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**The governance of formal university-industry interactions:
Understanding the rationales for alternative models**

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Abstract

This article develops a conceptual framework to explain the economic rationales underpinning the choice of different modes of governance of formal university-industry interactions: personal contractual interactions, where the contract regulating the collaboration involves a firm and an individual academic researcher, and institutional interactions, where the relationship between the firm and the academic is mediated by the university. Although institutional interactions, for numerous reasons, have become more important, both governance modes are currently being implemented; we would argue that they have some important specificities that need to be understood if university-industry knowledge transfer is to be managed effectively and efficiently.

Keywords: University-industry interactions, governance modes, knowledge transfer, academic consulting, transaction costs, appropriability.

JEL: R11; O31; O32

1. Introduction¹

Since the 1980s, in most advanced economies, views about the role of universities in the economic system have changed. The contemporary university is an economic organization that engages actively with external stakeholders, rather than an ‘ivory tower’ where academics perform research in isolation. The term ‘university-industry knowledge transfer’ refers to a wide range of interactions at different levels, involving the exchange of knowledge and technology between universities and firms. These interactions are varied and growing. They include, among other things: various types of equity or contract-based relationships between universities and industry (research joint ventures, collaborative research projects, contract research and academic consulting commissioned by industry); interactions around the commercialization of intellectual property rights emerging from university research (licensing and purchase of university patents, creation of start-up firms); and employment-based interactions (joint training and supervision of graduates, graduate recruitment and personnel exchanges) (Debackere, 2004; D’Este and Patel, 2007).

From the perspective of the universities, these activities are often described as ‘third stream’ or ‘third mission’. Their scale and scope have increased in parallel with the increasing importance given to them by policymakers and the business and academic communities: measured effects of the more intense engagement of universities with external stakeholders include increased numbers of papers co-authored with industry (Hicks and Hamilton, 1999), increased industry funding for academic research (Slaughter and Rhoades, 1996; Geuna, 1999), more university-assigned patents (Henderson et al., 1998; Geuna and Nesta, 2006) and increased income from royalties (Argyres and Liebeskind, 1998; Feller, 1990; AUTM, 2002).

This article examines the rationales underpinning the different modes of governance of formal interactions between university and industry which involve a formalized agreement among the participants with respect to the division of labour and the rules for joint decisions and assignment of outputs. The traditional mode of governance of formal interactions between academia and industry — in some contexts dating back to the late nineteenth century (Meyer-Thurow, 1982; Liebenau, 1984; Swann, 1989; MacGarvie and Furman, 2005) — implies a direct contract between a firm and an individual academic scientist. We call this the personal contractual mode of interaction. Over time, however, the number of collaborations

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involving contractual arrangements between a firm and a university (e.g., the university department, research centre, technology transfer office, etc.) has increased steadily. We call this the institutional agreement mode of interaction.²

In many countries, this qualitative shift in the governance of interactions between industry and academia has taken place in parallel with the development of an institutional infrastructure intended to support the diffusion of knowledge from universities to firms (Block, 2008; Geuna and Muscio, 2009). This infrastructure now comprises a variety of organizational forms which include university-industry liaison offices, technology licensing offices, technology transfer offices, joint industry-university research centres, academic spin-offs, technology consultancies (Peters and Etzkowitz, 1990; Cohen et al., 2002; Rothaermel and Thursby, 2005; Link et al., 2007). Some of these organizational forms, such as university-industry technology transfer offices, date back to at least the mid-twentieth century and have increased in importance; other organizational arrangements are more innovative, for example the creation of limited partnerships between universities and private companies (Feller, 1990).

There is a large and growing literature investigating numerous aspects of university-industry interactions (recent discussions of the main research topics can be found in D'Este and Iammarino, 2010; Rothaermel et al., 2007; Wang and Shapira, 2010; and for the Italian case, Muscio, 2010), but comparative analyses of the two modes of governance described above are rather scarce. The modes of governance tend to be studied in isolation: most studies focus on the institutional mode, and only a few try to analyse the characteristics of direct personal interactions, focusing generally on academic consulting, which often is mediated by universities. Problems such as the rationale for the use of each governance mode, the effect of each mode on the efficiency of knowledge transfer and on processes of economic development, and whether the two governance modes are complementary or substitutes for each other, have been rather overlooked.

