National Science Foundation and U.S. Department of Energy, under the direction of Barry Bozeman, School of Public Policy, Georgia Tech. Opinions expressed in this work are not necessarily shared by the RVM 2005 project leadership or the projects' sponsors.

[5] Experimental Program To Stimulate Competitive Research (EPSCoR), Historically Black Colleges and Universities (HBCU).

Table 1 Description of variables (n = 1643)

Name	Description	Sample proportion (unweighted)	Estimated population proportion (weighted by discipline, gender and rank)	Range	Std. dev. (unweighted)
RESTIME	Percentage of research time devoted to working with researchers in the US industry	3.1%	3.1%	0–50	6
WORCOMP	Had any working relationships with a private sector company	51.2%	54.3%	0–1	0.5
CONTACTED	Persons from a private company have asked for information about my research and I have provided it	37.4%	38.9%	0–1	0.48
ICONTACTED	I contacted persons in industry asking about their research or research interests	19.1%	21.0%	0–1	0.39
CONSULT	I served as a formal paid consultant to an industrial firm	18.3%	14.8%	0–1	0.39
STUDENTS	I helped place graduate students or post-docs in industry jobs	25.2%	22.7%	0–1	0.43
WORKED	I worked with a company with which I am an owner, partner or employee	3.5%	2.5%	0–1	0.18
PATENT	I worked directly with industry personnel in work that resulted in a patent or copyright	5.5%	5.6%	0–1	0.22
TRANSFER	I worked directly with industry personnel in an effort to transfer or commercialize technology or applied research	16.1%	15.3%	0–1	0.36
COAUTH	I co-authored a paper with industry personnel that has been published in an academic journal of in refereed conference proceedings	15.1%	15.3%	0–1	0.36
TOTCOL	Total number of collaborators	8.4	7.5	0–370	38.69
CENTER	Affiliated with university research center	31.0%	31.0%	0–1	0.46
TIMEGOVT	Percentage of work time supported by government grants and contracts	21.7%	21.1%	0–100	21.31
AGE	Age	47.0	41.7	27–82	10.55
BASIC	Worrying about possible commercial applications distracts one from doing good research (Likert scale, 1 = Strongly disagree 4 = Strongly agree)	2.2	2.1	1–4	0.9
BIOL	Biology	7.7%	13.3%	0–1	0.27
CS	Computer Science	8.4%	9.0%	0–1	0.28
MATH	Mathematics	6.7%	14.0%	0–1	0.25

Table 1 continued

Name	Description	Sample proportion (unweighted)	Estimated population proportion (weighted by discipline, gender and rank)	Range	Std. dev. (unweighted)
PHYS	Physics	9.2%	11.6%	0–1	0.29
EAS	Earth and Atmospheric Sciences	10.5%	5.6%	0–1	0.31
CHEM	Chemistry	8.5%	10.7%	0–1	0.28
AGRI	Agriculture	8.2%	3.0%	0–1	0.27
CHE	Chemical Engineering	7.5%	4.5%	0–1	0.26
CE	Civil Engineering	10.5%	6.4%	0–1	0.31
EE	Electrical Engineering	7.5%	10.6%	0–1	0.26
ME	Mechanical Engineering	8.9%	8.3%	0–1	0.29
MTE	Material Science And Engineering	6.3%	3.0%	0–1	0.24
TENURED	Tenured	73.0%	81.0%	0–1	0.44
MALE	Male	48.0%	81.7%	0–1	0.05

Table 2 Tobit estimates from Eq. (1), $n = 1643$ (standard errors in parentheses)

	Percentage of time spent working with researchers in the US industry
Persons from a private company have asked for information about my research and I have provided it	3.967*** (0.948)
I contacted persons in industry asking about their research or research interests	1.817** (0.891)
I served as a formal paid consultant to an industrial firm	3.686*** (0.883)
I helped place graduate students or post-docs in industry jobs	2.424*** (0.904)
I worked with a company with which I am an owner, partner or employee	–2.885 (1.809)
I worked directly with industry personnel in work that resulted in a patent or copyright	1.701 (1.393)
I worked directly with industry personnel in an effort to transfer or commercialize technology or applied research	5.820*** (0.951)
I co-authored a paper with industry personnel that has been published in an academic journal of in refereed conference proceedings	6.250*** (0.917)
Biology	–6.112*** (2.118)
Computer Science	0.276 (1.692)
Mathematics	–6.606*** (2.429)
Physics	–6.057*** (2.022)
Earth and Atmospheric Sciences	–4.831*** (1.856)
Chemistry	–0.701 (1.764)
Agriculture	1.990 (1.667)
Chemical Engineering	2.301 (1.676)
Civil Engineering	–0.332 (1.624)
Electrical Engineering	2.989* (1.698)
Mechanical Engineering	1.439 (1.634)
Affiliated with university research center	0.119 (0.771)
Male	0.551 (0.749)
Total number of collaborators	0.007 (0.006)
Percentage of work time supported by government grants andcontracts	–0.021 (0.017)
Tenured	–0.151 (0.988)
Age	0.034 (0.043)
Worrying about possible commercial applications distracts one from doing good research (Likert scale, 1 = Strongly disagree 4 = Strongly agree)	–0.561 (0.395)
Constant	–9.494*** (2.463)
Tobin's sigma	10.63 (0.36)
PseudoR^2	0.113
χ^2 (d.f.)	603.62(25)***
log likelihood	–2400.38

