

Published as: Bodas Freitas, I.M.; Geuna, A. and Rossi, Federica (2013) Finding the right partners: institutional and personal modes of governance of university–industry interactions. *Research Policy* 42 (1), pp. 50-62.

Finding the Right Partners: Institutional and personal modes of governance of university-industry interactions

Bodas Freitas Isabel Maria*
*DISPEA, Politecnico di Torino
& Grenoble Ecole de Management*

Aldo Geuna **
*Department of Economics S. Cagnetti De Martiis, University of Torino
BRICK, Collegio Carlo Alberto
& Grenoble Ecole de Management*

Federica Rossi***
School of Business, Economics and Informatics, Birkbeck, University of London

April 2012

Acknowledgments

This paper benefited greatly from comments from participants to the conference: “Technical Change: History, Economics and Policy. A Conference in Honour of Nick von Tunzelmann” held in Brighton in March, 2010. We want to thank Piedmont’s Chamber of Commerce for help with data collection; we thank Barbara Barazza for her support and comments. The UIPIE database used for this analysis was created with support from the project IAMAT coordinated by Fondazione Rosselli. Financial support from the European Commission (FP6) Project, NEST-2006-PATH-Cul, CID, Contract n.: FP6 - 043345 is gratefully acknowledged. Comments from two anonymous referees have greatly contributed to improving the paper.

*: DISPEA, Politecnico di Torino, Corso Duca degli Abruzzi, 24b, 10129 Torino, Italy email: isabel.bodasdearaujofreitas@polito.it

** : Department of Economics S. Cagnetti De Martiis, University of Torino, Via Po 53, 10124 Torino, Italy, Tel: +39 0116703891, Fax: 0039 011 6703895; email: aldo.geuna@unito.it

***: School of Business, Economics and Informatics, Birkbeck, University of London, Malet Street, London WC1E 7HX, UK; email: f.rossi@bbk.ac.uk

Abstract

We study two different governance modes of university-industry interactions: in the institutional mode, interactions are mediated by the university through its administrative structures (such as departments or dedicated units like technology transfer offices), while in the personal contractual mode interactions involve formal and binding contractual agreements between firms and individual academics, carried out without the direct involvement of the university. We argue that the choice of which form of governance to adopt involves different decision-making processes for firms and that both governance forms have important roles to play in the context of university-industry knowledge transfer. Relying on a representative sample of firms in the Italian region of Piedmont, we examine the characteristics and strategies of firms that interact with universities under different governance modes. Our results indicate that ignoring personal contractual arrangements with individual researchers, as does previous literature, amounts to overlooking at least 50% of university-industry interactions. The econometric estimations suggest that personal contractual interactions are used relatively more by small firms involved in technology and open innovation strategies, while institutional interactions are mostly used by large firms that vertically integrate R&D activities.

Keywords: University-industry interactions, academic consulting, open innovation, governance, technology transfer

JEL: O31; O32; L25

1. Introduction

In recent years, university-industry relationships have been extensively studied by academic researchers and have often been debated by policymakers. Empirical analyses emphasize the contribution of university-industry knowledge transfer to the promotion of higher productivity and greater economic growth, as well as the role of universities as key sources of innovation (Mansfield, 1991; Cohen et al., 2002; Mueller, 2006). Various features of university-industry interactions have been studied - focusing on the characteristics of individual researchers (previous experience, entrepreneurial capacity to win both public and private funding, seniority and tenure, gender, etc.), universities (size, disciplinary orientation, culture, academic quality, existence of formal knowledge transfer infrastructure, attention to local development, features of the local environment, etc.) and firms (size, ownership structure, technology/industry sector, research and development (R&D) intensity, openness to external knowledge sources, proximity to academic research, etc.). Focusing on different forms of interaction – whether they are formal or informal, collaborative or contractual, involving the enforcement of intellectual property rights (IPR) on research outcomes or not – the existing literature has stressed that several forms and mechanisms of interactions are often used at the same time (Cohen et al., 2002; D’Este and Patel, 2007), and that there are crucial inter-industry and inter-disciplinary differences in the intensity and typology of interactions used (Schartinger et al., 2001; Bekkers and Bodas Freitas, 2008).

However, most of these studies have constrained their analysis only to university-mediated interactions and, even when they focused on academic consulting activities carried out by individual researchers, they usually considered these activities to be mediated by the university (Perkmann et al., 2009; Jensen et al., 2010). Our study shows that the analysis of university-mediated interactions captures only a part of the complex

set of interactions going on between firms and universities. Firms can also collaborate with university researchers through contracts and agreements signed directly by individual university researchers, and the latter have not been yet properly studied.

Therefore, in our study, we focus on two forms of governance of university-industry interactions, which, we argue, currently co-exist and involve different decision-making processes for firms: (i) institutional governance, which refers to formal relationships and contracts with a university, usually mediated by administrative structures such as faculty departments or dedicated Knowledge Transfer Organizations (KTO), and (ii) personal contractual governance, which refers to direct contract-based arrangements with university researchers.

Recognizing the existence of two governance modes (institutional and personal contractual) is of uttermost importance for the correct development of policy interventions. For the last thirty or so years, policies in this area have built on the assumption that universities are not interacting sufficiently with firms and that, therefore, there is a need for governmental action to incentivise and facilitate the interaction. This policy paradigm was (and is) based on the assessment of institutional interactions only, as personal contractual mode of governance was (and still is) often ignored or neglected by university managers and policy-makers.¹ The lack of appreciation of the role played by personal contractual relationships may lead to the development of policies for the support of institutionalisation of knowledge transfer that could result in an overall reduction of knowledge transfer, as only a small group of firms have capabilities and resources to benefit from institutional forms of transfer. Institutional forms of interaction with university may not simply substitute for personal contractual relationships with individual university researchers. A better understanding of the two forms of governance

¹ One of the most striking examples of this policy myopia is the case of major changes in regulation for academic patenting in Europe. See, among others, Lissoni et al. 2008, Crespi et al., 2010.

and of the characteristics of firms that are involved in one or the other mode of interaction is needed in order to develop policies in support for institutional interactions only when the knowledge needs of firms are not met either by other actors in the knowledge market or by the direct interaction with university researchers.

With this aim in mind, our study intends to provide evidence on how firm characteristics may affect the choice between institutional and personal contractual modes of governance for the interaction with university researchers. We focus on a subset of firm characteristics (such as size, absorptive capacity and technology openness) that have often been investigated when explaining the presence and intensity of university-industry relationships, but that have not yet been used to explain the choice of governance structure.

The empirical investigation presented in this study relies on an original dataset of 1,058 representative firms localised in the North-Western Italian region of Piedmont (the sample was developed and validated by Piedmont's Chamber of Commerce). Our results suggest that, when compared to institutional interactions, personal contractual ones are used relatively more by small firms involved in open technology and innovation development strategies, thus providing an important alternative knowledge transfer channel for these firms.

The article is organized as follows. Section 2 frames the discussion in the general context of the literature on university-industry relationships, presents the two governance forms and a related discussion of how the characteristics and strategies of firms may influence their choice of governance for university-industry interactions. Section 3 describes the data used in order to test the determinants of this choice, and Section 4 describes the methodology used. Section 5 presents the results of the empirical analysis. Some concluding remarks and policy implications are discussed in Section 6.

2. The relationship between firm characteristics and choice of governance mode

This section introduces the two governance modes for university-industry interactions that we intend to investigate – institutional and personal contractual – and describes some of their key characteristics and relative advantages. On the basis of these arguments, some expectations on the relationships between firm characteristics and choice of governance mode are derived.