This article focuses on the economic rationales underpinning the choices of governance mode. It develops a conceptual framework that explains the reasons for choosing a particular mode of governance, in terms of minimizing different types of transaction costs, and presents some supporting quantitative evidence. The data were collected from two original surveys addressed respectively to a sample of firms based in the Italian region of Piedmont (UIPIE survey) and a sample of inventors working in the same region (PIEMINV

²Another trend, not explored in this paper, is the progressive increase in the number and importance of the interactions between firms and universities, compared to the relative decline in importance, since the 1990s, of the interactions between firms and public research centres. The existence of such a trend has been noted for many European countries, including Ireland, Denmark, the UK, Iceland, Italy and Hungary (Senker et al., 1999), although notably not Germany (Senker et al., 1999).

survey). Data from the same region provide the complementary perspectives of managers and inventors on both types of governance of industry interactions with universities.

This article is organized in three main sections. Section 2 contextualizes and introduces the two governance modes (sub-section 2.1) and the reasons for the relatively few comparative analyses (sub-section 2.2). A conceptual framework is developed to explain the specificities and reasons for the continuing coexistence of the two governance modes (sub-section 2.3). Section 3 presents some empirical evidence supporting this framework, which shows that several firm and project characteristics are associated with the modes of governance of formal university-industry interactions. Section 4 concludes and discusses some policy implications.

2. Two modes of governance of formal university-industry interaction

2.1. Formal university-industry interactions: Context and characteristics

Since the 1980s, industrial research and development (R&D) processes have become more open and distributed (Chesbrough, 2003; Powell and Grodal, 2005; Nesta and Saviotti, 2006) and the involvement of universities as innovation partners has increased. Several processes have combined to make interaction between firms and universities more appealing for both parties.

From the perspective of firms, the growing complexity of products and processes and their scientific and technological content (Arora and Gambardella, 1994) increases the costs of vertically integrating all the competences needed for their development and makes it more convenient for firms to look for complementary competences outside their boundaries. Interacting with universities allows firms to access wide international networks of scientists with heterogeneous competences and opportunities to establish relationships with the potential to generate innovations (Antonelli, 2008).

The increased pace of organizational and technological change generates uncertainties about the economic context in general, and the likely development of technological trajectories and the emergence of dominant designs in particular. By building relationships with other organizations, especially universities, firms can hedge against the risk of backing the 'wrong' technology, by engaging in several innovation processes at the same time (Powell et al., 1996; Wang and von Tunzelmann, 2000), and at a fraction of the cost of fully vertically integrated R&D activities. They can keep up to date with scientific developments (Meyer-

Kramer and Schmoch, 1998) and enhance their learning and research opportunities by accessing advanced infrastructures and very qualified human resources.

Interactions with universities are particularly cost effective for firms. The economics of knowledge shows that the costs of knowledge production in academic are lower than in the private research system because of the split structure of academic salaries (Dasgupta and David, 1994): university researchers' fixed costs are covered by the payments received for their teaching activities, so that 'the compensation schemes practiced in the academic system allow the supply side to operate on a variable cost base' (Antonelli, 2008, p. 12). Also, a university affiliation signals quality and competence, based upon the institution's reputation in the open science system, which is an independent system that confirms the competence of academic researchers, lowers firms' search costs for high-quality competences, and reduces the agency problems inherent in collaborations with knowledge workers whose skills are difficult to assess (Antonelli, 2008).

