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Catalysts and barriers: Factors that affect the performance of university-industry collaborations

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Abstract

This paper explores the factors that affect the performance of university-industry collaborative projects, and determines whether different types of projects lead to different type of results. In particular, we examine how this performance relates to the origin, the implementation, and the financing of the collaborative project, as well as to the specific characteristics and the earlier experiences of both parties that collaborate. Our study relies on 30 in-depth, semi-structured case studies of university-industry collaborative projects. We complement that analysis with a large-scale written questionnaire sent to industrial and academic researchers in the Netherlands, examining the views of researcher towards collaborations including perceived barriers. Our results show that university-driven projects, though being more risky and troublesome, allow for unexpected fruitful scientific and technological achievements, with high spillovers to other fields. Industrial-driven projects, in contrast, result in more modest achievements, but they are more likely to be adopted for use by the participating firms. The absorption of the knowledge developed in the collaboration depends mainly on factors residing on the industrial side, such as the firm's competences to use and further develop the knowledge in question, and the firm's investment in knowledge transfer channels such as labour mobility. We also examined the criteria that the partners use to evaluate their collaborations. Here, we find that university and industry use quite similar evaluation criteria. Differences in their evaluation are associated with differences in the original expectations for the project. This is particularly true for publicly funded projects that aim to further develop the findings of

earlier collaborations. Finally, researchers' views on university-industry collaboration depend on their academic, entrepreneurial, and relational experiences as well as the incentives that exist in their research environment.

1. Introduction

The number of studies on the importance and embodiment of knowledge transfer between university and industry has multiplied in recent years. One branch of studies aimed at analysing the relative importance of the various channels of knowledge transfer. Recent contributions have shown that publications and personal contacts, followed by collaborations, are reported to be the most important channels of knowledge transfer between universities and industries, whereas activities by the Technology Transfer Offices (TTOs), spin offs and university patents and licensing tend to be the least valued by researchers (Bekkers and Bodas Freitas, 2008; Cohen et al., 2002). Another branch of studies focused on differences in incentive mechanisms (both at universities as in industry), and on the impact of these mechanisms on the willingness of researchers (on both 'sides') to collaborate on specific research projects. Most of these studies have shown that differences in objectives, incentives and research focus may result in problems to transfer knowledge transfer university and industry (Dasgupta and David, 1994; Rosenberg and Nelson, 1994; Foray and Steinmueller, 2003). Furthermore, some authors have examined the performance of specific mechanisms of knowledge transfer. Here, particular attention has gone to university patenting and spin offs (see Bach and Llerena, 2007, among others).

Despite university-industry collaborations being regarded as one of the most successful knowledge transfer mechanisms, relatively few research efforts have been put in exploring their performance. This paper is an attempt to address that gap, by both studying the performance of actual collaborations and by examining the views of researchers on collaboration.

We analyse the catalysts and barriers of university-industry collaboration by looking at a sample of collaborative projects as well as by examining the views of a large sample of potential collaborators (i.e. university and industrial researchers) on issues that affect such a performance. Are the findings on the effectiveness of actual collaborations similar to the views of the larger potential audience of university-industry collaborations? We expect that those without own experiences to be more likely to report a greater number of problems often told about (prejudices) university-industry collaboration. Additionally, we expect that researchers with some experience to report problems specifically related to their experiences, and their social and technological background.

Our starting point is that performance may depend on one or more of the following aspects: (1) different levels of involvement of university and industry in the originating phase and the implementation phase of the collaborative project, (2) to specific forms of implementation of projects, (3) to the previous collaborative experiences of both parties, and (4) characteristics of the individual researcher and his/her working environment. We adopt a broad concept of performance, defined as (a) the level of scientific and technological achievements, (b) the degree to which firms make use of knowledge that was developed, and (c) the subjective evaluation of the success of the by both parties involved. For this purpose we rely upon case study data on actual university-industry collaborations to the development of a specific knowledge and/or technology. Of course such cases only learn us about collaborations that effectively took place. Therefore we also looked at views on collaboration of a larger audience, i.e. all researchers that might potentially get involved in collaborations. To do so, we used survey data collected via two questionnaires—one addressing industrial researchers and the other academic researchers— both conducted in the Netherlands.

Our results suggest that university-driven projects allow for unexpected fruitful scientific and technological developments, with high spillovers to other fields; while industry-driven projects are more likely to benefit participating firms. Absorption of the knowledge that was developed in the collaborative project depends mainly on factors residing on the industrial side. Firms need to invest in capability building and in knowledge transfer, especially in labour mobility. Having earlier experiences positively influences the positive evaluation of new collaboration, for both parties. Parties having earlier experiences also less often overemphasize barriers to collaboration. Still, when parties start with a project yet having different expectations, and when the projects results are of different value for each party, we see larger discrepancies between the evaluation of both parties.

Additionally, the examination of the responses to a large-scale written questionnaire sent out to industrial and academic researchers, suggests that the researchers' views on university-industry collaboration depend on their academic, entrepreneurial and relational experiences as well as on the incentives in their research environment. In other words, when inquiring the larger sample of potential collaborators, their views will be either affect by their experience of by the existing information on main issues affecting collaboration. The more experienced collaborators are the ones less likely to report barriers to collaborations, reflecting eventually their previous work of reorganization and networking building that allows to combine their academic and industrial research agenda.

As university-industry collaboration is increasingly acknowledged to be among the most efficient means of bringing academic inventions to the market, we hope that this study helps firms and policy-makers to foster successful university-industry collaborations.

2. Data and Methodology

This section describes the methodology we used to collect and analyse the data. We start with discussing the case studies, followed by the large-scale survey.

In-depth semi-structured case studies

We conducted 30 case studies of university-industry collaboration. Data on the cases was collected on the basis of interviews with those involved in the project both at firms and at university. As such, we conducted around 90 interviews. We complemented this with secondary sources of information on the cases we studied, such as theses, public information provided by the collaborating partners, and funding organisations (if applicable). Data was collected using a standardized protocol, containing around 200 questions requiring short written answers. The protocol focused on various elements of the process of knowledge transfer between university and firms (Kingsley et al., 1996; Bozeman, 2000; Bercovitz and Feldman, 2006). Among other things, information is collected on the origin of the project, the design and development of the project; the channels of knowledge transfer used, the role of other organizations and institutions, and the past experience of both parties concerning collaborations. The unit of analysis of these cases is 'a piece of knowledge/technology developed as part of collaboration between university and industry'. Note that is independent of whether it was in fact commercialised or not. For more details, please see (Bodas Freitas and Verspagen, 2009).

Based on this case study evidence, we analyse the characteristics of university-industry collaborative projects across their different levels of performance. In particular, we examine how different levels of performance relate to different levels of involvement of university and industry in the origin and implementation of the collaborative project, to specific forms of implementation of projects, as well as to previous experience of both parties in collaboration. Moreover, we explore differences in the overall appraisal by university and industrial researchers of their collaboration. Given the type of data and the limited number of observations, we build on results from the non-parametric correlation coefficients and T-tests. Table 1 provides the description of the variables used on the analysis.