It has been pointed out that at least two different models of governance of university-industry interactions have developed over time and now are co-existing (Geuna and Muscio, 2009). On the one hand, university-industry knowledge transfer can be governed by personal contractual interactions between university researchers and firms, a form of governance that pre-dates the institutionalization of university-industry links and has been in place since the end of the 19th century, in Germany, and the early 20th century in the US (Meyer-Thurow, 1982; Liebenau, 1985; Swann, 1989; MacGarvie and Furman, 2005). This type of governance is often the result of the participation of university and industry researchers and engineers in the same social and professional networks (Colyvas et al., 2002), and is based on some degree of trust (sometimes due to a common educational background, as in the case of alumni associations in the US or the *Esprit du Corp* of the French Grandes Écoles and Italian Politecnici). These interactions are not informal: although the university structure is not involved, they are usually formalized through binding contracts and agreements.

On the other hand, since the late 1980s there has been an increase in institutional university-industry interactions, mediated by units such as departments, university technology transfer offices and other kinds of KTOs (Santoro and Gopalakrishnan, 2000). Universities are increasingly providing organizational support for such interactions. In a

small number of cases, the creation of an institutional infrastructure for the exchange of knowledge between universities and firms has resulted from the university's own drive to regulate and benefit from industry contracts and has sometimes been advocated by academics themselves. In most cases, however, this is a direct or indirect result of policy actions aimed at the promotion of structured knowledge transfer activities within universities (see Geuna and Muscio, 2009, for a discussion).

It is important to appreciate that the two models of governance can and do coexist - particularly in countries, such as Italy, where there has been less emphasis on public policies to support the institutional model. Most policy actions supporting the development of university-industry interactions in various European countries were premised on the argument that universities were not doing enough to develop activities relevant for economic development – a view based on an assessment of institutional activities of the university only.² These policies were mainly informed by the large body of literature dealing with third stream activities, such as the Triple Helix approach (Etzkowitz and Leydesdorff, 1996; Etzkowitz, 2001) to new role of the university (sometimes referred to as the second academic revolution), which argued for the support and further development of the institutional knowledge transfer model. The recognition of the coexistence of different governance structures implies that firms' engagement in interactions with university under one or the other governance modes involve different decision-making processes.

To our knowledge, the determinants of personal contractual interactions between industrial and academic researchers have not been yet properly studied. One important reason for this is that gathering data on this form of governance is very difficult as it lays in the grey area (not properly regulated) of outside activities that academic researchers

² See for example the discussion of how European countries have implemented Bayh-Dole act-like regulations for institutional ownership of academic patents partly on the basis of an incomplete evaluation of the patenting output of European universities (Geuna and Rossi, 2011).

are either allowed or tolerated to do. Many studies implicitly assume that personal interactions occurring without the mediation of the university institution are informal (not regulated by a contract) and hence that formal channels of knowledge transfer are all university-managed. This is evidenced by the fact that numerous important surveys used for the analysis of university-industry relationships do not explicitly include personal contractual governance as a channel for knowledge transfer, but refer to institutionally mediated research collaborations and contracts, on the one hand, and informal contacts, on the other³. While academic consulting activities are sometimes explicitly considered as a distinct channel of knowledge transfer between university and industry (Rebne, 1989; Meyer-Kramer and Schmoch, 1998; Cohen et al., 2002; Beath et al., 2003; Abreu et al., 2008; Perkmann and Walsh, 2008; Jensen et al., 2010), these activities are also mediated by the university institution, which channels consulting income through its accounts and often applies overheads (Beath et al., 2003; Perkmann, King and Pavelin, 2009).⁴ Instead, the personal contractual interactions we analyse in this study are formal (contract-based) agreements between individual academics and firms, different both from university-mediated consultancy activities and from informal personal relationships. While sometimes acknowledging the importance of personal contractual interactions (Boardman and Ponomariov, 2009), studies which investigate university-industry links from the perspective of individual researchers do not specifically focus on investigating the organizational determinants of this form of governance. Rather, when analysing the determinants of different types of interaction channels, personal contractual interactions

³ See, for example, the Carnegie Mellon survey (Cohen et al., 2002), the Policies, Appropriation and Competitiveness in Europe (PACE) survey (Arundel and Geuna, 2004), the Cambridge Centre for Business Research (CBR) Innovation Benchmarking Survey (Abreu et al., 2008)

⁴ These studies emphasize that academic consultancies occur frequently and comprise a wide range of activities linked to exploitation of existing knowledge, commercialization of research results and performance of original research (Perkmann and Walsh, 2008; Dechenaux et al., 2007). Most of the literature on academic consulting focuses on the problem of whether such activities are competing with or enriching academics' original research activities (Rebne, 1989), and on the problem of determining incentives to academic consulting (Jensen et al., 2010).

are considered together with consulting activities (Boardman and Ponomariov, 2009; Giuliani et al, 2010) and sometimes also with contract research (D’Este and Patel, 2007). Table 1 summarizes some key characteristics of the two modes of governance of university-industry interactions, which we termed institutional and personal contractual. We think of the dichotomy below as the description of two extremes, where in practice the characteristics of most interactions fall somewhere in between. On the one hand, institutional interactions include both “collaborative” research where both firm and university collaborate as partners in research (often with public funding, or in the context of a joint venture where both partners contribute financially) and “contract research” where the firm provides all or most of the financing. The characteristics of institutional interactions described below refer to the one extreme of “collaborative research” co-financed with public funds, but institutional interactions fall along a continuum where, at the other extreme, the features of “contract research” are often more similar to those of personal contractual interactions. Still, some personal contractual interactions can be more open ended and research-based (Perkmann and Walsh, 2008), and have characteristics that are more similar to those of institutional interactions.

Table 1. A summary of key characteristics of institutional and personal contractual interactions

Contractual personal collaborations	Institutional collaborations
Individual scientist is hired as external consultant to work on the firm’s project	Firm contracts with the university for the realization of a project.
Scientist works on the project as a self-employed external consultant	Scientist works on the project as a university employee
Firm decides scope and content of the project	Firm needs to organize scope and content of the project so that it is acceptable to university organization
Firm organizes and monitors project activities	Firm and university jointly organize and monitor project activities
Firm “fully” appropriates the results of the project	Firm negotiates with the university the results of the project that are going to be publicly diffused and those that the firm will “appropriate”

Source: authors’ elaboration

The characteristics of the two governance forms outlined in Table 1 suggest that the firm's choice of institutional and personal contractual governance modes of interaction with university researchers involve different decision-making processes. Personal contractual interaction involves contracting an expert to support a project organized and directed by the firm. This form of governance gives the firm greater control on the organization of the collaboration and on the appropriation of its results, while at the same time it requires putting greater effort into the coordination and monitoring of the collaboration. Institutional interaction instead involves entering into a contract that compels the company to share resources and information with one specific, socially distant organization, the university, to undertake a project. Because the university institution provides support in drawing up the contract and organizing the collaboration, as well as sometimes in seeking external funds to support the project, institutional governance may permit firms to reduce the costs associated with the interaction. Moreover, since the academic is working on the project in his or her capacity as an employee of the university, monitoring costs for the firm may be lower. However, complexities in the interaction with university bureaucracy and increasing assertive IPR appropriation strategies by university TTOs managers may discourage firms and raise the cost of the interaction. Lacetera (2009) argues that working on a project within the context of his or her university employment reassures the scientists that the work will be carried out according to the norms and standards accepted by the scientific community and that the project will not be terminated early should it not bear immediate results – and this in turn should increase the scientists' effort and commitment to the project. On the other hand, this form of governance may limit the degree of control that the firm has on the project's scope and contents.

Firms with different characteristics may be more or less likely to engage in each of these types of projects, and consequently to benefit from different governance forms. In order to systematically contribute to the existing literature, we focus on a subset of firm characteristics that have often been investigated when explaining the presence and intensity of university-industry relationships, but which have not previously been associated to the choice of different governance modes. In particular, we focus on how size, absorptive capacity and degree of technology openness of firms can be associated with their choice of governance for the interactions with university researchers.

