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An examination of the Swedish setting

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Abstract

The issue of through what processes R&D collaboration with universities affects a firms' innovation performance remains under-researched. In particular, university relationships have not been fully integrated in the open innovation framework. This study explores the relationship between firms' collaboration with universities and their capabilities for innovation, as perceived by R&D managers. Drawing on a series of interviews with R&D managers at 45 randomly selected firms collaborating with two research universities in Sweden, we explicitly recognise mechanisms through which university relationships contribute to successful R&D management.

Keywords: **University-Industry Link, Innovation, Technology transfer, R&D, Research collaboration**

JEL-Codes: **I23, O31, O32**

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1. Introduction

"In the study of technology transfer, the neophyte and the veteran researcher are easily distinguished. The neophyte is the one who is not confused." (Barry Bozeman, 2000, p. 627)

The topic of this paper is the processes through which R&D collaboration with universities affects a firm's innovation performance. A large body of empirical studies confirms that the use of academic knowledge is beneficial to technological change, innovation and growth in the private sector through new theoretical insights, new techniques, and new skills of a kind that industrial firms find difficult to provide themselves. See Griliches (1979, 1986), Nelson (1986), Jaffe (1989), Mansfield (1997, 1998), Hendersson et al. (1998), Zucker et al. (1998), Adams (2002), Zucker & Darby (2005). It has also been suggested that regions with strong research universities have better opportunities to attract and support innovative industries than other regions. However, as Griliches (1994) notices, investigating the importance of academic knowledge on business activities is not a simple exercise. In part the problem is due to difficulties in constructing the experiments that would isolate the connection between science and innovation.

A number of quantitative studies confirm a positive association between the university-industry link and innovativeness at the firm level (Mansfield, 1998; Cassiman & Veugelers, 2006). In particular, firms who collaborate with universities are generally those who introduce the most original innovations, whereas no general association between collaboration and a firm's ability to introduce incremental types of innovation can be found (Hanel & St-Pierre, 2006; Monjon & Waelbroeck, 2003).

It should be noted that since the university collaborators is a selective group of firms, the results reported above can be interpreted as mere correlations. However, studies using counterfactual estimation techniques to address causality issues with control groups seem to support the positive impact of R&D collaboration on firms – at least for certain types of firms. Lööf and Broström (2008) report evidence from Swedish CIS data that university collaboration positively influences innovation sales as well as the propensity to apply for patents for manufacturing firms with more than 100 employees. In contrast, whatever specification of the empirical model, the data show no significant association between university collaboration and the average service firm's innovation sales or propensity to apply for patents. Arvanitis et al. (2008), who perform a similar analysis on Swiss data, do not distinguish between firm types, but between different types of interaction with

universities; research oriented and educational oriented respectively. The authors find that both types of interaction improve the innovation performance of firms in terms of sales of considerably modified products, research activities in addition also in terms of sales of new products.

Despite this evidence on a possible positive effect, many researchers emphasize that our knowledge on the interaction between universities and industry is still limited and ambiguous. The issue of *through what processes* R&D collaboration with universities affects a firm is far from unambiguously resolved by previous research (Hall et al., 2003; Jacobsson, 2002; Fontana et al., 2003). In particular, the role of university relationships to strategic management in an 'open innovation' context remains under-researched (Perkman & Walsh, 2007).

As documented by Chesbrough (2003), many firms are increasingly active in managing external R&D relations. The objective of this paper is to contribute to the understanding of how knowledge transfer between university and industry may lead to increased innovation performance in a firm. In particular, given that the literature on university-industry relations tends to extrapolate findings from studies of the US to non-US settings, we see a need to explore this issue in a European setting. Both the institutions of higher education themselves and the legal framework as well as the culture of industrial R&D has been found to differ between continental Europe and the US.