Note: There are 1,008 left-censored observations at RESTIME = 0 and 536 uncensored observations

* Denotes significance at the 0.10 level

** Denotes significance at the 0.05 level

*** Denotes significance at the 0.01 level

Alternatively, prior research has reported that the most important source of R&D information for private companies are informal interactions with university scientists and engineers (Cohen et al., 2002). Moreover, some authors speculate that information sharing in informal interactions is a key factor in creating an ''innovative climate'' (Saxenian, 1994). Such processes of informal interactions in which scientists from universities and industry contact each other have been appropriately charac-

terized as generating and refining the ''intangible raw material of technical change—ideas'' (Powell & Grodal, 2006, p. 71) . Considering that informal interactions are mentioned most often as an important source of R&D information, and that such interaction may be stimulating an ''innovative climate'' it is likely that they will overlap with, and indeed increase the likelihood of the formation of other types of interactions, such as collaborative research. The latter possibility is at the core of this paper: given the general acknowledgement that informal interactions ''matter'', we attempt to estimate the extent to which such interactions trigger more structured types of interactions, such as collaborative research. Therefore, our hypothesis is that informal interactions between university scientists and private companies positively influence the extent of collaborative research with industry that scientists engage in. To formalize and test this hypothesis we use the following as our dependent variable:

> RESTIME—Our dependent variable is the percentage of university scientists' research time devoted to working with researchers in the U.S. industry. For the subgroup of scientists spending non-zero percent of their research time working with the U.S. industry ($N = 528$), the average is 9%, and the range is 1–50%.

The measure of informal interaction between university scientists and their counterparts in the private sector that we employ as the primary independent variable is the following:

> CONTACTED—Our chief independent variable of interest is a dummy variable coded 1 if during the past twelve months the respondent has been contacted by persons from a private company about his or her research and has provided it. Otherwise the variable is coded zero.

Being contacted by a private sector company is an imperfect, but defensible measure of informal relationships. The measure does not necessarily limit the context of university-industry contact to informal contact, and this type of interaction is just one of many possible dimensions of informal interaction. Nevertheless, it is a valid measure at least of some aspects of informal networks. It represents the occurrence of a ''choice contact,'' which is a key aspect of informal networks, among other measures such as existing contacts, sought out contacts, and chance meetings (Faulkner, Senker, & Velho, 1995). Based on simple transaction cost reasoning, moreover, it is plausible that a private firm would contact a university scientist if an informal relationship is already established and would perhaps seek more formal mechanisms (e.g., contractual) in the absence of such a relationship.

Our hypothesis relating contact with a private firm to percentage of research time spent working with industry:

H University scientists who have been contacted by private companies are more likely to engage in collaborative research with industry scientists and to spend more of their research time in such research

If a private company contacts a university researcher about her research, that researcher is already engaged in research with potential relevance to industry,

whether intentional or not. The company would not contact the researcher otherwise (Santoro & Chakrabarti, 2002). In the context of ''steady state'' funding for university based research (Ziman, 1994), moreover, it is plausible that as a result of the contact the scientist will act as an ''academic capitalist'' (Slaughter & Lesslie, 1997) and engage further in industry related research. The contacted university scientist may engage in industry related research to keep apprised of future opportunities either with the contacting company or more broadly within the company's industrial sector (Randazzese, 1996). Or, the contacted scientist may engage in industrial research for the same reasons she would collaborate on any research project regardless of sector, for instance for potential access to expertise (Katz & Martin, 1997; Melin, 2000) and to resources (Beaver, 2001, Thorsteinsdottir, 2000). In short, such relationships between scientists and industrial companies are generally reciprocal—requests for information or assistance are generally expected to be returned (Kreiner & Schultz, 1993). However, what remains to be assessed is what—if any—are the particular outcomes of such general informal exchanges. The present paper suggests that one such outcome of informal interactions is the greater likelihood of collaborative research.