First of all, we consider firms' size. Small firms often possess few spare resources (financial resources, personnel, managerial skills) needed to initiate and organize a contract with a cognitively and socially distant organization like a university, especially if funded by research sponsors, which may require specific forms of reporting and accounting. Therefore, we expect smaller firms to be more likely to rely on personal contracts, organized directly with an individual academic, rather than to seek institutional modes of governance for the interaction.

Secondly, we consider firms' absorptive capacity (Cohen and Levinthal, 1990). Firms which have a high degree of absorptive capacity (for example because they possess an internal R&D unit, or they employ a greater share of graduates) have been found to be more likely to benefit from more basic research projects, which are uncertain but enhance their research productivity and allow unexpected technological spillovers, which they will be better able to detect and eventually benefit from (Fontana et al., 2006; Laursen et al., 2011). Therefore, everything else being equal, firms with greater absorptive capacity are expected to be more likely to engage in collaborations focused on relatively more basic scientific knowledge. In turn, basic research projects are more likely to be carried out with the institutional involvement than by personal contractual agreements with

researchers because the university is involved as a partner (Hall et al., 2000; Panagopoulos, 2003). In fact, the institutional involvement of the university increases the scientists' commitment to the research (as they ensure greater alignment with the norms and values of the research community; Lacetera, 2009) thus helping to lower monitoring and coordination costs, which would be otherwise very high when research is complex and open ended. Moreover, basic research projects are more likely to be at least partly supported by public funds (Nelson, 1959) whose assignment generally requires institutionalized forms of collaboration.

Thirdly, we consider that firms also differ according to their technology and knowledge sourcing strategies, which to some extent are independent of structural firm characteristics and are influenced by managerial choice (Veugelers and Cassiman, 1999; Laursen and Salter, 2004; Cassiman and Veugelers, 2006). Firms may have different personality types, some are more open to the interaction with external knowledge sources while others are more inward looking (Malecki and Poehling, 1999). Firms which rely more on technology sourcing from external organizations (via collaborations, licensing of IP, etc.) are more likely to have developed searching and screening capabilities to identify knowledge providers, as well as technological and codification capabilities to define and specify "correctly" the content of knowledge/technology sourcing contracts. These acquired capabilities through technology and knowledge sourcing will permit firms to experience lower costs in the search for potential collaboration partners as well as lower coordination costs when organizing their collaborations. Hence, we expect them to be less likely to need institutional support when interacting with academic partners, and therefore to be more likely to engage in personal contractual collaborations.

Finally, some firm characteristics related to openness to international competition and involvement in international networks of production and ownership relationships may

influence firms' decision to collaborate with external knowledge providers. Firms involved in international competition may have greater incentives to innovate and to develop local and international linkages and collaborations that allow the internal integration of different knowledge sources (Powell et al., 1996). Similarly, firms that outsource more of their production and development processes may be more likely to experience greater organizational challenges in integrating learning and production activities developed in other locations (Wang and von Tunzelmann, 2000; Brusoni et al., 2001). Outsourcing also implies the development of relational (network) skills that can be used in other forms of cooperation. Given the potential greater incentives for collaboration experienced by firms facing international competition and involved in international networks of production and ownership, we control for these firms characteristics when examining the role of organizational structure, absorptive capacity and technology openness on their choice of the governance mode for university interaction. We also control for the technological focus of the firm as we expect this to bias the impact of size on the choice of governance structure, such as in the case of small high-tech companies that are well connected to scientific-technological networks.

We test the predictions of our framework by examining the characteristics and strategies of firms involved in the two governance modes of interactions with universities/university researchers of the same region, the rest of Italy, and other countries.

3. University-industry interactions in Piedmont: the UIPIE survey

We use data from an original survey (UIPIE) sent to a representative sample of manufacturing firms with more than 10 employees in the Piedmont region, located in the

North-West of Italy.⁵ With a total population of about 4.4 million, Piedmont produces about 8.5% of Italian GDP. The 450,000 or so companies active in the region in 2006 were focused relatively more on manufacturing. Thus, employment in manufacturing is quite high (33% vs 63% in services) when compared with other Italian and European regions. While Italy generally suffers from structural weaknesses in R&D investment (R&D expenditure in 2006 as a percentage of GDP was 1.1% vs an average of 1.9% in EU-25), Piedmont is better positioned with the third highest value of R&D expenditure among the Italian regions in both absolute and relative terms (public expenditure on R&D as a percentage of regional GDP was around 1.8% in 2006). In particular, Piedmont is characterized by a high share of private R&D in total R&D investment: 80% (€1.4 bn) against an Italian average of only 47%. This is mostly due to some large firms which invest heavily in R&D, particularly FIAT (with its CRF research centre) and Telecom Italia (and its TiLab research centre). The third Community Innovation Survey (CIS3) indicates that about 33% of Piedmontese companies are innovative, a few percentage points higher than the Italian average.

The UIPIE sample was developed and validated by Piedmont's Chamber of Commerce, which integrated our questionnaire with its quarterly regional economic foresight survey. Though the completion of the survey was not compulsory, the expected non-response was very low due to respondents' loyalty and the compact structure of the questionnaire. The questionnaire was circulated in October/November 2008, from the representative sample of 1,058 firms, we obtained 1,052 valid responses (i.e. a response rate of 99.4%).

⁵ This is the official representative sample developed and validated by the regional Chamber of Commerce. It is a stratified sample on 10 industrial sectors and 3 dimensional classes based on the ISTAT census of 2001. The UIPIE questionnaire was sent together with the quarterly manufacturing survey of the Chamber of Commerce. The questionnaire was managed and validated by the Chamber of Commerce with statistical treatment for the outliers.

The Chamber of Commerce asked us to limit the number of questions, which constrained the amount of firm-specific data and information on firms' relationships with universities that we were able to collect. Also, the Chamber of Commerce were more interested in investigating institutional interactions. Therefore we collected relatively more information on this form of governance. Nevertheless, they gave us access to a rich dataset on firm characteristics such as firm size, industry, internal structure, R&D activities, investment activities, exports and export performance, which allowed us to build numerous independent and control variables (see section 4 on methodology).

Firms were asked whether they had engaged in institutional interactions (through contracts and agreements signed by university organizations) in the previous three years, and if so, which universities they collaborated with (universities in Piedmont, in the surrounding regions, elsewhere in Italy, in Europe or outside Europe). For each university collaboration, respondents were asked about the objectives of the collaboration (from the options: technological development, testing and analysis, organization and management, marketing, logistics, and legal issues), the amount of money spent, and whether the collaboration was satisfactory (based on four levels of satisfaction). Those firms that did not indicate any institutional interactions were asked to specify their reasons for not collaborating. One of the reasons given was the existence of contractual personal interactions with a university researcher.

About 17.5% of firms are involved in some form of interaction with university researchers (institutional or contractual personal). 104 firms (9.9%) responded that they had engaged in institutional interactions with universities in the previous three years. We do not have information on whether the firms that engaged in institutional interactions were also involved in personal contractual ones. We can identify 83 respondents (7.9%) that had only contractual personal interactions with university researchers (i.e. they stated

that they did not interact institutionally with any university because they had contracts with individual researchers). Hence, the governance of university-industry linkages based on personal contractual agreements plays an important role in the regional innovation processes. Finally, 865 firms responded that they were not involved in any kind of interaction with universities.

Table 2 shows the distribution of firm characteristics across different subgroups of respondents: the entire sample, the set of firms with institutional interactions with universities (which may have or not been engaged simultaneously in personal contractual interactions with the universities), the set of firms with only personal contractual interactions with university researchers, and those firms that do not interact at all. There are some important differences in the characteristics of firms choosing different modes of governance. In the total sample, the firms that engage in interactions mediated by the university institution are large (in terms of size and turnover), more likely to invest in internal R&D and design, and are significantly over-represented in the province of Torino and in the Chemicals, Rubber and Plastics industry, and under-represented in the province of Novara and in the Textiles industry. Firms that engage only in interactions governed through a contract with an individual academic researcher are over-represented in the Production of Electrical, Electronic and Communication Equipment industry, under-represented in the province of Novara, and also more likely to engage in internal R&D, although less than those that had institutional interactions.