We explore the relationship between university collaboration and innovation performance through interviews with R&D managers in 45 firms. The respondents' firms were randomly selected for interview among all firms engaged in formalised R&D relationship with two Swedish research universities in the period 2003-2005. Drawing on this material, we suggest that such interaction supports five distinct R&D management tasks. Rather surprisingly, the opinion that the main benefit of the relationship is that it helps the firm build and maintain its capacities for R&D is as common as the opinion that collaboration generates concrete results that are

useful for the firms' R&D activities. We also find that collaboration with a university helps some firms market an innovative product, which is an aspect of university-industry interaction largely ignored by previous studies.

The rest of the paper is organised as follows. Section 2 reviews the explanations for how university collaboration may affect innovation performance, as offered in previous literature. Section 3 presents results from a series of interviews. Section 4 concludes the paper.

2. Explanations of Collaboration Effects

In this section, we review empirical studies on the link between university-industry collaboration and firm innovation performance, pointing out some general lines of argument for why collaboration may help a firm perform strongly as innovator. We also state that the heterogeneity of innovation processes motivates different analytical approaches.

2.1 Transfer of technology from university

One strand of the literature considers the possibility that technology transfer from universities to the industry can enhance national, regional and firm growth. The term 'technology transfer' has been established in the literature of economists, management scholars, sociologists, anthropologists and related fields of social science (Bozeman, 2000). Technology transfer in its most general sense is often used as the ultimate universal ultimate objective of *all* R&D related interaction. Etzkowitz (1998) uses the following definition of technology transfer between universities and existing firms, which we believe fairly well reflects the most common use of the term in the literature on innovation studies: (1) the product originates in the university but its development is undertaken by a firm, (2) the commercial product originates outside of the university, with academic knowledge utilised to improve the product. Common to both definitions is a perspective of the university as a source of knowledge or technology which is *transferred* to the firm.

The first of Etzkowitz' two definitions is roughly identical to the most basic of all conceptual models for firms' utilization of university research: the one nowadays frequently referred to as

'the linear model' or as technology transfer in its most narrow sense. According to this view, technological development in firms draws from the pool of research results produced at universities. Although the view that universities have a major economic role to play as disseminators of research results to firms and to potential (academic) entrepreneurs has faced extensive criticism (Cohen et al., 2002; Agrawal & Henderson, 2002) and the basic linear model has been declared invalid and 'dead' numerous times (Stokes, 1997; Rosenberg, 1994) it is still influential in both academic and policy-related debates. Recent papers devoted to the resurrection (or re-formulation) of the linear model include Colyvas et al. (2002) and Etzkowitz & Goektepe (2005). An unusually precise model of how firms benefit from organised relations in a strongly linear fashion is presented by Siegel et al. (2003). The authors depict the transfer of a technology from a university to a firm as a one-way chain from Scientific Discovery via Patenting to License to Firm. Colyvas et al. (2002) also assume that some research results have a value for industry in a way clearly influenced by the linear model. They describe two types of university inventions: those that are "ready to use" for a firm and those that need further development to be commercially useable.

2.2 Collaboration that gives the firm increased capabilities to learn and to innovate

A few studies on research joint venture (RJVs) report firm motives for participation of a more indirect nature than the direct exploitation of university IPR. Hall et al. (2000) document two broad industry motivations, the first being access to complementary research activity and research results, the second access to key university personnel. Caloghirou et al. (2001) report from a large set of RJVs established in the context of the European Framework Programmes over a period of fourteen years, that the main motivation for firms is to achieve a "positive impact on their knowledge base". Hall et al. (2001) take a departing point in data from the Advanced Technology Program (ATP) funded by the US government. They find that "industrial research participants perceive that the university could provide research insight that is anticipatory of future research problems and could be an ombudsman anticipating and translating to all the complex nature of the research being undertaken."[1]

[1] While the latter studies cover a broader set of collaborative projects and can be expected to be more representative than the single case, the type of publicly sponsored programmes which they document are not fully representative of firm's R&D collaboration with universities. Hall et al. (2001) note that ATP projects are supposed to be characterized by "high social value and high risk, involve largely generic rather than largely proprietary technology, and be at such an early stage in development that the technology is not easily appropriable".