From the universities' perspective, the developments in science-based technologies make industrial collaborations important for individual academic scientists to test models, and to access funds, and production and testing facilities (Koumpis and Pavitt, 1999; Lee, 2000). University institutions have become more proactive at seeking collaborations with firms because political trends are forcing them to find ways to reduce their dependence on public grants. These trends include reduced funding for university defence research and reduced government intervention in the economy, (Geuna and Muscio, 2009). Policy interventions are encouraging universities to engage in third stream activities and are highlighting the role and importance of institutional interactions with industry and supporting the creation of an institutional infrastructure for knowledge transfer between universities and firms (Macdonald, 2010). Examples of these interventions include the creation of publicly-funded regional knowledge transfer organizations in Germany, joint university-business competence centres in Sweden (Sellenthin, 2006) and support for the adoption of model contracts for university-industry collaboration in the UK (HM Treasury, 2003). As a result, third stream activities have become increasingly important for universities as a direct source of funds derived from commercial transactions and as a means of acquiring visibility and legitimacy and providing benchmarks for policymakers to measure their effectiveness (see, e.g. the UK Lambert Review, HM Treasury, 2003).

The greater engagement of universities in third stream activities brings some problems. The literature highlights such issues as the possible effects of increased dependence on private funding on the direction and content of research activity and the autonomy of the

scientific enterprise, and on the functioning of the open science system. Universities' engagement in commercial transactions may have negative effects on firms' innovation processes by putting the parties into direct competition, which may result in universities restricting access to scientific information making it more difficult for firms to appropriate the results of collaborative research with universities.

A possible side effect of the increased participation in third stream activities could be the replacement of more traditional forms of interaction with industry based on direct personal contractual relationships with academic researchers, by interactions mediated by an institutional knowledge transfer infrastructure. While some (Etzkowitz and Leydesdorff, 2000; Gibbons et al., 1994) argue that the supposedly more efficient new institutional knowledge transfer model is substituting for the older model and should be developed further, we would suggest that there are important differences between the two models that are not related to whether an individual academic or a representative of the university is signing the contract. The two models of governance have different histories, characteristics and economic implications (Geuna and Muscio, 2009) and, potentially, play different roles in the knowledge transfer process.

Personal contractual interactions involve an official contract between an academic and a firm. These interactions are often described as academic consultancies, and the individual scientist is hired to work as an external consultant on a firm project. The firm organizes and monitors project activities, which means that the firm retains control over the scope and organization of the project, but also has to bear the project coordination costs. Also, because the scientist working on the project is a self-employed, external consultant, monitoring the work is relatively costly for the firm because of high agency costs.

Much of the empirical research overlooks this type of university-industry interaction, concentrating instead on analysing the interactions, even in consulting activities, mediated by the university structure. This in part is because generally it is easier to collect this type of data, as we discuss in the next subsection, but it is also because the nature of personal contractual interactions is often misunderstood. It is often assumed that most interactions with individual academics are informal and, hence, difficult to measure and that, even if they are formalized, they involve 'soft' topics such as the application of business methods or the solution of simple day-to-day business problems (see e.g. HM Treasury, 2003; Bercovitz and Feldman, 2005). However, studies that explicitly consider formal academic consulting activity as a distinct knowledge transfer channel highlight its importance (see e.g. Rebne, 1989; Cohen et al., 2002; Beath et al., 2003; Perkmann and Walsh, 2008; Jensen et al., 2010)

and suggest that consulting includes a wide range of activities linked to the exploitation of existing knowledge, the commercialization of research results and the performance of original research (Perkmann and Walsh, 2008; Dechenaux et al., 2007).

Personal contractual interactions traditionally played a major part in knowledge transfer from academia to industry. There is evidence of significant interactions between companies and university scientists in the late nineteenth century in Germany and England, and in the early twentieth century in America. In Europe, these interactions continued to constitute the main share of university-industry collaborations throughout the twentieth century. The absence of formal business networks involving industry and academia meant that these interactions usually built on social networks (often based on a common educational background, as in the case of alumni associations) involving academic researchers and their industry counterparts and were characterized by high levels of interpersonal trust (Colyvas et al., 2002). The freedom of academics to contract with external organizations enabled these personal contractual interactions, which in most contexts, were tolerated or regulated by specifying the number of hours per month that an academic could devote to external consulting activities.³