To control for the possibility that other types of relationships with the private sector, including more formal ones, could influence the extent of collaborative research in which scientists engage in while also being correlated with the chief independent variable, in our model we include alternate independent variables indicating other types (some of them more formal than others) of interaction with industry:

ICONTACTED—Coded 1 if the respondent has contacted persons in industry asking about their research and research interests and coded zero otherwise.
CONSULT—Coded 1 if the respondent has served as a formal paid consultant for a private company and zero otherwise.
STUDENTS—Coded 1 if the respondent has helped place graduate students or post-docs in industry jobs, and zero otherwise.
WORKED—Coded 1 if the respondent has worked at a company with which he or she is an owner, partner or employee, and zero otherwise.
PATENT—Coded 1 if the respondent has worked directly with industry personnel in work that has resulted in a patent, and zero otherwise.
TRANSFER—Coded 1 if the respondent has worked directly with industry personnel in an effort to transfer or commercialize technology or applied research, and zero otherwise.
COAUTH—Coded 1 if the respondent has co-authored paper with industry personnel.

As with informal interaction (CONTACTED), we hypothesize that all of these different types of interactions with the private sector will positively correlate with the probability of undertaking collaborative research with a private firm as well as with the percentage of time allocated to such research.

In addition to the independent variables representing interactions with industry, we include the following set of control variables in the model:

CTRAFF—Coded 1 if the respondent indicates that she works in a university research center and zero otherwise.

We hypothesize that center affiliation will positively correlate with the intensity of collaborative research with industry. This hypothesis is justified in light of respondents who indicate affiliation with NSF university research centers such as ERCs, as NSF mandates that these centers collaborate with industry.

TENURED—Coded 1 if the respondent has been awarded tenure in her academic department and zero otherwise.

We hypothesize that having tenure will positively correlate with the percentage of research time devoted to collaborative research with industry. This hypothesis is justified by the possibility that companies are more likely to seek collaborations with scientists with established reputation—the accumulation of such can be approximated by being awarded tenure. Secondly, collaboration with industry may be viewed by untenured-but-tenure-track (hereafter ''junior-level'') researchers as time and effort taken away from potentially academic career-advancing activities—namely the publication of basic research in peer-reviewed journals—in that work with the private sector may be expected to be more applied and hence not as highly valued as publications by academic departments making tenure and promotion decisions.

TOTCOL—A count variable indicating the number of collaborators with which a respondent has worked in the past twelve months (regardless of sector or rank, including graduate students and post-docs).

We hypothesize that the number of collaborators will positively correlate with the intensity of collaborative research with industry. Total number of collaborators is a useful proxy for the fact that some researchers are simply more likely to actively seek collaboration opportunities, and thus it is likely that this would imply higher number of collaborations of all types, including collaborations with the private sector.

TIMEGOVT—Indicates the percentage of time devoted in the past twelve months to working on government-sponsored grants, contracts, and cooperative agreements.

We tentatively hypothesize that time spent working on research related to government grants will negatively correlate with percentage of research time spent working with industry, arguing (again, tentatively) that time working on government contracts may involve tradeoffs with other types of research, including working on applied problems with the private sector. However, we qualify that government grants come in many varieties and may even mandate collaboration with industry. Therefore, though we hypothesize the reverse, it may be the case that being heavily involved with government-supported grants signals specific strengths and competences to the private sector and thus result in higher likelihood of working with the private sector.

BASIC—The scientists' response to the statement ''Worrying about possible commercial applications distracts one from doing good research'', evaluated by respondents on a four point Likert scale.

We include this attitudinal variable about one's preference for applied research to control for the fact that some scientists simply may be more predisposed to working on more applied versus more basic research problems and thus may be more likely to seek (and be sought for) collaborative research with industry.

Last, we include a series of mutually exclusive dummy variables for twelve of the thirteen disciplines from which our respondents were selected (material science and engineering being the reference group). We hypothesize that scientists from engineering disciplines variable will be more likely to engage in collaborative research with industry. This hypothesis is based simply on the fact that engineering disciplines (such as civil, industrial, electrical engineering) in general are more explicitly concerned with application of general principles and development of new technologies than are the natural sciences (e.g., physics, chemistry). Moreover, considering that the private industries are more concerned with enhancing their competitiveness by means of technological improvements rather than with generating basic knowledge, it is more likely that the expertise of researchers from the engineering disciplines would be more relevant to and thereby more actively sought out by industry than that of natural and life and social scientists.