The ability of a firm to exploit external knowledge was sucessfully conceptualised by Cohen & Levinthal (1989, 1990). Their concept of "absorptive capacity" was presented as an intangible asset created by research investments, in that research activities facilitate creation of internal competence and of useful network that allows the firm to identify, assimilate and exploit external information. Important aspects of such a capacity includes abilities to remain oriented about relevant technological development and to locate emerging sources of valuable technological knowledge. As argued by Lim (2000) and Howells et al. (2003), cooperation with both academic and commercial actors can be a way for the firm to build such absorptive capacities. One possible conclusion to draw from this literature' is that the firms' cooperation with universities should primarily be seen as a way to increase the firm's absorptive capacity and, indirectly, its ability to technological, market driven development. This hypothesis seemingly fits with the finding that with possible exception for certain emerging "science-based" sectors, the primary sources of impulses to innovation can be found among customers, suppliers and, to some extent, competitors rather than in universities (Fontana et al., 2003; Klevorick et al. 1995).

2. 3 Collaboration that allows the firm to manage costs and risks more efficiently

A growing strand of research literature recognises that outsourcing rationales impact firms' decisions also in the area of R&D (Gerybadze & Reger, 1999; Harryson et al, 2006; Lambert, 2003; OECD, 2001). This development is driven by a tendency towards greater and broader knowledge needs to ensure competitiveness and by a simultaneous pressure for effectiveness and focus (Gerybadze & Reger, 1999). Barnes et al. (2002) find that "part of the attraction for companies entering into collaborations is that research can be conducted that could not otherwise be justified in-house, since it provides a means of sharing the cost and risk of the work".

The decision whether to perform a certain task inside or outside of the own organisation (outsourcing) is traditionally driven by a simultaneous analysis of costs and risks for the firm. In our case, the choice to work with a university may allow a firm to share research costs with the university, other companies and/or public sources. As regards the risk factor, the decision to outsource R&D can be understood as a mean to avoid the risk inherited in building internal competence in a certain field that is potentially important, but that may later prove less lucrative, i.e. to avoid technological lock-in (Nelson, 1982; Dosi, 1988).

As a tool for cost and risk management, outsourcing behaviour may lead to greater efficiency. It is worth noting that since collaborating firms are generally found to invest more in innovation than other firms (Laursen & Salter, 2004; Fontana et al., 2006), we should avoid interpreting efficiency gains from collaboration as mainly a way to reduce long-term costs for innovation, but rather as a way to afford continued investments.

2.4 The transmittal mechanisms

While there are extensive evidence that the flow of knowledge between the academic and the industrial sector is important, Kim et al. (2005) and others have noticed that little is known about the transmittal mechanisms. In part the problems are due to the fact that transmission is a complex process that involves many variables interactions that are understood very imperfectly. Therefore, as Pavitt (2005) suggests, the practical benefits of most university research emerge from processes that are roundabout and indirect.

Another difficulty in the inadequate accounting of the interactions between university research and commercial firms is the heterogeneity in the innovation processes. The nature of knowledge requested differ greatly between (i) different stages in the product cycles, (ii) different fields of specialisation, (iii) small and large firms, (iv) process and product development, (v) knowledge-, labour and capital intensive production and (vi) between manufacturing and services.

Given the intrinsic problems tracing the channels of knowledge dissemination between universities and firms, it is not surprising that the literature does not offer a robust explanation for how collaborative efforts are realised into increased innovative capacity of firms. We believe that the lack of systematic study of these important effects is caused by a rather natural methodological problem: the problem of connecting an effect found on the general level through statistical analysis to its causes is clearly related to the strengths and weaknesses of the respective research methods used. Much of our current understanding of university-industry linkages are based on innovation surveys and on quantitative output data (patents, bibliometrics, etc). Resent literature (see for instance Phan & Siegel, 2006) suggests that inductive, qualitative research can be a useful approach to study through what processes R&D collaboration with universities affect firms' innovation processes and how the effectiveness can vary across different types of initiatives.