[Insert Table 1 about here]

Survey data

To analyse the different views by university and industry researchers on collaboration, we use survey data conducted from May to June 2006 in the Netherlands. Unlike many other questionnaires relating to R&D; this survey was conducted among staff actually performing R&D, rather than their managers. Our respondents are the real users and developers of knowledge in the university and in industry, and therefore we believe that they are better positioned to answer our questions. In total, we received 575 valid responses from university researchers and 454 from industrial researchers, corresponding to a response rate of 27.6% and 24.7%. Both questionnaires are available for review at http://home.tm.tue.nl/rbekkers/techtrans/

At various points, we used factor analysis to reduce larger number of questions into groupings. Table 2 reports on the four factor analyses, and below we will briefly discuss these.

[Insert Table 2 about here]

The first factor analysis was done on the questions we surveyed on the views of university researchers on collaboration with industry. We derived three factors: 1: “Industry is not interested”, 2: “Difficult to find interesting industry partners”, 3: “Costly and time-consuming”. Details on the factor loadings are given in Table A in the appendix.

The second factor analysis was done on the questions on the views of *industry* researchers on collaboration with university. We derived five factors: 1: “Research focus or culture too different”, 2: “Information leakage and high management costs”, 3: “Incompatible views on IPR ownership”, 4: “Problems in matching the knowledge needs”, 5: “Confirmation of the importance of university knowledge”. Details on the factor loadings are given in Table B in the appendix.

The third factor analysis was done on the actual experiences of researchers with different types of university-industry interaction, i.e. the use of different knowledge transfer channels. Here, we derived five factors, shown in Table 2. More details on the factor loadings are presented in Table C in the annex. The final factor analysis was done on disciplinary origin of the researchers’ field. Here, we derived four factors, shown in Table 2. More details on the factor loadings are presented in Table D in the annex.

Our dependent variables are constructs based on the first two factor analysis. Here, we created categorical variables equalling 0 for factor loadings inferior to 0, equal to 1 for factor loadings between 0 and 1, and equal to 2 for factor loadings exceeding 1. Using these ordinal variables, we estimate ordered logistic models for each identified perspectives on collaboration for university and industrial researchers. We first estimate this model using the enter method (entering all variables at the same time) and secondly using the backward method (stepwise removal of variables from the model with the lowest explaining power). Results obtained from both methods are very robust, in the sense that the significance of estimators using any of the two methods remains constant.

Our prior expectations were that researchers’ perception on university-industry collaborations will be impacted by (1) their different individual features, (2) their actual experiences with different types of knowledge transfer channels, (3) their working environment and (4) the disciplinary nature of the field they work in. Hence, as independent variables we include variables that proxy for these aspects. In particular, we characterise respondents by their age (Age), the number of authored or co-authored papers (Npubl), the number of patents in which they are listed as inventor (Npatent), as well as whether the respondent has established any spin-off (Spin) or start-up (Startup). For actual experiences with different types of university-industry interaction (i.e. experience in the use of specific knowledge transfer channels), we use the five factor loadings on this dimension as presented above. We characterise the working environment of researchers by identifying the type of research performed by the organisation (i.e. basic, applied or experimental, as defined in OECD's Frascati manual). The first two categories are entered as dummies; the third one is the reference group. We also include variables characterising the knowledge environment at stake in terms of codification (codified), tacitness (embodied), interdependence vs. systemicness (interdependent), and whether the knowledge is expected to result in a breakthrough.[1] Furthermore, for the disciplinary nature of the field, we use the four factor loadings that were also discussed above. Finally, when analysing the views of academic researchers, we also included a variable that captures the dependence of the research group on commercial contracts (*Contract_fund).*

Table 3 reports the descriptive statistics of all the variables used in our analysis. Table E in the Annex shows the correlation coefficients.

[Insert Table 3 about here]

3. Performance of University-Industry Collaborations

We first focus on the aspects of performance of university-industry collaborative project related to the specific characteristics of the projects, as well as of the industry and university parties. In particular, we take a broad concept of performance and we examine the scientific and technological outcomes, the level of absorption, use and commercialisation of knowledge developed in the project, and the subjective overall evaluation done by firms and university of the collaborative project. Table 4 provides information on the level of performance of our 30 cases.

[Insert Table 4 about here]

In two out of the thirty cases, the collaborative project did not achieve the scientific or technological objectives (e.g. those defined when starting the project), while in four cases the outcomes were above the expected ones. In seventeen cases, projects led to commercialisation or plans to commercialise new products. Despite these good outcomes, universities overall evaluate 26 projects as fully positive, while firms are more critical and only report the same level of satisfaction in 21 of the 30 cases.

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[1] These items were measured on a four-point rating scale using the following statements: 'knowledge is mainly expressed in written documents', 'knowledge is mainly embodied in people', 'major knowledge breakthrough are expected', and 'knowledge refers to systematic and interdependent systems'. (For more details, see the questionnaire, available on the internet: ....).

We now move to the analysis of the relationship between performance on the one hand and the characteristics of collaborative projects on the other. Table 5 reports the Spearman's correlation coefficients for significant non-parametric T-test differences.

[Insert Table 5 about here]

Generally, the project's scientific or technical outcomes (Table 5, column 1) are more likely to match or to be above the defined ones, if the idea for the project comes from university research activities rather from firms' project development activities or from previous collaborative projects. Typically, such projects do not run smoothly as they encounter unexpected and severe technical problems while being carried out. Moreover, the scientific and technological outcomes of collaborative projects seems to be positively associated with frequency of interaction between university and industry during the project, and negatively associated with project that apply for competitive grants.

The four projects that exceeded the aimed scientific or technological outcomes tended to be initiated by a university. In three out of these four cases, the project was initiated by researchers with previous industrial experience, reflecting the importance of labour mobility and research collaboration for collaboration. Despite the fact that the industrial partners participating in these four projects being quite knowledgeable, they might not have had the capabilities to identify and plan the required research in order to achieve the project' results. All these four projects were considered to be successful by both firms and universities, and their results were used (by either participating or non-participating firms in the R&D project). Three of these projects focused on substitutes to existing technologies. Concerning financing, one project was mainly undertaken with research grants, other one with a mix of research grants, firms and university resources, and the third with both grants and firms' money, while the remaining one was funded only by the participating partner. In two cases, projects led to plans for launching new product, in the two other projects, results were less ready to commercialised and instead led to products development projects.

Concerning the level of knowledge transfer to firms, we find that outcomes of collaborative projects, which were patented, used by firms in further product development research and had an impact on the research objectives of firms and universities, were all used by participating or non-participating firms in the collaborative project.

In particular, our results (Table 5, column 2) suggest that knowledge is more likely to be absorbed and used by *participating* firms, when the idea for the project comes from industrial project development activities and technological problems faced by firms, often proposed by part-time professors, rather from research activities at university. Moreover, this seems more likely when participating firms join on the design, performance of R&D and university provides feedback and advice on R&D activities of the firms. Knowledge developed in the project is more likely to be used by participating firm, when these firms invest in learning and knowledge transfer through a large number of channels, especially through labour mobility and meetings, and partially finance the project (and consequently set formal or informal contractual stipulations about the ownership of the research results). Knowledge is more likely to be used by participating firms, when the R&D project did *not* encounter severe or unexpected technical and scientific problems while being carried out.