Table 2. Distribution of firm characteristics across different subgroups of respondents

	Sample	No interaction	Institutional interaction	Personal interaction	
	N = 1052 % of sample	n = 865 % of respondents	n = 104 % of respondents	n = 83 % of respondents	
Sector	Food, Beverages and Tobacco	10.1	9.5	15.4	9.6
	Textiles, Apparel and Shoes	15.3	16.5 **	5.8 **	14.5
	Wood and Furniture	5.8	6.4	1.9	4.8
	Paper, Printing and Publishing	5.9	6.4	4.8	2.4
	Chemicals, Rubber and Plastics	9.9	9 *	17.3 *	9.6
	Production of Metals and Metal Goods	17.8	18.6	12.5	15.7
	Machinery	14.6	14.1	19.2	14.5
	Production of Electrical, Electronic and Communication Equipment	6.7	6.1	6.7	12 *
	Production of Transportation Equipment	4.3	3.9	6.7	4.8
	Other Manufacturing companies	9.7	9.5	9.6	12
	Total	100	100	100	100
Province	Alessandria	12.5	12.1	16.3	12
	Asti	8.1	7.7	12.5	6
	Biella	10.3	10.6	5.8	12
	Cuneo	14.1	14	14.4	14.5
	Novara	14	15.7 ***	4.8 ***	7.2 *
	Torino	26.7	24.7 **	39.4 **	31.3
	Verbania-Cusio-Ossola	7	7.4	3.8	7.2
	Vercelli	7.3	7.6	2.9	9.6
Total	100	100	100	100	
Size	10-49 employees	70.6	74.7 ***	36.5 ***	71.1
	50-249 employees	23.6	21.4 ***	40.4 ***	25.3
	more than 250 employees	5.8	3.9 ***	23.1 ***	3.6
	Total	100	100	100	100
Turnover	less than 2m	30.6	34.2 ***	0 ***	31.3
	2-5m	22.9	25.7 ***	1.9 ***	20.5
	5-10m	16.6	16.2	16.3	21.7
	10-20m	12	9.9 ***	30.8 ***	9.6
	20-50m	9.6	5.8 ***	41.3 ***	9.6
	over 50m	8.3	8.2	9.6	7.2
	Total	100	100	100	100
R&D or design investment	Yes	35	31 ***	58 ***	41 **
	No	65	69 ***	42 ***	59 **
	Total	100	100	100	100

Note: *** Significance at 1% (2-tailed), ** Significance at 5% (2-tailed); * Significance 10% (2-tailed)

Firms that do not engage in either form of interaction are significantly over-represented in the small firms category and under-represented in the large firms category, and less

likely to engage in internal R&D – in line with the findings in the empirical literature (Mohnen and Hoareau, 2003; Arundel and Geuna, 2004; Laursen and Salter, 2004; Fontana et al., 2006). They are also more likely to belong to the Textiles industry.

4. Methodology

4.1. Dependent variables

As argued in section 2, interacting institutionally or through a personal contract with a university researcher involve different types of decisions: institutional interaction implies contracting and sharing resources and information with one specific, socially distant organization, the university, while personal contractual interaction implies contracting an expert to support a project that is organized and directed by the firm. Our survey does not provide us with information about potential overlap between these governance forms. Given the characteristics of our data, we have information on the following firms' choices: (1) to interact institutionally with a university; (2) to engage only in contractual personal interactions with university researchers; or (3) not to engage in academic interactions at all (and instead rely on internal production of knowledge or on collaboration with other actors). In addition, we have more information about institutional interactions (such as reasons for not collaborating institutionally).

Our dependent variable, the categorical variable *Governance*, includes information on three independent and exclusive governance decisions. *Governance* takes the values 0 if the firm did not interact at all, 1 if the firm maintained only personal interactions with individual researchers, and 2 if the firm had institutional interactions with universities.

4.2. Independent and control variables

In our regression analysis, we test whether the expectations on the relationships between firm characteristics and choice of governance form for university-industry interactions, which were outlined in Section 2, are supported by the empirical data. In particular, we explore the impact of firms' size, absorptive capacity (proxied by investment in internal R&D and design activities), and technology openness (proxied by investment in the acquisition of external embodied and disembodied knowledge). We control for the presence of production units abroad, export intensity, level of outsourcing and industry activity. Industry dummies are included too.

The variables *Size* and *Square Size* report the logarithm of number of employees and its square, and they are the proxies for the organizational size of firms.⁶ We expect size to be positively related to involvement in institutional interactions.

The variable *Absorptive Capacity* provides information about whether firms invest in internal R&D or design activities. Investment in internal R&D and design efforts proxies the firm's research and innovative competences and, consequently, the ability to learn from research collaborations with a university – absorptive capacity (e.g. Laursen and Salter, 2004). Everything else being equal, we expect firms with greater absorptive capacity to be more likely to engage in institutional interactions.

The variable *Technology Openness* captures information on whether the firm invests in the acquisition of external embodied and disembodied knowledge, in particular patents, know-how and informational and processing software and hardware. Technology openness is often understood as degree of technology sourcing and engagement in technology market transactions (Arora et al., 2001; Cassiman and Veugelers, 2006). All

⁶ In our results, the variable *Square Size* is always non-significant. Results without the variable *Square Size* proved similar to those included in this article. They are available from the authors.

else being equal, we expect this variable to be positively related to engagement in personal contractual interactions.

We also control for the presence of production units abroad, export intensity, and level of outsourcing. To measure the degree of exposure to international competition we use the export intensity of firms, and whether the firm has multinational activities. The variable *Export* provides information on whether the firm exports more than 20% of production. The variable *Multinational* contains information on whether the firm owns production activities abroad that represent more than 5% of total output. The variable *Outsourcing* provides information on the level of production outsourced (logarithm of production outsourced to other firms in Italy or abroad). Finally, we control for industry effects by including industry dummies (other manufacturing is the reference category).

Table 3 lists the independent and control variables and their descriptive statistics. As Table 3 reports, some of the variables have a few missing observations, which affects mainly firms that did not collaborate at all with universities (i.e. the largest group analysed). We use 908 observations, which represent 86% of the surveyed sample. Table A in Appendix 1 presents the correlation coefficients for the entire sample of firms.

Table 3. Descriptive statistics for independent variables used in the regressions

Variables	Variable name	Description	N	Min	Max	Mean	Std. Devi
Size	Size	Logarithm of the number of employees	1,058	0	9.47	3.42	1.20
	Square Size	Square of the logarithm of number of employees	1,058	0	89.60	13.17	9.62
Absorptive Capacity	Absorptive Capacity	1 if the firm commits efforts to internal R&D or design activities, 0 otherwise	950	0	1	0.35	0.48
Technology Openness	Technology Openness	1 if the firm invested in either acquisition of patents, external know-how or informational and data process equipment and software, 0 otherwise	915	0	1	0.37	0.48
Export	Export	1 if the firm exports more than 20% of their production, 0 otherwise	1,058	0	1	0.42	0.49
Multinational	Multinational	1 if the firm produces 5% or more of their product in plants outside the country	1,058	0	1	0.19	0.39
Production Outsourcing	Outsourcing	Logarithm of the share of production outsourced in Italy or abroad to subcontractors	1,058	0	1	0.10	0.29
Industry	Food	Food, Beverages and Tobacco	1,057	0	1	0.10	0.30
	Textiles	Textiles, Apparel and Shoes	1,057	0	1	0.15	0.36
	Wood	Wood and Furniture	1,057	0	1	0.06	0.23
	Paper	Paper, Printing and Publishing	1,057	0	1	0.06	0.24
	Chemical	Chemicals, Rubber and Plastics	1,057	0	1	0.10	0.30
	Metals	Production of Metals and Metal Goods (excluding Jewellery)	1,057	0	1	0.18	0.38
	Equipment	Machinery	1,057	0	1	0.15	0.36
	Electronic	Production of Electrical, Electronic and Communication Equipment	1,057	0	1	0.07	0.25
	Transport	Production of Transportation Equipment	1,057	0	1	0.04	0.21
	Other	Other Manufacturing companies	1,057	0	1	0.10	0.30

4.3. Econometric modelling

To examine the firm's choice of governance form for university-industry interactions, we use the multinomial logit estimation model, which assumes independence of the different

decisions of firms concerning the governance of interactions with university. Our dependent variable *Governance* includes three distinct and independent governance decisions (i.e. no interaction at all, personal contractual interactions only, and institutional interactions).⁷ As we mentioned earlier, our data does not permit to differentiate between firms that chose both institutional interactions with university and personal interactions with individual researchers. To check for robustness of our results, we make use of additional available information on institutional interactions (such as reasons for not collaborating institutionally), and we model the different governance decisions independently using a set of binary logit models.