3. Data and Methodology

We have performed semi-structured interviews with R&D managers at firms with collaborative experience. To avoid biased results, we need to control the selection of firms. We therefore apply a random sampling method. For availability reasons, we use the full lists of firm collaborating with two leading Swedish research universities; the Royal Institute of Technology (KTH) and the Karolinska Institute (KI) as starting point for this selection.[2]

From data supplied by the two universities, we identified firms who paid a total sum of at least 100.000 SEK (app. €9.500) in connection to research collaboration with either one of these universities during the period 2003-2005. 138 firms were identified in this manner. 34 firms collaborating with KTH and 29 firms collaborating with KI were randomly selected, giving us a stratified group of 66 firms.[3] The relative sizes of the two strata correspond to the relative size of each group in our total sample.

For twelve firms collaborating with KI, we were not able to conduct interviews (either the KI researcher or the identified person at the firm denied us to interview her/him, or the information about a proper contact at the firm could not be retrieved). For two of the interviewed firms, interviews showed that the collaboration is not even loosely coupled to innovation activities in these firms. For three further firms, interview revealed that collaboration is limited to clinical trials. Since we believe that these firms would not indicate university influence in innovation in the typical innovation survey from which the effects of collaboration is derived in previous literature, these five were removed. We are thus left with a final stratum of eleven firms. Most of the twelve first-mentioned twelve that did not lead further were identified as clinical trial collaborations, so we do not think that the inclusion of these respondents would have given us reason to question the results of the analysis. Negative results were also given from attempts to contact six firms who worked with KTH, lending us a final stratum of 28 firms. The data presented here thus represents 45 firms, which is about a third of the total group of collaborating firms meeting our requirements.

[2] Universities are often unwilling to provide full lists of their industrial collaboration partners and details on how much money that has been paid by these firms to the university. However, in Sweden Universities are obliged to provide such information by law.

[3] The stratification was motivated by a need to balance the study between the needs of firms collaborating with a typical engineering university (KTH) and a typical medical university (KI) respectively.

For each of the selected firms, a university researcher collaborating with the firm was identified. The researcher was asked to identify the proper contact person at the firm; a person who was both personally involved in the collaboration and who had significant influence over the decision to enter into this particular university collaboration. Of the 45 persons identified in this manner, 15 were classified as "project managers"; i.e. while performing certain R&D management tasks, they were personally active in operative R&D projects. 17 were classified as "R&D managers", since they were primarily tasked with management of the R&D organisation of the firm. The remaining 13 were "general managers", performing broader management functions than R&D. A first result of this study is thus the observation that beyond the typical relation between an industrial and an academic researcher, firms manage relations to universities from very different levels of organisational hierarchies.

The firm contact persons were asked to participate in semi-structured research interviews, lasting between 45 and 120 minutes. Most questions were phrased in an open-ended fashion, but in some questions the respondents were asked to assess a statement or an effect using a four-point Likert-scale. In five cases where an operational R&D project manager in a firm with extensive R&D was identified, a second person at a corporate R&D management level was interviewed as a means to control for differences in perception between operational and top-level managers. Interestingly, these additional five interviews gave accounts strongly in line with those provided by the first respondent.

4. Perceived Effects of R&D Collaboration

We now proceed to report results on of how the collaborating R&D managers perceive that collaboration helps the firm innovate. To keep an overview of the cases, responses from both open and closed (Likert-scale) questions were assessed, and each respondent classified in a number of dimensions. A set of themes derived from the narratives of our respondents are presented in Table 1.