In one third of cases (11), *non-participating* firms used the knowledge developed in a collaborative research project. Knowledge absorbed and used by non-participating firms is often associated with spin off creation, since the knowledge developed in the project does not fit the core technological capabilities and product line of the participating firms. Moreover, it is associated with cases in which other firms join later the project either to provide specific equipment and material, to perform small parts of the project or to participate in the exploitation of knowledge produced in the project. For example, in one case, the customers of the participating firm join on the testing of the prototype developed in the project and then soon after they adopt the product. In other case, an non-participating firm learns about the unexpected scientific and technological developments of the project, because it participates in other projects financed by the same research council, and it asks to be integrated in the project.

Results (Table 5, column 3) suggest that knowledge is more likely to be absorbed and used by *non-participating firms*, when participating firms are not involved in the design and performance of R&D, and financing is mostly assure by other sources such as research grants (except for two cases in which participating firms financed most of the project). As firms are less involved in developing of R&D, knowledge transfer tends to occur through prototypes rather than through meetings. Institutional and organisational barriers resulting from the different incentives and objectives frameworks of industry and university do not seem to be the reason for non-participating firms to benefit from the projects. Indeed, despite knowledge developed being also absorbed/ used by non-(originally) participating firm, participating firms are willing to keep further collaboration with the same university researchers.

Hence, knowledge developed in collaborative projects is more likely to be absorbed and used by *participating or non-participating firms*— such as spin-offs, firms that become aware of the knowledge developments or firms that joined to support project development—in projects in which firms invest in a large number of mechanisms to insure knowledge transfer, including labour mobility (Table 5, column 4).

The industrial use of knowledge developed seems associated with firms' competences to use and further develop knowledge created in the project, as well as on their experience to collaborate with university for research and development.

Other measure of performance of university-industry R&D projects refer to whether or not the project led to the *commercialization* of new products. Commercialisation of knowledge developed in the project (Table 5, column 5) is associated with results of collaborative multi-disciplinary projects that lead to the publication of several patents, as well as with the industrial employment of university researchers involved in the development project. Commercialisation is also more likely when participating firms do not own a research lab, and when university research group has a great number of published patents. Consequently, collaborative research focused on very applied technological issues, even that often requiring the development and test of proof of concepts. Market dynamics may have also prevented commercialisation (3 cases).

Finally, we look at the overall, subjective evaluation done by the parties involved in the project. Positive evaluation is more likely to positively evaluate collaborative projects with level of scientific and technological achievements, level of commercialisation (or plans) and level of transfer to non-participating.

University evaluation (Table 5, column 6) of the collaboration with industry is more likely to be positive in multi-disciplinary projects, when university was involved in the development and test of a proof of concept, while the industrial partner provided access to equipment and materials and feedback on university research work, but did not participate on the design, performance or the finance of the project. University researchers, with large collaborative experience, also with the same firm, are more likely to rate positive the collaborative project. Instead, they tend to evaluate projects as not completely satisfactory when they involve the use of university knowledge that has been patented (either by the university or by the firm in the beginning of the project). Moreover, projects in which there were relational problems derived from the different objectives and incentives frameworks of university and industry occur during the project are more likely to be evaluated as non satisfactory.

Curiously, firm's evaluation is based on the same criteria as university evaluation (Table 5, column 7). Firm's evaluation of collaboration with university is also more likely to be positive, when projects were proposed by university, and in which university was involved in the development and testing of a proof of concept. Firms also evaluate positively projects with high level of interaction between university and industry, as well as with few relational problems due to cultural and organisational differences between the two organisations. Firms recognise the university efforts and competences and evaluate positively projects that suffered several technical and scientific problems during development. In particular, firms evaluate positively projects set up with university departments with who they had had previous collaborations. Finally, they also tend to evaluate projects as not completely satisfactory when they involve the use of university knowledge that has been patented (either by the university or by the firm in the beginning of the project).

In 5 projects, there were differences in the overall evaluation by university and firms of their collaborative project. In most cases, university rated projects higher than firms. This mismatch seems to underlie different expectations from the project. These projects were initiated as follow-up of previous collaborative projects with the same partners, financed fully or partly by public research grants, and implemented by university with a low level of interaction among the parties. Evaluation differences also exist when projects did not to encounter severe technical problems during development, and when firms did not invest in technological development to use research results. Hence projects set to access public sponsoring for exploring interesting new R&D opportunities emerged from previous collaboration are likely to be differently evaluated by the two parties eventually by the different efforts and expectations put by both parts. Indeed, differences in the potential uses of the research results by the two parties- they feed further university research, but not firms' product development- are likely to bring along disparity on the evaluation.

4. Perceptions concerning collaboration

In this section, we examine how the views of researchers on university-industry collaboration is affected by individual characteristics (academic, technological and entrepreneurship) as well as organizational incentives. We will discuss the result for industrial researchers in Section 4.1, and those for university researchers in Section 4.2.

4.1 Perceptions on collaboration by industrial researchers

Table 6 presents the estimates of Ordered Logit models of the level of the five main views of industrial researchers on collaboration with university. As explained before, we compared these results, obtained by the *enter* method, also with the outcomes when using the backward method (Table D in the Annex). We conclude that our results are robust.

[Insert Table 6 about here]

Results show that those respondents that stress that the *research focus or culture are too different* (factor 1) are more likely to be industrial researchers with a low number of co-authored publications, limited experience in interacting with university through academic output and informal contacts, as well as through research collaboration. Also, this group mostly works with embodied knowledge, works in areas where breakthroughs are not expected, and works in scientific fields not related to chemical, material or biomedical sciences.

Information leakage and high management costs (factor 2) are mainly recognised as difficulties in collaboration with university and are mostly found among older industrial researchers, working with embodied knowledge, and working in material and chemical sciences, or in social sciences. To a certain extent, these researchers tend to have little experience in formal collaboration and in the use of formal mechanisms of interaction with university.

Those that stress *incompatible views on IPR ownership* (factor 3) are particularly industrial researchers that have (many) patents, thus with experience of interacting with university through flow of students as well as Formal channels to access university research (such as patents, licensing, spin-offs and TTO's activities), but not through Alumni. Researchers that report IPR as barriers to collaboration with university are likely to be involved in the development of systemic knowledge related to biomedical rather than engineering.

Problems in matching the knowledge needs (factor 4) are mostly raised by entrepreneurial industrial researchers, who have founded a start up and have been accessing university knowledge through formal mechanisms. This view is mainly shared by industrial researchers not working in technological fields of material or chemical sciences. To a certain extent these researchers are not used to employ academic outputs and informal contacts to interact with the university.

Finally, industrial researchers that *acknowledge the importance of university knowledge for their industrial R&D activities* (factor 5) are mainly those with experience in interacting with university through academic output and informal contacts, but not through Alumni. They are used to scan and search in academic publications to inform their industrial R&D activities, and they experience in formal collaboration with university. These researchers are more likely to be working in a research environment focused on basic research and not on biomedical sciences, and to a lesser extent, to be involved in the creation of a spin off.