5. The choice of the governance form for university-industry interaction

5.1. Model estimation

Using a multinomial logit model, we estimate the factors that lead firms to decide on the governance of interactions with university. Results are reported in Table 4.

Compared to firms that decided not to interact at all with universities, firms that interacted with universities only via personal contractual arrangements are more likely to rely on the acquisition of external embodied or disembodied knowledge and know-how (*Technology Openness*), and to a lesser extent to be more present in international markets (Table 4; column 1). The model controls for differences across industries, but they are not significant.

Compared to firms that did not interact at all with universities, firms that interacted institutionally with university are more like to be large and to invest highly in innovation

⁷ An alternative modelling strategy could be the nested logit model that is used to account for similarities between pairs of alternatives which are similar in unobserved factors (Brownstone and Small, 1989; Heiss, 2002; Hensher and Greene, 2002). Given that personal and institutional contracts involve different types of decisions, as well as the limitations of the data available, we cannot create a meaningful hierarchical structure of nests of alternatives. Consequently we cannot model the decision of firms to collaborate and the choice of governance mode for the collaboration as a nested logit.

through R&D and design (*Absorptive capacity*) (Table 4; column 1). We find some industry differences: firms active in the Food industry are more likely to develop institutional interactions, while firms active in Textiles are less likely to do so.

Table 4. Multinomial logit model estimation of institutional interactions, personal contractual interactions and non-interaction with universities

	Personal contractual versus no interaction	Institutional versus no interaction	Institutional versus personal
Absorptive Capacity	0.32	0.87***	0.54
	(0.26)	(0.25)	(0.349)
Technology Openness	0.68**	-0.12	-0.8***
	(0.28)	(0.26)	(0.36)
Size	0.19	1.45***	1.26*
	(0.60)	(0.53)	(0.76)
Square Size	-0.04	-0.09	-0.06
	(0.07)	(0.06)	(0.09)
Multinational	-0.17	-0.27	-0.10
	(0.41)	(0.44)	(0.57)
Export	0.51*	0.40	-0.11
	(0.29)	(0.29)	(0.39)
Outsourcing	0.00	0.00	0.00
	(0.01)	(0.01)	(0.029)
Intercept	-3.1***	-6.52***	-3.42**
	(1.15)	(1.13)	(1.52)
Industry dummies			
Food	0.22	0.89**	0.67
	0.51	0.42	0.61
Textiles	-0.10	-1.63***	-1.54**
	0.45	0.57	0.69
Wood	-0.31	-1.66	-1.35
	0.68	1.04	1.22
Chemicals & Plastics	-0.06	0.29	0.36
	0.51	0.44	0.63
Metals	-0.18	-0.41	-0.22
	0.45	0.44	0.60
Machinery	-0.20	-0.37	-0.18
	0.45	0.43	0.58
Electrical equip	0.31	-0.25	-0.56
	0.52	0.56	0.72
Transport equip	0.00	-0.09	-0.09
	0.70	0.52	0.81
Observations	908		
Wald chi2	125.18***		
df	30		
Pseudo R2	0.12		
Log pseudolikelihood	-480.48		

Note 1: *** Significance at 1% (2-tailed), ** Significance at 5% (2-tailed); * Significance 10% (2-tailed)

Note 2: Robust standard errors in parentheses

Finally, compared to firms that interacted with universities only via personal contractual arrangements, firms that interacted institutionally with university tend to be larger, and less likely to rely on the acquisition of external embodied or disembodied knowledge and know-how (*Technology Openness*). Firms active in Textiles are less likely to engage in institutional interactions with industry.

Overall, these results suggest that firms interacting with universities via personal contractual arrangements only, tend to be smaller than firms that interact institutionally, and also rely upon the sourcing of external knowledge via other complementary investments, such as patents or know how, more than firms that do not interact at all or that interact institutionally. Firms with high innovative and research competences – high absorptive capacity – are more likely to interact institutionally with universities. Small technology-closed firms, instead, appear not to engage in any type of interaction with universities.

5.2. Robustness test

To check robustness of our results, we model the different governance decisions independently, exploiting some additional information on institutional interactions.

First, we examine why firms decided not to develop institutional interactions with a university. In particular, we explore the differences between firms that did not interact institutionally but had personal contractual arrangements with university researchers, and firms that did not interact at all with universities.

Second, we examine the characteristics of firms that interacted institutionally (which may have also engaged in personal contractual collaborations, but we cannot be certain about this) in order to understand how they differ from firms that did not interact institutionally

(either because they did not interact at all, or because they only interacted with university researchers through personal contracts).

5.2.1. Reasons for not interacting at all with universities

The survey asked respondents to identify their reasons for not having engaged in institutional interactions with universities in the previous three years, choosing among seven options (firms could choose more than one option). The distribution of respondents' answers is presented in Table 5. Slightly more than 50% of firms identified a single reason for not interacting; about 17% indicated two reasons; 6.4% indicated three or more reasons; about 10% did not answer the question. Most firms did not interact because they did not feel the need to do so, or because they had in-house competences. The third most frequently cited reason was lack of resources.

Table 5. Reasons for not interacting with universities: distribution of answers

	No. of Cases	% of Cases
The firm has no need for interactions	568	53.7%
The firm already has the advanced internal competences it needs	168	15.9%
The firm acquires the necessary knowledge from other partner firms	88	8.3%
The firm interacts with external non-university research centres	76	7.2%
The firm may be interested in interacting with universities, but it lacks the resources for this kind of investment	124	11.7%
The firm only engages in interactions with individual researchers (payment is made directly to the researcher or to his/her own firm)	83	7.8%
The firm finds it difficult to contact universities	55	5.2%
Other reasons (specify)	14	1.5%

Note: 927 observations

The seven main reasons that firms provided to explain their lack of institutional interactions with universities in the previous three years are strongly correlated. To create a lower number of uncorrelated variables, we extract the principal components of these

data. Table 6 reports the principal components extracted, and the variables created with this information.

Table 6. Rotated load factors for reasons for not engaging in institutional interactions with universities in the previous 3 years

	Principal components		Independent variables used		
	1	2	No Need	Alternative sources	Difficult and Costly
The firm has no need for interactions	-0.45	-0.51	+		
The firm already has the advanced internal competences it needs	-0.05	0.63		+	
The firm acquires the necessary knowledge from other partner firms	0.04	0.58		+	
The firm interacts with external non-university research centres	0.03	0.62		+	
The firm may be interested in interacting with universities. but it lacks the resources for this kind of investment	0.76	-0.06			+
The firm only engages in interactions with individual researchers (payment is made directly to the researcher or to his/her own firm)	0.39	0.27			
The firm finds it difficult to contact universities	0.74	-0.07			+
Share of Variance explained	24.5%	17.3%			
Eigen value	1.7	1.2			
Min			0	0	0
Max			1	2	3
Average			0.613	0.192	0.358
Std. Deviation			0.487	0.470	0.626

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

Results in Table 6 show that two factors explain 41.9% of total variance. The first (Factor 1) is that interaction with university is difficult and costly, in financial terms and in terms of the time required to establish an institutional contact with a university. The second (Factor 2) is the recognition that there are other sources and ways to develop relevant know-how than through interacting with a university. The firm can develop know-how

internally or in collaboration with industry partners or research centres that are not universities. In both cases, the reason that ‘The firm has no need for interaction’ is negatively loaded, which might itself be a reason. In both cases, the reason that ‘The firm only engages in interactions with individual researchers (payment is made directly to the researcher or to his/her own firm)’ is loaded with very low scores. This would suggest that firms that do not engage in formal interactions with a university because they collaborate with individual researchers fall into a specific group not highly correlated with any of the other reasons for non-institutional interaction.