Themes in narratives about what benefits R&D managers perceive to gain from university collaboration with the Royal Institute of Technology and/or Karolinska institutet university.	Percentage of R&D managers confirming the presence of such effects
Facilitates important learning effects	56
Provides impulses to innovation	44
Allows firm R&D experts to keep in touch with related research development	42
Opportunities to access particular expertise for problem solving	40
Creates legitimacy towards scientific community	38
Allowing long-term recruitment	38

Collaboration considered a cost effective alternative to internal work	27
Collaboration an attractive alternative to setting up new line of research internally	24
Affect university agendas	20
Creates legitimacy towards costumers and/or regulator	20
Allows the firm to keep track of relevant sources of competence (screening)	18
Developing new technology in partnership	18
Access to equipment	13
Develop innovation originating in university	11
Facilitates marketing of innovation	4
Marketing the product and associated methodology of an academic researcher	2

Table 1: Themes developed from interviews

We interpret the heterogeneity between respondents displayed above as arising from different objectives and opportunities of the involved firms. While differences between sectors and between firms with differing sizes and research organisations clearly are important determinants of the particular benefit found from interaction with universities (Nelson, 1986; Meyer-Krahmer and Schmoch, 1998; Santoro and Chakrabarti, 2002), we analyse the interviews so that the different themes and differing views on the aspects delineated above are related to which management task the respective project is contributing to. Five such management tasks seem most relevant from our interviews.

A first critical management task is to ensure that the firm *builds capacities for R&D in the extended firm*. That means first and foremost that proper competencies need to be available in the firm and that R&D personnel must be properly up-dated on relevant developments in science and technology. As indicated in Table 1, university collaboration is found to be perceived as a means to these ends. But it must also be ensured that complementary competence is available in potential partners or through commission in the firm's external contact network. In some cases, firms may for example want to affect agendas of university researchers in order to secure future collaboration and recruitment opportunities. Furthermore, the firm may need to perform competence screening activities of academic competence and possibly develop necessary legitimacy as a scientific collaboration partner.

Three further general tasks of R&D managers concern the flow of projects. Firms need to *identify opportunities for innovation*. Contacts with universities may provide such opportunities, often in the form of serendipitous impulses. In the extreme case, IPR developed at the university can be spun-in to the firm. In order to take the necessary step from identification of opportunities to the formulation of a feasible R&D project, the firm needs to dispose over the necessary competencies and resources. R&D managers furthermore need to *address the needs of current R&D projects*. In

such efforts, it may be necessary to access particular external expertise, e.g. found in universities. In some cases, firm R&D personnel may work in joint projects with university researchers. Access to particular equipment found in academic institutions may also be needed. For process innovation, this step may mark the last in the innovation chain. For product innovations, however, the potential business value created through R&D processes must be realised: firms need to *market innovation*. Somewhat surprisingly, our interviews suggest that collaboration with universities may facilitate also this task. One type of example found in our interviews is the medical firms for whom leading academics are important opinion leaders, whose recognition of a newly developed may influence both regulation and early customers. Another example is firms for whom academics are an important customer group.

An overarching task for R&D managers is to perform all of the above four tasks that lie under their direct responsibility while *managing costs and risk levels*. Collaboration with universities may in this context for example be an attractive alternative to setting up internal resources when a firm seeks to develop a new line of R&D outside its present knowledge base. Joint ventures with universities and other firms in research consortia is also reported to be a cost effective way to manage non-competitive, exploratory R&D. Interestingly, a few respondents in larger firms indicate that the opportunity to leverage R&D money through university collaboration supported by the government or by other actors can be a very important instrument in the constant struggle for R&D funds within multinational corporate structures.

Our interviews thus suggest that collaboration with universities can be used as a tool for five R&D management tasks. These tasks represent challenges that must be managed continuously and simultaneously. In Table 2, these tasks are derived from the themes derived in Table 1. Table 2 thus illustrates the multitude of mechanisms through which university-industry collaboration may enhance the innovative performance of the firm.