4.2. Perceptions on collaboration by university researchers

Table 7 reports the results of Ordered Logit estimation models of the level of three views of university researchers on collaboration with industry. As referred in section 3, we proceed to the estimation of this model using both the *enter* and the *backward* method. Results are identical. The first three columns of the table report the enter method, and the last three columns the backward method.

[Insert Table 7 about here]

University researchers that report *industry is not interested* (factor 1) are more likely to work with engineering sciences rather than with social sciences, and they tend to have little experience in interacting with industry using Students. Nevertheless, this model explains very little the reasons why university researchers report this view.

University researchers that acknowledge the *difficulty in finding interesting industrial partners* (factor 2) are more likely to be older researchers, working with embodied knowledge in areas where breakthroughs are not expected and in research environment with a low incentive to application. Researchers affiliated to research groups with high levels of commercial funding of their research are less likely to report this difficulty in finding industrial partners.

Finally, university researchers, who view technology transfer as a *costly and time consuming activity* for universities (factor 3), are typically older researchers with little experience in the use of formal mechanisms of transfer (i.e. patents, licensing, spin offs and TTOs). They are more likely to work with embodied and systemic knowledge. There is however not sufficient evidence confirming that researchers affiliated to research groups with high levels of commercial financing are less likely to report this view.

5. Conclusions

This paper has aimed at analysing the factors influencing performance of university-industry collaborations, and at examining the views of researchers on collaboration. It has addressed these research questions by using case-studies and survey data collected in the Netherlands. Our case study findings suggest that university-driven collaborative project's not benefiting from public grants, are more likely to develop outcomes that match or are above to the previously defined ones. Typically, such projects do not run smoothly as they encounter unexpected and severe technical problems while being carried out. In contrast, industrial-driven projects, dealing with technological problems related to product development, in which firms participate in the design, performance and finance of R&D activities, as well as invest in several means especially labour mobility to learn and to transfer knowledge, are more likely to lead to results that are absorbed and used by participating firms. Thus, our results stress how university-driven research, though being more risky and troublesome, allows unexpected fruitful developments with potential high spillovers to other fields. Absorption of knowledge developed in collaborative research projects seems to depend on features and attitudes on the side of industry. Firms need to invest in capability building and in knowledge transfer. In particular, participating or non-participating firms need to have the competences to use and develop further the knowledge in cause, as well as to invest in knowledge transfer through several channels, in particular labour mobility.

Moreover, our evidence shows how university and industry have similar evaluation criteria and how evaluation depends positively on their experience to collaborate: Both parties tend to evaluate collaborations as being positive when they are university-driven multi-disciplinary projects, focusing on the development and test of proof of concepts, and have a great level of interaction. Firms, in particular, positively acknowledge the efforts of universities to solve severe technical and scientific problems during the project. Differences in evaluation seem to be associated with (implicit) differences between expectations at the outset of the project. Differences are also more likely when projects are initiated to develop further some findings of previous collaboration, when they are financed by public grants, when they are developed by the university with a low level of interaction, and when the project's results have different a value for the parties involved.

These case study findings are in line with the our survey results, which suggest that industrial researchers that have little experience in interacting with university are more likely to report high barriers to collaboration (i.e. different framework frameworks and difficulty of identifying, locating and accessing university knowledge). Instead, industrial researchers, who are more experienced at collaborating and networking with university researchers, and at scanning and searching academic publications to inform their industrial R&D activities, see fewer barriers. Industrial researchers that have been intensively involved in patenting and in interacting with universities through TTOs often emphasise concerns about IPR ownership issues or high management costs.

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Table 1. Description of variables characterizing university-industry collaborative projects

Variable	Description
Origin of collaborative project	
University Idea	1 The project originates from a university proposal, 0 the project originates from an industry proposal
Previous_collab	1 The origin of the project is attributed to previous/on-going collaboration, 0 otherwise
University_K_patents	1 The origin of the project is attributed to previous patents based on university knowledge, 0 otherwise
Characteristics of University Researcher	
Part-time	1 at least one of the university researchers involved has a part-time appointment in industry and part-time appointment in university, 0 otherwise
Characteristics of the university research group	
Univ_patents	Count of the number of patents of the research group in the last 5 years. It takes values from 0 to 65
Univ_exp_same firm	1 whether the university department had previous collaborative experience with the same firm
Characteristics of the participating firms	
Firm_rd_capabilities	1 the firm is able to evaluate, plan and undertake the required R&D activities for accomplish the project's objectives; 0 otherwise
firm_collab_exp	1 the firm's experience in interacting with universities mainly through students' trainships, 2 the firm is also used to interact through Master thesis; 3 the firm interacts with university also through collaborative research projects
RD_lab	1 the firm has a R&D lab, 0 the firm does not have one.
Capab_use_develop	1 the firm had the competences to use and develop further the knowledge developed in the project, 0 the firm does not have these competences
Finance of the collaborative project	
Project_financing	1, mainly public financing, 2 both public and private financing, 3 mainly private financing
Sponsoring	1 the project was carried out with public research grants
Only_public _funding	1 the project was financed only with public money being either grants or university resources, 0 otherwise
Labour and Knowledge division in the project	
Proj_performance	1 R&D project is mainly performed by the university, 2 industry participates on the project performance, 3 project mainly performed by the firm
Firm_perform	1 the firm participated on the performance of the R&D activities of the project, 0 otherwise
Univ_feedback	1 the firm provided only advice and feedback to the R&D activities performed by the firm
Frequency	1 if interactions among the parts occurred often, 0 if these interactions occurred occasionally
N_disciplines	Number of disciplines involved in the project. It takes values from 1 to 6
IPR_stipulations	1 whether the parts agreed in specific IPR stipulations before the contract, 0 otherwise
N_patents	Number of patents resulting from the project. It takes values from
Problems during project development	

Technical problems	1 the project encountered severe technical problems in implementing technological principles, 0 otherwise
Cultural differences	1 the project suffered from a misalignment of the cultures in university and industry, 0 otherwise
Channels of knowledge transfer used	
Mobility	1 Mobility of researchers or students was used to support knowledge transfer, 0 otherwise
Techn_development	1 technological development in firms of university developed knowledge supported knowledge transfer, 0 otherwise
Meetings	1 Meetings were used to support knowledge transfer, 0 otherwise
Employment	1 employment of university researchers or students was used to support knowledge transfer, 0 otherwise
Prototype	1 prototypes developed by the university was used to support knowledge transfer, 0 otherwise
University advice	1 university provided advice and feedback on firms' RD activities to support knowledge transfer
N_channels	Number of channels of knowledge transfer used. It takes the value from 0 to 3. Being 3 all the cases with more than 3 patents
Measures of Performance	
Outcomes_match	0 the project scientific and technological outcomes are bellow expected, 1 the outcomes match the expected, 2 the outcomes are above the expected
Partic_absorbed_used	0 the knowledge was transferred but not absorbed by the participating firm, 1 the knowledge was transferred and absorbed, 2 the knowledge was also used
Non_partic_absorbed_used	1 the knowledge was transferred but not absorbed by a non-participating firm, 1 the knowledge was transferred and absorbed, 2 the knowledge was also used
Part_NonPart_absorb_used	2 the knowledge was transferred but not absorbed by a participating or a non-participating firm, 1 the knowledge was transferred and absorbed, 2 the knowledge was also used
Comercialization	1the project led to the commercialisation or to plans for the commercialisation of a new product, 0 otherwise
Univ_Evaluation	0 the university evaluates the project as not completely satisfactory, 1 as positive and satisfactory
Firm_Evaluation	1 the firm evaluates the project as not completely satisfactory, 1 as positive and satisfactory
Differences_eval	1 the university and firm evaluate differently the project, 0 both parts evaluate similarly the project