To better understand the differences between the 865 firms that did not undertake any form of interaction with universities and the 83 firms that engaged only in contractual personal interactions with university researchers, we run a binary logit model. The dependent variable is the dichotomous variable *No institutional collaboration but engagement in contractual personal collaborations* with university researchers. This variable takes the value 0 if the firm does not interact with a university (either institutionally or through a personal contract), and 1 if the firm does not interact institutionally with a university, but engages in contractual personal interactions with individual researchers. We estimate the basic model including all the independent and control variables presented in section 4, and three variables capturing the reasons for lack of interaction, based on the factor analysis (see Table 6). One categorical variable captures information on whether the firm considers interaction with university a difficult and costly investment (*Difficult and Costly*), another one captures information on whether the firm has other sources and ways to develop relevant know-how (*Alternatives sources*); these variables were both created from the sum of the variables that scored high in the two factors referred to above. We also include a dichotomous variable to capture

information on whether the firm indicated that it did not feel the need to interact (*No need*).

Table 7. Logit model estimation of probability of firms that do not interact institutionally to engage in personal contractual interactions with individual academics

	Personal contractual interaction versus no interaction
Absorptive Capacity	-0.0249 (0.425)
Technology Openness	0.476 (0.435)
Size	-1.153* (0.695)
Square Size	0.109 (0.0852)
Multinational	-0.0387 (0.611)
Export	0.0125 (0.560)
Outsourcing	0.0198 (0.0129)
Difficult and Costly	1.084*** (0.359)
Alternative Sources	1.531*** (0.283)
No need	0.416 (0.440)
Intercept	-2.104 (1.286)
Industry dummies	
Food	-0.206 (0.845)
Textiles	-0.684 (0.678)
Wood	0.487 (0.972)
Chemicals & Plastics	-0.491 (0.738)
Metals	-0.598 (0.728)
Machinery	-0.387 (0.761)
Electrical equip	-1.055 (0.816)
Transport equip	0.092 (0.840)
Observations	759
Wald chi2	64.28***
Df	18
Pseudo R2	0.21
Log pseudolikelihood	-109.8

Note 1: *** Significance at 1% (2-tailed), ** Significance at 5% (2-tailed); * Significance 10% (2-tailed),
Note 2: Robust standard errors in parentheses

Table 7 reports the results of the logit estimation of the probability that the firm that did not interact institutionally but engaged only in contractual personal interactions with university researchers, compared to firms that did not interact at all with the university/university researchers in the last three years. Smaller firms are more likely to engage in contractual personal interactions. Firms that engage in contractual personal interactions are more likely to use other sources and ways to develop relevant know-how, and to find interaction with university a difficult and costly investment, than firms that do not interact at all.

5.2.2. Institutional interactions vs. either personal contractual interactions or no interactions at all

We examine the factors that have led firms to interact institutionally during the previous three years. In particular, we estimate two logit models on the variable *Institutional collaboration*. First, we explore the characteristics of firms that interacted institutionally in relation to the full sample of firms, and subsequently we exclude from the analysis firms that did not interact at all with universities. Hence, first, *Institutional collaboration* takes the value 1 if the firm engages in institutional interaction with a university, and zero otherwise. Subsequently, *Institutional collaboration* takes the value 1 if the firm engages in institutional interaction with a university, and zero if the firm has only contractual personal interactions. Results are presented in Table 8.

The first column of Table 8 presents the results for the full sample. Consistent with the results of previous literature larger firms and firms that invest internally in innovation through R&D or design (*Absorptive Capacity*) are more likely to interact with universities.

Table 8. Logit model estimation of institutional collaboration with universities

	Institutional versus non-institutional collaboration	Institutional versus personal- contractual
Absorptive Capacity	0.832*** (0.252)	0.679* (0.409)
Technology Openness	-0.192 (0.258)	-0.962** (0.433)
Size	1.434*** (0.524)	1.246 (0.776)
Square Size	-0.087 (0.057)	-0.0525 (0.089)
Multinational	-0.252 (0.437)	-0.360 (0.660)
Export	0.350 (0.285)	0.0584 (0.421)
Outsourcing	0.002 (0.0139)	0.019 (0.0206)
Intercept	-6.546*** (1.129)	-3.556** (1.666)
Industry dummies		
Food	0.861** (0.420)	0.733 (0.672)
Textiles	-1.625*** (0.571)	-1.797** (0.872)
Wood	-1.637 (1.038)	-1.355 (1.004)
Chemicals & Plastics	0.298 (0.437)	0.494 (0.717)
Metals	-0.390 (0.439)	-0.301 (0.627)
Machinery	-0.290 (0.559)	-0.783 (0.785)
Electrical equip	-0.354 (0.423)	0.062 (0.632)
Transport equip	-0.0881 (0.514)	-0.309 (0.884)
Observations	908	166
Wald chi2	108.66***	38.56***
df	15	15
Pseudo R2	0.19	0.19
Log pseudolikelihood	-245.8	-91.88

Note 1: *** Significance at 1% (2-tailed), ** Significance at 5% (2-tailed); * Significance 10% (2-tailed)

Note 2: Robust standard errors in parentheses

The second column in Table 8 presents results for the subsample of firms that interacted with university, either only through personal arrangements with university researchers or through institutional arrangements with the university. Results suggest that larger firms

that invest internally in innovation through R&D or design (*Absorptive Capacity*), but do not invest in the acquisition of external embodied or disembodied knowledge and know-how (*Technology Openness*) are more likely to interact institutionally rather than through personal contracts.

Overall, the results of the binary logit models presented in Table 7 and 8 are consistent with those presented in section 5, confirming the independence of the three decisions.⁸

6. Discussion and Conclusions

This study has explored the choice of institutional and personal contractual modes of governance of firms' interaction with universities, which we argued involve different decision-making processes. In particular, we examined how the choice of governance mode is related to characteristics and strategies of firms. To address this issue empirically, we used data from an original survey, UIPIE, targeting a representative sample of manufacturing firms with more than 10 employees that Piedmont's Chamber of Commerce selects and maintains for its regular quarterly regional economic foresight survey.

While much of the existing literature on university-industry knowledge transfer focuses on collaborations mediated by the university, even when focusing on academic consultancy (see, e.g. Bercovitz and Feldman, 2006), we show that interactions and knowledge transfer also frequently happen through direct contractual personal arrangements between firms and individual academics. Our data show that the majority of firms in the region (82.2%) did not collaborate with universities, 9.9% relied on institutional collaborations with university, and 7.9% engaged only in personal contractual interactions with specific university researchers. As firms that have

⁸ As an additional robustness check we ran a Heckman probit analysis to account for the selection mechanism in the firm's decision-making process: the model was statistically rejected.

institutional interactions may also have personal contractual ones, the latter form of governance is likely to be as frequent as the former. Ignoring personal contractual arrangements with individual researchers, as does previous literature, amounts to overlooking at least 50% of university-industry interactions. So far, research in the field of university-industry cooperation has focused only on one half of the picture, neglecting the other half and thus biasing the assessment of the importance of university-industry interactions and probably also providing a partial if not misleading analysis of their efficiency. Clearly, this conclusion is only robust in the case of the Piedmont region and we do not know how generalizable it is.⁹ However, the technological and industrial characteristics of Piedmont, discussed in Section 3, would position the region among those in the first half of the distribution making the case relevant for a large number of technologically and industrially advanced regions. Moreover, anecdotal evidence in a few European countries point to the existence of contractual personal relationships. Thus, we would expect the phenomenon to be relevant across Europe.