R&D management tasks	**Themes in narratives about what benefits R&D managers perceive to gain from university collaboration with the Royal Institute of Technology and/or Karolinska institutet university.**
Build capacities for innovation	Facilitates important learning effects
	Allows firm R&D experts to keep in touch with related research development
	Affect university agendas
	Allowing long-term recruitment
	Creates legitimacy towards scientific community
	Allows the firm to keep track of relevant sources of competence (screening)
Identify opportunities for innovation	Provides impulses to innovation
	Develop innovation originating in university

	Marketing the product and associated methodology of an academic researcher
Address the needs of current R&D projects	Opportunities to access particular expertise for problem solving
	Developing new technology in partnership
	Access to equipment
Market innovations	Facilitates marketing of innovation
	Creates legitimacy towards costumers and/or regulator
Manage cost and risk levels	Collaboration considered a cost effective alternative to internal work
	Collaboration an attractive alternative to setting up new line of research internally

Table 2: University collaboration as a feasible tool for five R&D management tasks

To exemplify how different collaborations are reported to support different R&D management tasks, we present four of the 45 university-enterprise collaborations studied in this paper. The first two cases illustrate relation to the universities used to build capacities for R&D. In the first case, this goal was met through consultation with experts in a related knowledge field, in the second through exploration of a complementary knowledge base. The second case also shows how the firm used collaboration as a mean to manage costs and risks of R&D, and how the firm planned to use collaborative projects to generate opportunities for innovation. The third case illustrates how collaboration is used to address the needs of current R&D projects. In the fourth case, we see an example of how a firm seeks to use a collaborative relation both to market an existing technology/innovation and to identify opportunities for future innovation.

Case 1: A medium sized firm in the biotechnology sector

The firm sees collaboration with leading academic researchers as critical to its ability to scan the development of the biotechnology field and to build the capacity needed to assess and develop the ideas that evolve internally. The use of such contacts applies both to early phase R&D and the clinical phases. The respondent reports the firm also runs some well-defined projects with university researchers where concrete research results are expected, but sees these kinds of contacts as less critical.

Case 2: A large manufacturing firm in the pulp & paper business

The firm had a narrow, 'traditional' set of R&D competencies associated with its main products. In a recent strategic remodelling of its R&D processes, the firm sought to concentrate its internal R&D expertise even further. However, management experienced a need to scan new developments in broad scientific areas such as surface chemistry, nanotechnology and biotechnology, as it was felt that advances in these areas could likely impact their business. A concentration strategy therefore had to be complemented with a strategy for increased and more

organised collaboration with universities, among others the Royal Institute of Technology. According to the respondent, hiring own expertise in the area of biotechnology had been considered as an option, but that strategy would imply considerable costs and create the risk that the firms acquired competences it was still not sure it would really need, collaboration was seen as a more fruitful strategy. The firm, which was quite passive in the relation to the Stockholm university, planned to initiate an exploratory joint-venture collaboration project with university researchers, should the collaboration lead to the identification of a specific opportunity.

Case 3: A large manufacturing firm in the business of electronic equipment

Due to military connections and therewith associated needs for secrecy and due to the very special types of facilities needed for product development in the firm's line of business, the firm is not a very frequent collaborator. However, the firm has identified an innovation opportunity that can only be explored through further development of a generic technology. This task demands knowledge of theoretical physics, in which the firm has no expertise of its own. By collaborating with researchers at the Royal Institute of Technology, the firm is able to pursue the development of the technology, which has possible applications in a number of the firm's product lines.

Case 4: A large computer systems firm

The firm engaged in a collaborative effort with Karolinska institutet, where firm equipment and expertise were used in the establishment of a new centre for research on the human brain. This interaction, which was coordinated by the firm's local sales and marketing organisation, was motivated by a wish to investigate new areas in which the firm's technologies for large-scale computing capacity may allow it to respond to emerging market needs and to win possible marketing advantages.