Table 2. Overview of all factor analyses

Dimension	Factors	Variance explained	Eigen values
University researchers' perception on cooperation with industry	1: "Industry is not interested"	19.4%	2.14
	2: "Difficult to find interesting industry partners"	19.23%	2.11
	3: "Costly and time-consuming"	14.18%	1.56
Industry researchers' perception on cooperation with universities	1: "Research focus or culture too different"	16.67%	2.67
	2: "Information leakage and high management costs"	15.62%	2.5
	3: "Incompatible views on IPR ownership"	12.39%	1.98
	4: "Problems in matching the knowledge needs"	10.83%	1.73
	5: "Confirmation of the importance of university knowledge"	6.75%	1.08
Channels of technology transfer between university to firms	1: "Collaborative research"	23.57%	9.36
	2: "Flow of students and staff"	11.99%	2.02
	3: "Patents, spin-offs and TTOs"	10.31%	1.32
	4: "Publications & informal contacts"	10.15%	1.08
	5: Alumni	9.06%	1.08
Disciplines	1: "Engineering"	19.29%	3.51
	2: "Biomedical sciences"	19.26%	2.83
	3: "Material sciences"	17.26%	2.33
	4: "Social sciences"	16.04	1.38

Table 3. Description and descriptive statistics of dependent and independent variables

	Name variable	Description of variable	N	Minimum	Maximum	Mean	Std. Deviation
Individual characteristics	Npubl	Number of Co-authored papers	818	1	6	2.9	1613.0
	Npatent	Number of patents cited as inventor	816	1	5	2.0	1219.0
	Spin	Personally involved in creating a spin-off	819	0	1	0.1	0.3
	Startup	Personally involved in establishing a start-up	819	0	1	0.1	0.3
	Age	logarithm of the age of the respondent	814	3.22	4.39	3.7	0.3
Experience in Interacting with university through different channels	Collaboration	Collaborative research	721	-3	3	0.0	1.0
	Students	Flow of students and staff	721	-4	2	0.0	1.0
	Formal	Patents, spin-offs and TTOs	721	-2	3	0.0	1.0
	Academic	Publications & informal contacts	721	-5	2	0.0	1.0
	Alumni	Alumni	721	-3	2	0.0	1.0
Knowledge Characteristics	Codified	'knowledge is primarily expressed in written documents'	811	1	4	3.4	0.7
	Embodied	'knowledge is predominantly embodied in people and is difficult to lay down in written documents'	801	1	4	2.2	0.8
	Breakthroughs expected	'major technological breakthroughs are expected within the next five years'	797	1	4	3.0	0.7
	Interdependent	'we often work with systems that have many interdependent parts; changes in one part imply changes in many other parts'	800	1	4	2.8	0.8
Characteristics of research environment	Basic	Basic research percentage	775	0	100	26.9	30.8
	Applied	Applied research percentage	788	0	100	50.5	28.7
University characteristics	Technuni	Technical University	812	0	1	0.3	0.5
	Contract_fund	% of research group financing from Commercial funding	396	0	100	20.69	22
Disciplinary/ Technological Field	SOC	Social sciences	752	3	15	5.9	2.9
	BIO	Biomedical sciences	746	3	15	8.0	4.0
	MAT	Material sciences	747	4	20	13.7	4.0
	ENG	Engineering	758	5	25	17.1	4.4
University researchers' perceptions	Ind_interest	Industry is not interested	361	0	2	0.6	0.7
	Find_partners	Difficult to find interesting industry partners	361	0	2	0.6	0.7
	Time_money	Costly and time-consuming	361	0	2	0.7	0.7
Industry researchers' perceptions	Focus	Research focus or culture too different	361	0	2	0.6	0.7
	Leakages	Information leakage and high management costs	361	0	2	0.6	0.7
	IPR	Incompatible views on IPR ownership	361	0	2	0.7	0.7
	Matching	Problems in matching the knowledge needs	361	0	2	0.6	0.7
	University_importance	Confirmation of the importance of university knowledge	361	0	2	0.6	0.9

Table 4. Various performance levels of the cases

	Below	*Match*	*Exceed*
Outcomes compared to the defined objectives	2	24	4

	Neither absorbed or used	*Absorbed, not used*	*Absorbed and used*
Firms participating in project	5	3	22
Third parties (non-participating firms)	17	2	11
Any firm	1	2	27

	Negative or neutral	*Positive*
Overall university evaluation	4	26
Overall firm evaluation	9	21

	Different evaluation	*Similar evaluation*
Discrepancies in evaluation	5	25

	Not commercialized	*Commercialized*
Knowledge Commercialization	13	17

Table 5. Spearman's Correlation coefficient for significant non-parametric T-test differences between the characteristics of collaborative projects with different performance levels

Variable	Outcomes	KT-participating firm	KT-non participating firm e	KT-any firm	Commer-cialization	University Evaluation	Firm Evaluation	Differences In evaluations
Origin of collaborative project								
University Idea	0.479**	-0.0.91*					0.279	
Previous_collab	-0.264						-0.257	0.402*
University_K_patents			-0.285			-0.523**	-0.267	
Characteristics of University Researcher								
Part-time		0.329*						
Characteristics of the university research group								
Univ_patents					0.284			
Univ_exp_same firm			0.516**			0.429**		0.270
Characteristics of the participating firms								
Firm_rd_capabilities	-0.496**	0.269	-0.246					
Firm_collab_exp		0.263		0.339*				
RD_lab			-0.297		-0.279	-0.257		
Capab_use_develop		0.359*		0.459**				
Finance of the collaborative project								
Project_financing		0.423**	-0.397*			-0.334*		-0.304
Sponsoring	-0.310*							0.239
Only_public _funding		-0.613**	0.295					0.280
Labour and knowledge division in the project								
Proj_performance		0.413*	-0.594**			-0.326*		
Firm_perform		0.390*	-0.407*			-0.385*		
Univ_feedback		0.390*	-0.407*					
Frequency	0.241		-0.328*		-0.281		0.269	-0.398*
N_disciplines					0.422*	0.299		
IPR_stipulations		0.406*	-0.228					0.316*
N_patents				0.329*	0.266			

Problems during project development								
Technical problems	0.496**	-0.309*	0.246	0.272			0.386*	-0.365*
Cultural differences			-0.428**		-0.235	-0.539**	-0.400*	
Channels of knowledge transfer used								
Mobility		0.557**		0.381*				
Techn_development				0.356*				-0.299
Meetings		0.477**	-0.475**		-0.302			
Employment			0.308*		0.375*			
Prototype			0.515**		0.247			
University advice			-0.357*					
N_channels		0.499**		0.412*				