This study provides evidence that the two modes of governance are chosen by firms with different characteristics, in terms of size and propensity to adopt open approaches to technology and innovation development. When compared with firms that do not interact at all and with firms that interact institutionally, firms that only engage in personal contractual interactions are more likely to be small and to engage in open technology and innovation strategies. Firms that interact institutionally with universities are more likely to be large and to have greater absorptive capacity than firms which do not interact at all. Overall our evidence is consistent with previous research that has shown that firms are more likely to interact with universities when they are larger, they have greater absorptive capacity (e.g. they are more research-intensive and have greater innovative

⁹ We are currently carrying out a new survey in three other European regions (in The Netherlands, Spain and The UK) and Piedmont to assess the importance of personal contractual relationships outside Italy.

capabilities) and they adopt open information and knowledge searching and scanning strategies (Mohnen and Hoareau, 2003; Arundel and Geuna, 2004; Laursen and Salter, 2004; Fontana et al., 2006; Bodas Freitas et al., 2011).

However, while previous studies have not provided any insights on how these characteristics are associated with different propensity to use either institutional or personal contractual governance modes for their interactions with university, our analysis suggests that size and technology openness have an effect on the choice of governance mode. In particular, large firms with strong absorptive capacity are only more likely to engage in institutional collaborations, but not more likely to engage in personal contractual interactions with university researchers. Moreover, while previous research has shown that open information and knowledge searching and scanning strategies are positively associated with firms' collaboration with universities (Laursen and Salter, 2004; Bodas Freitas et al., 2011), our evidence suggests that technology-open firms are more likely to interact with universities under personal contractual rather than institutional governance mode.

These results allow us to derive some policy implications. First, the presence of personal contractual interactions between small firms and university researchers suggest that it is possible for small firms to engage in knowledge transfer activities without relying on any institutionalized infrastructure for knowledge transfer, which contrasts with the claims made by the proponents of the Bayh-Dole act, who saw the institutionalization of knowledge transfer processes as essential in order to involve small firms (see Schacht, 2005; Feldman and Stewart, 2006). Since small firms seem more likely to use personal contracts to interact with university researchers, policy measures supporting this form of interaction rather than supporting the institutionalization of knowledge transfer could be particularly beneficial for small firms. Firms that find it difficult to interact with the

university and lack the resources to do that could still benefit very much from the interaction with university researchers not mediated (and sometimes complicated) by the institutional bureaucratic university infrastructure. Facilities for meeting researchers and more generally support for getting better connected to the technological and scientific network also for those companies that cannot access that through their employees' educational network (such as in the case of engineers of the Politecnico) would probably be effective policies in support of contractual personal relationships.

Second, our results suggest that individual academic researchers, being involved in contractual personal interactions, which are as prevalent as institutional ones, may play an important role in regional knowledge transfer. This is especially important in the case of interactions between firms and academics based within the same region, where the existence of local network links may minimize the transaction costs involved in setting up personal contractual relationships compared to establishing institutional arrangements. Therefore, the development of a legal status for different forms of personal contracts between university researchers and firms (through revision of universities career rules, and accumulation of industrial activities, possibility of temporary exchanges, etc...) should be considered as highly in the policy agenda as the improvement of the existing mechanisms supporting institutional collaboration.

Clearly, this study is not without its limitations. Firms that engage in institutional interactions with universities may also use personal contracts, and the two forms of interaction can be complementary. However, the data do not allow us to develop a more fine-grained classification of these typologies in terms of companies that use both types of interactions, those that only use personal contracts and those that only rely upon interactions mediated by university institutions. Work in this direction based on a new survey of industry inventors is ongoing (ref, 2012). Further research is needed to examine

the specific contribution to the process of knowledge development and the integration of the different forms of interaction with university research.

References

- Abreu, M., Grinevich, V., Hughes, A., Kitson, M. & Ternouth, P. (2008). Universities, business and knowledge Exchange, Council for Industry and Higher Education and Centre for Business Research, London and Cambridge.
- Adams, J. D., Chiang, E. P. & Jensen, L.J. (2003). The Influence of Federal Laboratory R&D on Industrial Research, *Review of Economics and Statistics*, 85(4): 1003-1020.
- Arora, A., Fosfuri, A. & Gambardella, A (2001). Markets for Technology and their Implications for Corporate Strategy. *Industrial and Corporate Change*, 10(2): 419-451
- Arundel, A., & Geuna, A. (2004). Proximity and the Use of Public Science by Innovative European Firms. *Economics of Innovation and New Technology* 13: 559-580.
- Baldwin, W. & Link, A. (1998). Universities as research joint venture partners: does the size of the venture matter. *International Journal of Technology Management*, 15(8): 895–913.
- Beath, J., Owen, R., Poyago-Theotoky, J. & Ulph, D. (2003). Optimal incentives for income-generation within universities. *International Journal of Industrial Organization*, 21: 1301-1322.
- Bekkers, R., & Bodas Freitas, I.M. (2008). Analysing preferences for knowledge transfer channels between universities and industry: To what degree do sectors also matter? *Research Policy*, 37: 1837-53.

- Bercovitz., J. & Feldmann, M. (2005) Entrepreneurial universities and technology transfer: a conceptual framework for understanding knowledge-based economic development. *Journal of Technology Transfer*. 31: 175–188.
- Boardman, P.G. & Ponomariov, B.L. (2009). University researchers working with private companies. *Technovation* 29, 142-153.
- Bodas Freitas, I.M, Clausen, T., Fontana, R. & Verspagen, B. (2011). Formal and informal external linkages and firms' innovative strategy. A cross-country comparison. *Journal of Evolutionary Economics*, 21(1): 91-119.
- Brownstone, D., & Small, K.A. (1989). Efficient Estimation of Nested Logit Models. *Journal of Business & Economic Statistics*, 7(1): 67-74
- Brusoni, S., Prencipe, A., & Pavitt, K. (2001). Knowledge Specialisation, Organizational Coupling, and the Boundaries of the Firm: Why Do Firms Know More Than They Make? *Administrative Science Quarterly*, 46: 597-621.
- Carayol, N. (2003). Objectives, agreements and matching in science-industry collaboration: reassembling the pieces of the puzzle. *Research Policy*, 32: 887-908.
- Cassiman, B., & Veugelers, R. (2006). In search of complementarity in innovation strategy: internal R&D and external knowledge acquisition. *Management Science*, 52(1): 68–82.
- Cohen W.M. and Levinthal, D.A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly*, 35: 128-152.
- Cohen, W.M., Nelson, R. & Walsh, J.P. (2002). Links and Impacts: The Influence of Public Research on Industrial R&D, *Management Science*, 48(1): 1-23.
- Cohen, W.M., Florida, R., Randazzese, L. & Walsh, J. (1998). Industry and the Academy: Uneasy partners in the cause of technological advance. In Noll, R. (ed.) *Challenges to research universities*. The Brookings Institution, Washington, D.C.