3.1 Caveat about university level effects

Though the proposed model incorporates only individual-level variables, future research should consider the possibility of contextual (e.g., university-level) factors that might influence individual behavior. For example, some universities may be better than others at encouraging entrepreneurial behavior among their faculty. For the purpose of this paper, we assume that such effects, if any, will be randomly distributed in the error term. Moreover, even if some of these contextual variables affect the variance in the dependent variable, we suspect that such effects will be less pronounced or not at all relevant for the independent variable.[6]

4 Model and results

To test our hypothesis, we include the above variables in the following model:

$$\begin{aligned} RESTIME = & \beta_1 + \beta_2 CONTACTED + \beta_3 ICONTACTED + \beta_4 CONSULT \\ & + \beta_5 STUDENTS + \beta_6 WORKED + \beta_7 PATENT + \beta_8 TRANSFER \\ & + \beta_9 COAUTH + \beta_{9\text{–}18} CONTROLS + \varepsilon_{19} \end{aligned} \quad (1)$$

[6] While university scientists' time allocations is likely structured somewhat by university context, the propensity of the scientists to engage in informal (by definition non-institutionalized) interactions, is less likely to be influenced by the context of the university, but more likely to be a function of individual traits, circumstances and strategies. So we do not anticipate that there is spurious relationship between the chief independent variable of interest and the dependent variable. Moreover, the two behaviors do not overlap. Not all scientists who routinely spend some of their research time on research with industry interact with private sector companies, and not all scientists who do engage in such interactions also engage in collaborative research. While we believe that the effects of university context are extremely interesting and promising problem to be addressed in future research, we suggest that for the purpose it is more important to focus specifically on establishing the dynamics between informal interactions and research collaboration at the aggregate.

Since our dependent variable is censored, we use a tobit model to estimate the parameters in the equation. The tobit results are presented in Table 2.

The estimation results support our hypothesis. University scientists involved in informal interactions with industry (as approximated by being contacted by a private company) are more likely to engage in collaborative research and are more likely to spend larger proportion of their research time working with researchers in private firms, when compared to scientists who have not engaged in such informal interaction. This effect is statistically significant at the 1% level.

The types of interactions with private firms that result in the highest increases in the percentage of research time spent collaborating with researchers in private firms are (1) having worked with industry personnel in an effort to commercialize technology or applied research and (2) having co-authored a paper or refereed proceeding with industry personnel, followed by (3) being contacted by a private company.

Curiously, having worked with industry personnel in work that has resulted in a patent (not to be confused with 1 above) does not have a statistically significant effect on the dependent variable. While this non-finding needs additional research, it may also imply that patenting by university scientists does not necessarily capture the amount and intensity of applied research work transferred or transferable to the private sector. This is in line with Agrawal and Henderson (2002), who demonstrate that patents account for only about 10% of the knowledge transfer to the private sector (at MIT) as revealed by patenting faculty.

Having worked at a private company as an owner, partner or employee is also not statistically significant. Another positive predictor of the probability and intensity of collaborative research is having served as a formal paid consultant for a private company. Weaker, but statistically significant effects are also produced by having contacted private sector researchers and by having helped place graduate students in industry jobs.

Being involved in informal interactions with industry as approximated by choice contact from industry to the university scientist is associated with an increase of probability of involvement in collaborative research and with increase in the percentage of research time spent on such research. Moreover, the magnitude of the effects of such informal interactions are comparable with the effects of co-authoring papers or directly working with industry personnel on commercializing technology. This implies that the effects of informal connections may be quite substantial, especially considering that unlike information exchanges, co-authoring and working on commercializing technology almost my definition demand certain amount of collaborative research.

5 Implications

The results suggest that informal interactions between university scientists and private companies are more than elusive interactions with hard-to-specify outcomes. We find that involvement in informal interaction is associated with higher probability of undertaking collaborative research with industry as well as with a higher allocation of research time to collaborative research with industry. In short, informal interactions matter as catalysts of collaborative inter-sector research. The implication of this finding is that informal interaction between university and

industry scientists has impacts beyond serving as channels to transfer and exchange information, but can result in tangible outcomes such as collaborative research.

The second implication of the findings relates to possible policy intervention to facilitate collaboration between academia and industry. The current policy approaches towards instigating university-industry collaborations are directed more towards institutions than to individual scientists and aim to formalize such interactions by means of the creation of designated boundary-spanning institutions such as centers and other modes of formal research partnerships. Our results imply that programs facilitating interaction between university and industry at the individual level may also lead to tangible results while having the advantage of being simpler, cheaper, and easier to institute than formal dedicated institutions. As Melin (2000) has noted, most policy efforts to facilitate collaboration are directed at institutions, in spite of the fact that collaboration is ultimately dependent on individual connections and exchanges. Our results support the importance of research agenda to further investigate the determinants and implications of informal linkages between university scientists and private sector companies.

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