Note: One-Tail significance ** 1%, * 5%, nothing 10%

Table 6. Ordered Logistic estimation of factors explaining the views of industrial researchers on collaboration with university. Stepwise Backward method

		Focus	Leakages	IPR	Matching	University_ importance
Individual characteristics	Npubl	-0.28**	-0.15			
		0.11	0.09			
	Npatent	0.17		0.37***	-0.11	
		0.12		0.11	0.12	
	Spin	0.65*				0.69*
		0.39				0.39
	Startup			0.35	1.04***	-0.58
				0.37	0.35	0.45
	Age	-0.89	1.43**	0.77	0.71	0.94
		0.71	0.67	0.68	0.65	0.75
Experience in Interacting with university through different channels	Collaboration	-0.33**	-0.25*		0.18	0.28*
		0.16	0.15		0.14	0.17
	Students		-0.12	0.45***		
			0.12	0.14		
	Formal	0.17	-0.21	0.49***	0.41***	-0.15
		0.17	0.14	0.16	0.16	0.17
	Academic	-0.42***		-0.18	-0.21*	0.31**
		0.14		0.13	0.13	0.14
	Alumni	-0.21	-0.16	-0.38***	0.20	-0.56***
		0.15	0.14	0.15	0.14	0.16
Knowledge Characteristics	Codified			-0.25	-0.28	
				0.20	0.19	
	Embodied	0.69***	0.34*			
		0.20	0.18			
	Breakthroughs expected	-0.35*			0.21	
		0.21			0.20	
	Interdependent	0.19	0.16	0.34**		-0.17
		0.17	0.17	0.18		0.18
Characteristics of research environment	Basic	-0.02*		0.01	0.01	0.01**
		0.01		0.01	0.01	0.01
	Applied		0.01		0.01*	
			0.00		0.01	
Disciplinary/ Technological Field	SOC		0.08*	-0.05	-0.05	
			0.05	0.05	0.05	
	BIO	-0.08**		0.07**		-0.08**
		0.04		0.03		0.04
	MAT	-0.1***	0.05	0.03	-0.09***	0.05
		0.04	0.04	0.04	0.03	0.04
	ENG		-0.06*	-0.07*		-0.04
			0.03	0.04		0.04
	/cut1	-4.53	7.36	3.63	1.67	3.51
		2.96	2.89	2.76	2.65	3.06
	/cut2	-2.28	9.17	5.96	3.71	3.75
		2.95	2.91	2.78	2.66	3.06
	Observations	270	270	270	270	270
	Wald chi2	114.81***	32.17***	83.89***	36.01***	40.39***
	df	14	12	14	13	12
	Log pseudo likelihood	0.21	0.06	0.15	0.07	0.10
	Pseudo R2	-214.14	-243.27	-232.98	-242.88	-184.41

Table 7. Ordered Logistic estimation of factors explaining the views of university researchers on collaboration with industry.

		Enter Method			Stepwise Backward Method		
		Ind_interest	Find_partners	Time_money	Ind_interest	Find_partners	Time_money
Individual characteristics	Npubl	-0.16	-0.04	0.00	-0.14		
		0.10	0.10	0.10	0.09		
	Npatent	0.00	0.23	0.04			
		0.19	0.24	0.21			
	Spin	-0.14	-0.46	-0.68			-0.59
		0.62	0.69	0.74			0.59
	Startup	0.36	-0.49	0.21		-0.40	
		0.49	0.45	0.52		0.46	
	Age	0.76	1.08**	0.75	0.74	0.98**	0.89*
		0.56	0.56	0.66	0.55	0.49	0.51
Experience in Interacting with university through different channels	Collaboration	0.03	0.21	-0.07		0.18	
		0.16	0.16	0.14		0.13	
	Students	-0.21	-0.03	-0.20	-0.23*		-0.20
		0.15	0.15	0.15	0.14		0.14
	Formal	0.04	0.07	-0.27**			-0.26**
		0.14	0.15	0.13			0.13
	Academic	-0.02	0.06	-0.08			
		0.17	0.18	0.16			
	Alumni	0.14	0.07	-0.14	0.14		-0.16
		0.13	0.14	0.15	0.12		0.12
University characteristics	Contract_fund	0.00	-0.01**	-0.01		-0.01**	-0.01*
		0.01	0.01	0.01		0.01	0.01
Knowledge Characteristics	Codified	0.12	-0.06	0.20			0.20
		0.22	0.25	0.24			0.21
	Embodied	0.24	0.37**	0.31*	0.20	0.34**	0.31*
		0.17	0.18	0.17	0.17	0.17	0.17
	Breakthroughs expected	-0.21	-0.33*	-0.25	-0.25	-0.31*	
		0.20	0.20	0.18	0.18	0.17	
	Interdependent	-0.13	-0.14	0.46***	-0.13	-0.13	0.45***
		0.18	0.15	0.16	0.15	0.14	0.15
Characteristics of research environment	Basic	0.01	0.01	0.01			0.01
		0.01	0.01	0.01			0.00
	Applied	0.01	-0.01	0.00		-0.02***	
		0.01	0.01	0.01		0.00	
Disciplinary/ Technological Field	SOC	-0.11**	0.02	0.05	-0.11**		0.06
		0.05	0.06	0.06	0.05		0.05
	BIO	0.03	0.01	0.03	0.04		-0.26
		0.04	0.04	0.03	0.03		0.18
	MAT	-0.02	0.00	0.04			0.04
		0.03	0.04	0.04			0.03
	ENG	0.1***	0.01	-0.03	0.09***		-0.04
		0.04	0.04	0.03	0.03		0.03
	/cut1	3.88	3.16	5.37	2.68	1.83	5.20
		2.29	2.41	2.47	1.83	1.76	2.09
	/cut2	5.84	4.91	7.10	4.62	3.56	6.93
		2.30	2.43	2.48	1.85	1.77	2.11
	Observations	271	272	272	272	272	272
	Wald chi2	24.68	37.26**	29.01	19.4**	36.94***	34.89***
	df	21	21	21	10	8	14
	Pseudo R2	0.04	0.07	0.07	0.04	0.07	0.06
	Log pseudo likelihood	-256.95	-252.96	-260.519	-258.437	-254.65	-261.24

ANNEX

Table A. Rotated Factor loadings: Perceived views on collaboration by university researchers