The suggestion that effects and drivers for university-industry interaction can be studied from the perspective of shifting R&D management tasks represents a shift in attention, as most previous studies on external R&D relations have considered how modes and effects differ between firms or industries. Further evidence that project-specific issues are important determinants of benefits from R&D interaction were recently presented by Howells et al. (2008). Investigating the benefits of

university interaction from the perspective of R&D strategy also has revealed a broader potential scope for the role of university-industry relations than captured by most previous studies. We therefore argue that the conceptualisation of Table 2 provides a useful framework for further studies.

5. Which effects are most important?

We next qualify the analysis by discussing which types of R&D management tasks that are the most common underlying drivers for university interaction among the selected group of firms. Three questions of prioritisation were discussed with all respondents, revealing interesting differences within the studied group of firms.

A first issue of interest concerns the respondents' view on which of two aspects that are considered most important in the relationship to the Stockholm university: (1) to generate concrete results that are useful for the firm's R&D activities or (2) to build capacities for R&D in the extended firm? 17 respondents emphasise the first aspect, 18 respondents the second aspect and 10 indicate that both are equally important.

A second issue concerns where in the innovation processes of the firms that concrete results from collaboration are perceived to be important. The 27 respondents that assigned significant importance to the creation of concrete results useful for the R&D activities of the firm in the previous question were asked to describe a typical innovation cycle in their R&D context. Typically, such a cycle can be generalised into three consecutive stages: opportunity generation, development of identified opportunities and a final phase, consisting of e.g. validation of product characteristics and other preliminary marketing efforts. The respondents were asked to indicate whether or not the relation to the university in Stockholm was useful in each of these three phases. Half (13 of 27) of the group stated that results were important in the first of the three phases, two thirds (18 of 27) stated that results were important in the middle phase and a few (5 of 27) that results were important for the final development phase, closest to the market.

A final issue concerns whether it would have been possible to obtain equivalent benefits from a project run in-house, with reasonable limits on project time and cost? Respondents from 21 out of 45 firms agree that an in-house activity could have been a feasible option, in many interviews spontaneously remarking that the choice of external collaboration is related to considerations of

reducing the costs and/or risks involved (see last two themes of Table 1). We interpret this finding so that a significant share of the collaborative relationships studied here helps R&D managers manage cost and risk levels.

Interview results on these three issues are summarised in Table 3. The five propositions of Table 3 map directly to the five management tasks identified in the previous section. Table 3 thus offers judgement on which of the R&D management tasks that are perceived as most frequently supported by collaboration with the two Stockholm universities. Interestingly, the R&D managers emphasise the indirect effects of university interaction such as building capacities for R&D in the extended firm and managing costs and risks at least as much as the direct effects manifested as concrete results for R&D.

Proposition	*Management task*	*Agrees (percent)*
"To build capacities for R&D in the extended firm is at least as important as to generate concrete results that are useful for firm's R&D activities"	Build capacities for innovation	62
"To generate concrete results that allows us to identify opportunities for innovation is an important gain from collaboration"	Identify opportunities for innovation	29
"To generate concrete results that allow us to address the needs of current R&D projects is an important gain from collaboration"	Address the needs of current R&D projects	40
"To generate concrete results that allow us to market innovations is an important gain from collaboration"	Market innovations	11
"It would have been possible to obtain equivalent benefits from a project run in-house"	Manage cost and risk levels	47

Table 3: Statements about the most important aspect of relation to university

To make a preliminary investigation of whether firms manage collaborations associated with the different management tasks from different levels of the organisation, we investigated how the position of the respondent was related to all three issues described in this section. Somewhat surprisingly, no relation was found; project managers cited the need for concrete results from collaboration no more or no less than R&D managers or general managers, and R&D managers referred to cost/risk management argument equally frequent as general or project managers. As previously mentioned, the five cases where the statements of project managers were checked against those of R&D managers also revealed no major differences. Taken together, these

findings suggest that the views presented in this section are more than an artefact of our method for selecting respondents.