- Colyvas, J., Crow, M., Gelijns, A., Mazzoleni, R., Nelson, R., Rosenberg, N., & Sampat, B. (2002). How do university inventions get into practice? *Management Science* 48(1): 61-72.
- Crespi, A.C., Geuna, A., Nomaler, O., & Verspagen B. (2010). University IPRs and knowledge transfer: is university ownership more efficient? *Economics of Innovation and New Technology* 19: 627-648.
- Dechenaux, E., Thursby, M. & Thursby, J. (2007) Shirking, Sharing-Risk, and Shelving: The Role of University Contracts. *NBER Working Paper*.
- D'Este, P., Iammarino S. (2010), The Special Profile of University-Business Research Partnerships. *Papers in Regional Science*, 89 (2), 335-350
- D'Este, P., & Patel, P. (2007). University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry? *Research Policy*, 36: 1295-1313.
- D'Este, P. & Perkmann M. (2011). Why do academics engage with industry? The entrepreneurial university and individual motivations. *Journal of Technology Transfer*, 36, 316-339.
- Etzkowitz, H. (2001). The second academic revolution and the rise of entrepreneurial science. *Technology and Society Magazine*, 20(2): 18-29.
- Geuna, A., & Muscio, A. (2009). The governance of university knowledge transfer: A critical review of the literature. *Minerva*, 47(1): 93-114.
- Geuna, A., & Rossi, F. (2011). Changes to university IPR regulations in Europe and the impact on academic patenting, *Research Policy*, 40(8), 1068-1076.
- Giuliani E., Morrison A., Rabellotti R. & Pietrobelli C. (2010). Who are the researchers that are collaborating with industry? An analysis of the wine sectors in Chile, South Africa and Italy, *Research Policy*, 39(6): 748-761.

- Feldman, M. & Stewart, I. (2006) Knowledge transfer and Innovation. A review of the Policy Relevant Literature. Report prepared for the Ontario Ministry of Research and Innovation.
- Fontana, R., Geuna, A. & Matt, M. (2006). Factors affecting university-industry R&D projects: The importance of searching, screening and signalling. *Research Policy*, 35: 309-323.
- Hall, B.H., Link, A.N. & Scott, J.T. (2000). Universities as research partners, Working Paper No. W7643, NBER, Cambridge, MA.
- Heiss, F. (2002). Structural choice analysis with Nested Logit Models. *The Stata Journal*, 2(3): 227-252.
- Hensher, D.A., & Greene, W.H. (2002). Specification and estimation of the Nested Logit Model: alternative normalisations. *Transportation Research Part B: Methodological*, 36(1): 1-17
- Jensen, R., Thursby, J. & Thursby, M.C. (2010). University-Industry Spillovers, Government Funding, and Industrial Consulting. *NBER Working Papers 15732*, Cambridge, MA: National Bureau of Economic Research Inc.
- Joly, P.B., & Mangematin, V. (1996). Profile of public laboratories, industrial partnerships and organisation of R&D: the dynamics of industrial relationships in a large research organisation. *Research Policy* 25: 901-922.
- Lacetera, N. (2009). Different missions and commitment power in R&D organizations: theory and evidence on industry-university alliances, *Organization Science*, 20(3): 565-582.
- Laursen, K., Reichstein, T., & Salter, A. (2011). Exploring the effect of geographical proximity and university quality on university-industry collaboration in the UK. *Regional Studies*, 45(4), 507-523.

- Laursen, K., & Salter, A. (2004). Searching Low and High: What types of firms use universities as a source of innovation? *Research Policy* 33: 1201-1215.
- Leydesdorff, L. and Etzkowitz H. (1996). Emergence of a Triple Helix of University-Industry-Government Relations, *Science and Public Policy* 23, 279-86.
- Liebenau, J.M. (1985). Innovation in pharmaceuticals: industrial R&D in the early twentieth century. *Research Policy* 14: 179-187.
- Lissoni, F., P. Llerena, M. McKelvey and B. Sanditov. (2008). Academic Patenting in Europe: New evidence from the KEINS database. *Research Evaluation* 17:87-102.
- MacGarvie, M., and Furman, J. (2005). Early Academic Science and the Birth of Industrial Research Laboratories in the U.S. Pharmaceutical Industry, *NBER Working Paper 11470*. Cambridge, MA: National Bureau for Economic Research.
- Malecki, E.J. & Poehling, R.M. (1999). Extroverts and Introverts: Small manufacturers and their information sources. *Entrepreneurship and Regional Development* 11:247-268.
- Mansfield, E. (1991). Academic research and industrial innovation. *Research Policy*, 20, 1-12.
- Mansfield, E. (1995). Academic research underlying industrial innovations: sources, characteristics, and financing. *The Review of Economics and Statistics*, 77: 55-65.
- Meyer-Krahmer, F., & Schmoch, U. (1998). Science-based technologies: university-industry interactions in four fields. *Research Policy* 27: 835-852.
- Meyer-Thurow, G. (1982). The Industrialization of Invention: A Case Study from the German Chemical Industry. *Isis* 73(3): 363-381.

- Mohnen, P., & Hoareau, C. (2003). What type of enterprise forges close links with universities and government labs? Evidence from CIS 2. *Managerial and Decision Economics* 24: 133-145.
- Muscio, A. (2010). University-Industry Linkages: What are the determinants of long-distance collaborations? Mimeo DSEMS, Università degli Studi di Foggia.
- Mueller, P. (2006). Exploring the knowledge filter: how entrepreneurship and university-industry relationships drive economic growth. *Research Policy*, 35: 1499-1508.
- Panagopoulos, A. (2003) Understanding when universities and firms form RJVs: the importance of intellectual property protection. *International Journal of Industrial Organization*. 21: 1411–1433.
- Perkmann, M., King, Z. & Pavelin, S. (2009) Picking your partners: effects of faculty quality on university-industry relationships, *AIM Working Paper Series n. 7/2009*, Imperial College London.
- Perkmann, M., & Walsh, K. (2008). Engaging the scholar: three types of academic consulting and their impact on universities and industry, *Research Policy*, 37(10): 1884-1891.
- Powell W., K. Koput & L. Smith-Doerr (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly* 41: 116-145.
- Rebne, D. (1989). Faculty consulting and scientific knowledge: a traditional university-industry linkage. *Educational Administration Quarterly*, 25(4): 338-357.
- Rothaermel F.T., Agung, S.D., & Jiang, L. (2007) University entrepreneurship: a taxonomy of the literature, *Industrial and Corporate Change*, 16(4): 691-791.

- Santoro, M.D., Gopalakrishnan, S. (2000) The institutionalization of knowledge transfer activities within industry–university collaborative ventures. *Journal of Engineering and Technology Management*, 17: 299–319.
- Schacht, W. H. (2005). *The Bayh-Dole Act: Selected Issues in Patent Policy and the Commercialization of Technology*. Congressional Research Service Report for US Congress.
- Schartinger, D., Schibany, A., & Gassler, H. (2001) Interactive relations between universities and firms: empirical evidence for Austria. *Journal of Technology Transfer*, 26(3): 255-269.
- Swann, P. (1989). *Academic Scientists and the Pharmaceutical Industry: Co-operative Research in Twentieth-Century America*. Baltimore, MD: Johns Hopkins University Press.
- Thursby, J.G., Jensen, R., & Thursby, M.C. (2001) Objectives, characteristics and outcomes of university licensing: a survey of major US universities. *Journal of Technology Transfer* 26: 59-72.
- Veugelers, R., & Cassiman, B. (1999) Make and buy in innovation strategies: evidence from Belgian manufacturing firms. *Research Policy*, 28: 63–80.
- Wang J. & Shapira, P. (2009) Partnering with universities: A good choice for nanotechnology start-up firms? *Small Business Economics*, <http://dx.doi.org/10.1007/s11187-009-9248-9>.
- Wang, Q. & von Tunzelmann, N. (2000) Complexity and the function of the firm: breadth and depth. *Research Policy* 29: 805-818.

Appendix 1

Table A. Correlation coefficients of the independent and control variables for all firms

	Innovative Capabilities	Technology Openness	Size	Square Size	Multinational	Export	Outsourcing
Innovative Capabilities	1						
Technology Openness	0.230**	1					
Size	0.307**	0.371**	1				
Square Size	0.295**	0.355**	0.969**	1			
Multinational	0.075*	0.158**	0.149**	0.135**	1		
Export	0.205**	0.201**	0.428**	0.409**	0.149**	1	
Outsourcing	0.081*	0.116**	0.142**	0.151**	0.647**	0.128**	1

Note: 908 firms