University Barriers to cooperate with industry	**Factor 1** **"Industry is not interested"**	**Factor 2** **"Difficult to find interesting industry partners"**	**Factor 3** **"Costly and time-consuming"**
Private businesses active in my discipline are making too little use of the knowledge available in universities	**0.80**	0.13	0.05
I see significant barriers stand in transferring my knowledge to the industry	**0.82**	0.06	0.16
The industry is not interested in the knowledge developed at the university	**0.68**	0.24	0.12
Universities are not willing to spend time and money in transferring their knowledge to industry	0.20	-0.07	**0.84**
Cooperation with the industry is hindered by cultural differences between academic and commercial researchers	0.41	0.35	0.20
Transferring knowledge to the industry is too costly for universities (either in terms of money of time)	0.13	0.27	**0.65**
Companies do not want to cooperate on R&D with universities; they just want to absorb our knowledge	0.20	**0.74**	0.04
Conducting contract research only results in more income for our research group. We do not learn anything from conducting such research	0.13	**0.68**	0.04
It is hard to find appropriate industrial partners for joint R&D projects	0.25	0.44	0.38
Joint R&D is hindered by conflicts between academic researcher who want to publish research and commercial researchers who want to patent research	0.15	**0.63**	0.13
I hardly have any incentive to cooperate with the industry since my rewards mostly depend on scientific publications	-0.06	0.49	0.42
% of Variance explained	19.4%	19.23%	14.18%
Eigen values	2.14	2.11	1.56

Note: Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization

Table B. Rotated Factor loadings: Perceived views on collaboration by industry researchers

Industry Barriers to cooperate with university	Factor 1 **"Research focus or culture too different"**	Factor 2 **"Information leakage and high management costs"**	Factor 3 **"Incompatible views on IPR ownership"**	Factor 4 **"Problems in matching the knowledge needs"**	Factor 5 **"Confirmation of the importance of university knowledge"**
The most important R&D activities of my research group over the last few years could not have been realized without knowledge generated in universities or PROs	-0.07	-0.05	-0.08	-0.02	**0.95**
The most important R&D activities of my research group over the last few years could not have been realized without the involvement of researchers working in universities or	-0.63	-0.15	0.01	0.22	-0.07
Private businesses active in my sector are making too little use of the knowledge available in universities or PROs	-0.17	-0.22	0.00	**0.66**	-0.20
Significant barriers stand in the way of our using knowledge developed in universities and PROs	0.15	0.03	0.23	**0.70**	0.19
Knowledge developed in universities and PROs is too theoretic to be useful in our particular case	**0.83**	0.09	0.01	0.06	-0.04
Knowledge developed in universities and PROs is too general to address our specific knowledge needs	**0.82**	0.14	0.19	0.00	-0.01
Relevant knowledge developed in universities and PROs is difficult to locate (e.g., finding the right publications or people)	**0.51**	0.29	-0.11	**0.43**	-0.15
Researchers working in universities or PROs do not fit in well with our corporate culture	**0.48**	**0.42**	-0.12	0.35	-0.13
Being involved in the application of knowledge developed in universities or PROs is too costly (either in terms of time or money)	**0.45**	0.39	-0.07	0.39	-0.05
Joint research projects with universities or PROs imply a significant risk that our firm's knowledge could leak to competitors	0.13	**0.89**	0.13	-0.04	0.02
The results of joint research projects with universities or PROs imply a significant risk of leaks to competitors	0.12	**0.87**	0.19	-0.05	-0.01
Joint research projects with universities or PROs are difficult to manage and/or involve high overhead costs	0.25	**0.59**	0.03	0.09	-0.06
Our business will insist that the results of joint research projects with universities or PROs are patented	-0.07	-0.01	**0.82**	0.05	-0.01
Our business will always claim ownership of patents resulting from joint research projects with universities or PROs (as opposed to leaving ownership to the university or PRO)	0.23	0.10	**0.79**	0.03	0.08
We would rather offer a university researcher a personal consultancy contract than enter into a contract with the university or PRO	-0.04	0.22	0.33	**0.48**	0.00
Having an exclusive licence on knowledge developed in a university or PRO is absolutely necessary for our business to use that knowledge in our R&D projects	-0.07	0.20	**0.62**	0.24	-0.23
% Variance explained	16.67%	15.62%	12.39%	10.83%	6.75%
Eigen values	2.67	2.5	1.98	1.73	1.08

Note: Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization

Table C: Varimax Factor loadings: channels of technology transfer between universities to firms

Channels of technology transfer between university to firms	**Factor 1** **“Collaborative research”**	**Factor 2** **“Flow of students and staff”**	**Factor 3** **“Patents, spin-offs and TTOs”**	**Factor 4** **“Publications & informal contacts”**	**Factor 5** **“Alumni”**
Scientific publications in (refereed) journals or books	0.192	0.071	0.021	**0.802**	-0.053
Other publications, including professional publications and reports	-0.012	0.072	0.139	**0.706**	0.175
Participation of university staff in conferences and workshops	0.387	0.197	-0.008	**0.633**	0.198
Personal (informal) contacts with university staff	0.426	0.295	-0.054	**0.518**	0.141
Personal contacts via membership of professional organizations	0.198	0.102	0.037	0.243	**0.814**
Personal contacts via alumni organizations	0.242	0.138	0.135	0.054	**0.82**
Students working as trainees	0.233	**0.713**	0.152	0.063	0.177
Inflow of university graduates as employees (BSc or MSc level)	0.221	**0.84**	0.112	0.114	0.1
Inflow of university graduates as employees (PhD level)	0.348	**0.771**	0.037	0.229	-0.016
Inflow of new employees from university positions	0.405	**0.45**	0.21	0.189	0.309
Staff holding positions in both a university and a business	**0.566**	0.334	0.108	0.087	0.149
Temporary staff exchange with universities	**0.673**	0.236	0.138	0.129	0.25
Joint R&D projects with universities in the context of EU Framework	**0.592**	0.293	0.081	0.244	0.147
Other joint R&D projects with universities	**0.652**	0.318	0.06	0.349	-0.063
Contract research by universities or public research labs (excl. Ph.D. projects)	**0.712**	0.124	0.183	0.164	0.141
Financing of Ph.D. projects	**0.708**	0.285	0.02	0.267	0.029
Consultancy by university staff members	**0.746**	0.136	0.15	0.195	0.136
Contract-based in-business education and training, delivered by universities	**0.681**	0.138	0.256	0.014	0.338
Patent texts, as found in the patent office or in patent databases	0.039	0.068	**0.893**	0.071	-0.029
Licenses of university-held patents and ‘know-how’ licenses	0.332	0.16	**0.795**	0.091	0.132
University spin-offs (as a source of knowledge)	**0.545**	0.131	**0.524**	0.013	0.207
Specific technology transfer activities organized by the university’s Technology Transfer Office	0.472	0.12	**0.534**	-0.032	**0.408**
Sharing facilities (e.g. laboratories, equipment, housing) with universities	**0.597**	0.175	0.308	0.004	0.176
% Variance explained	23.57%	11.99%	10.31%	10.15%	9.06%
Eigen values	9.36	2.02	1.32	1.08	1.08

Table D: Varimax Factor loadings: disciplinary origin of their research field

Disciplines	Factor 1 "Engineering"	Factor 2 "Biomedical sciences"	Factor 3 "Material sciences"	Factor 4 "Social sciences"
Biology	-0.283	**0.83**	0.122	0.087
Medical science	-0.182	**0.913**	-0.039	0.139
Medical engineering	0.149	**0.858**	0.023	0.076
Chemistry	-0.355	0.297	**0.77**	0.03
Chemical engineering	-0.121	0.146	**0.852**	0.143
Physics	**0.544**	-0.092	**0.604**	-0.126
Material science	0.305	-0.262	**0.726**	-0.044
Mathematics	**0.805**	-0.044	0.112	-0.049
Computer science	**0.679**	0.101	-0.158	0.226
Electrical engineering	**0.762**	-0.19	-0.144	0.142
Mechanical engineering	**0.561**	-0.309	0.295	0.178
Economics and business studies	0.142	-0.14	0.194	**0.764**
Psychology, cognitive studies	0.083	0.211	-0.073	**0.86**
(Other) social sciences	0.062	0.207	-0.031	**0.863**
% Variance explained	19.29%	19.26%	17.26%	16.04%
Eigen values	3.51	2.83	2.33	1.38