It should be noted that one view of how interaction with universities helps a firm to succeed as an innovator that we expected to find is absent from the analysis: we only find marginal evidence that firms are able to exploit and market innovations or technology originating in the university. The 27 firms whose respondents indicate that the firm seeks to add new technology to their knowledge bases through the interaction with the universities mainly achieve this goal through co-production and/or outsourcing arrangements than through transfer of "off the shelf" technology from universities to the firm. This finding stands in stark contrast to the prevailing notion of "technology transfer" in its original, narrow sense as a key mechanism behind the economic impact of university research, but is fully in line with previous research indicating that ideas for innovations come from customers, clients and (to some degree) from competitors much more frequently than from contacts to universities (Fontana et al., 2003; Klevorick et al., 1995).

6. Summary and conclusions

This paper set out to contribute to improved conceptualisation of the processes through which collaboration with a university helps a firm become more innovative. Recognising a gap in the literature between studies of effects enjoyed by collaborating firms and the study of rationales for university contacts as part of an open innovation paradigm, we have suggested that the two ends of this chain of evidence can be connected through conceptualisation of university interaction as potentially supporting five distinct R&D management tasks.

We report results from semi-structured interviews with 45 randomly selected firms collaborating with two universities in Stockholm, Sweden. Adding to emerging evidence in the literature, our analysis suggests that collaboration is perceived as most strongly contributing to the development of the firm's capacities for R&D and to successful management of costs and risks associated with R&D. Interestingly, we find that beyond the commonly invoked "learning" argument found in the literature on how university interaction may increase the capabilities of a firm, collaboration can also allow firms to strengthen their innovation networks and manage their human capital. In particular, collaboration with universities is perceived to help firms build the capabilities necessary to successfully translate market opportunities evolving from within the firm or from contacts with other firms into technical or organizational problems. These findings call for further

studies of how firms use relations to public research to build capacities for R&D, from the perspectives of both firm management and public policy.

This finding that half of the interviewed R&D managers perceived the above kind of indirect benefits of collaboration more important than or equally important to the creation of new R&D results through collaboration suggests that the prevailing focus of the literature may be overly restricted. In particular, it illustrates how a focus on IPR transfer as main outcome of university-industry relations may be misleading in a context of open innovation. The analysis of university relations from the R&D strategy point of view opens up for a re-conceptualisation of how university-based knowledge creates economic value in a knowledge-based economy, by adding a view on wider set of effects from interaction that may arise within established firms to existing studies of spin-off firms and academic patenting.

For half of the studied firms, R&D managers also report that concrete results generated in interaction create important benefits for the firm, which motivates the interaction with the Stockholm university. Typically, these results are used in existing R&D projects or as enablers of future projects. However, a novel finding of this study is that university interaction may also facilitate marketing of innovations, typically in that the involvement of academic scientists creates legitimacy towards costumers or regulators. In some cases, firms are also found to collaborate with universities to investigate marketing opportunities for existing technologies.

The studied cases of interaction are managed from different organisational setups within the firm. About one third each of all collaborations are run by operative project managers, dedicated R&D managers and general managers, respectively. We find no evidence that the perceived benefits of university collaboration differ between these three groups of managers, which indicates that the conceptual framework presented in this article is a valid basic representation of firms' use of contacts to universities rather than an artefact of the process used to identify respondents. But this shifting organisation of university interaction also points to an important area for further research. By focusing attention on the management forms of firm-university relationships, we can win further insights about when and how firms can use these relationships to draw on the full scope of benefits identified in this paper rather than setting up different interfaces for each of the different management tasks that collaboration can potentially serve.

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