Table E. Correlation Coefficients of control and independent variables

	Npubl	Npatent	Spin	Startup	Age	Collabo ration	Students	Formal	Academic	Alumni	Codified	Embodied	Break through	Inter dependent	Basic	Applied	Technuni	Contract fund	SOC	BIO	MAT	ENG
Npubl	1																					
Npatent	-.105**	1																				
Spin	0.02	.159**	1																			
Startup	-0.049	.186**	0.045	1																		
Age	0.026	.375**	.204**	.157**	1																	
Collaboration	.270**	-.208**	0.031	0	-.194**	1																
Students	.130**	0.017	-0.022	-.146**	-0.056	0	1															
Formal	-.168**	.378**	.110**	.134**	.167**	0	0	1														
Academic	.285**	-0.001	-0.048	-0.033	-0.036	0	0	0	1													
Alumni	-.121**	-.148**	-0.012	0.023	-0.027	0	0	0	0	1												
Codified	.290**	-.193**	-.104**	-.075*	-.204**	.116**	.113**	-.099**	.301**	-0.056	1											
Embodied	-.245**	.200**	0.06	0.057	0.065	-0.058	-0.017	.140**	-.186**	-0.004	-.327**	1										
Breakthrough	.149**	.133**	.175**	.121**	.115**	.120**	0.061	.101**	.101**	-.087*	0.013	.102**	1									
Interdependent	-0.055	.107**	.116**	.082*	.091*	-0.009	0.068	.141**	-0.012	0.057	-.079*	.193**	.236**	1								
Basic	.358**	-.260**	-0.064	-0.059	-.201**	.122**	0.024	-.242**	.135**	-0.014	.291**	-.230**	-0.004	-.145**	1							
Applied	-.124**	.109**	0.05	-0.032	.082*	0.001	-0.025	.077*	0.023	-0.035	-.097**	0.067	-0.017	0.066	-.675**	1						
Technuni	.134**	-.345**	-.088*	-.084*	-.356**	.308**	.159**	-.158**	-0.037	-0.042	.142**	-.166**	-0.011	-0.061	.084*	0.027	1					
Contract_fund	-0.06	.175**	0.046	.169**	0.099	.219**	-0.035	0.104	-0.018	-0.044	-0.093	0.018	0.051	0.024	-.235**	.176**	.108*	1				
SOC	-.137**	.092*	.085*	.110**	.184**	-0.039	0.015	.078*	-0.012	.207**	-.132**	.144**	0.057	.151**	-.247**	.166**	-.202**	0.04	1			
BIO	.287**	0.053	.145**	0.059	0.04	.136**	-0.04	0.071	.261**	-0.042	.104**	-0.071	.214**	-0.044	.109**	-0.028	-.187**	0.007	.187**	1		
MAT	0.006	.103**	0.008	0.023	0.06	-0.016	-0.039	.208**	0.01	-0.032	0.038	.077*	.194**	.093*	0.062	-.114**	-.158**	-0.078	0.061	0.058	1	
ENG	-.134**	-0.034	0.013	0.02	0.068	0.033	.152**	0.073	-.096*	.079*	-.088*	.125**	0.069	.272**	-.200**	0.033	.275**	0.06	.213**	-.268**	.278**	1

Table F. Ordered Logistic estimation of factors explaining the recognition by industrial researchers of specific barriers to collaboration with university.

		Focus	Leakages	IPR	Matching	University_ importance
Individual characteristics	Npubl	-0.29**	-0.17	0.03	0.01	-0.09
		0.12	0.11	0.11	0.10	0.13
	Npatent	0.16	0.09	0.37***	-0.12	0.00
		0.13	0.12	0.12	0.13	0.13
	Spin	0.65	0.29	0.29	0.03	0.65
		0.41	0.40	0.36	0.42	0.41
	Startup	-0.16	0.08	0.36	0.99***	-0.65
		0.44	0.40	0.39	0.35	0.48
	Age	-0.88	1.31*	0.82	0.76	0.95
		0.78	0.71	0.67	0.69	0.76
Experience in Interacting with university through different channels	Collaboration	-0.35*	-0.22	0.01	0.16	0.3*
		0.19	0.17	0.15	0.15	0.16
	Students	0.00	-0.11	0.46***	-0.04	-0.02
		0.13	0.14	0.15	0.14	0.15
	Formal	0.17	-0.29*	0.48***	0.4***	-0.18
		0.17	0.18	0.17	0.15	0.18
	Academic	-0.45**	0.10	-0.14	-0.20	0.33**
		0.18	0.16	0.17	0.15	0.15
	Alumni	-0.19	-0.16	-0.38**	0.22	-0.58***
		0.16	0.14	0.17	0.14	0.16
Knowledge Characteristics	Codified	0.13	-0.03	-0.24	-0.24	0.12
		0.24	0.21	0.22	0.20	0.26
	Embodied	0.71***	0.35*	0.14	0.13	-0.01
		0.21	0.20	0.20	0.18	0.22
	Breakthroughs expected	-0.33	-0.10	-0.12	0.20	0.08
		0.23	0.20	0.24	0.22	0.23
	Interdependent	0.18	0.17	0.34*	0.01	-0.19
		0.18	0.17	0.20	0.18	0.20
Characteristics	Basic	-0.01	-0.01	0.00	0.01	0.01*

of research environment		0.01	0.01	0.01	0.01	0.01
	Applied	0.00	0.01	0.00	0.01	0.00
		0.01	0.01	0.01	0.01	0.01
Disciplinary/ Technological Field	SOC	-0.03	0.08*	-0.04	-0.04	0.02
		0.05	0.05	0.05	0.05	0.06
	BIO	-0.07*	0.00	0.07*	0.00	-0.08*
		0.04	0.04	0.04	0.04	0.04
	MAT	-0.1**	0.06	0.04	-0.08**	0.04
		0.04	0.04	0.04	0.03	0.04
	ENG	0.01	-0.06	-0.07**	-0.03	-0.04
		0.04	0.04	0.04	0.03	0.04
	/cut1	-4.01	6.53	3.77	1.89	3.78
		3.28	3.19	2.77	2.94	3.31
	/cut2	-1.76	8.35	6.11	3.93	4.02
		3.29	3.21	2.77	2.95	3.31
	Observations	270	270	270	270	270
	Wald chi2(20)	94.13***	35.06**	69.71***	38.92***	38.59***
	Log pseudo likelihood	0.21	0.07	0.16	0.07	0.10
	Pseudo R2	-213.78	-242.19	-232.24	-242.27	-183.85