As universities came under increasing pressure to intensify their knowledge transfer activity in order to procure funding and to demonstrate excellence in knowledge dissemination (a criterion used more and more by public funding agencies to assess university performance), academics were encouraged by their institutions to abandon personal contracts in favour of university-mediated arrangements. One of the arguments used by the university is that a formal arrangement insures the academic involved for any damage resulting from the performance of the contracted work. Institutional contracts are signed by the firm and a university representative. The scope and content of the project and the rules regarding the assignment of rights over the intellectual property emerging from the project, are often negotiated by the parties, but the coordination costs of organizing and monitoring project activities are shared. Also, since the scientist works on the project as a university employee, monitoring his/her work could be relatively less costly for the firm. Although many institutional interactions are based on personal friendships between academics and the commissioning firms, knowledge transfer offices are becoming proactive in looking for potential partner firms.

³ Academic consulting activities are also often mediated by the university institution, which channels consulting income through its accounts and may apply overheads (Beath et al., 2003; Perkmann et al., 2009). The personal contractual interactions examined in this paper are formal (contract-based) agreements between individual academics and firms, which are different from university-mediated consultancy activities and consultancy based on informal personal relationships.

Both governance modes are current and we argue that it is important to understand their differences in order to develop an effective and efficient knowledge transfer infrastructure.

2.2. Conceptual and measurement problems in the analysis of university-industry interactions

Although there is a large body of research on the characteristics of university-industry interactions,⁴ there are very few investigations of which governance form is most effective to mediate specific knowledge transfer interactions. There is also a lack of consensus on the most appropriate mechanisms for knowledge transfer between universities and industry. One of the reasons for this lack of agreement is that most studies that try to capture the complex phenomenon of university-industry relationships relying on different measures and data that are not comparable, resulting in major inconsistencies..

Several empirical studies use data collected through surveys of academics or/and firms, that take account of a wide range of alternative knowledge transfer channels. There is a recognition that several channels may be exploited simultaneously, and that formal channels allowing commercialization of university knowledge (i.e. spin offs, licences, patents) are among the least frequent (Schartinger et al., 2001; Cohen et al., 2002; D'Este and Patel, 2007; Bekkers and Bodas Freitas, 2008). According to Bruneel et al. (2009), conference attendance and graduate recruitment constitute the main forms of firm interaction with universities, while Abreu et al. (2008) suggest that the most frequent interaction occurs within collaborative research networks. D'Este and Perkmann (2007) find that, in the UK, collaborative research projects, including consultancies, are more important sources of income than licensing. Schartinger et al. (2001) highlight crucial inter-sectoral and inter-disciplinary differences in the intensity with which the different channels are used. Because of their broad focus, these studies provide little evidence on the governance of formal interactions and on the relative importance of difference governance forms.

In addition, knowledge transfer channels are categorized in different ways. For example, Perkmann and Walsh (2006) propose a distinction between socialized and non-socialized interactions, that is, between interactions that involve the establishment of social relationships (sponsored research projects, research consortia, collaborative joint ventures,

⁴ See, among others, the Special Issues of *Industrial and Corporate Change* 16(4), 2007, *Oxford Review of Economic Policy* 23(4), 2007 and *Journal of Economic Behavior & Organization* 63(4), 2007.

research centres) and those that are purely contractual (licensing, specific ad-hoc consultancy). Others indicate that all knowledge transfer channels - including those based on the sharing of codified knowledge, such as access to scientific publications and university patent licensing - are accompanied by the establishment of social relationships (Meyer-Kramer and Schmoch, 1998; Bozeman et al., 1995).

Most studies are based on one-off survey data or internal university information that is not standardized across universities. Evidence from different surveys is not always comparable due to respondent and sample biases. The results from comparing the responses from firm managers, R&D managers and inventors are often divergent (e.g., company researchers are usually more likely than firm managers to consider university research to be an important source of knowledge for firms). The survey design can also introduce bias. For example, the Community Innovation Survey (CIS) divides sources of knowledge into universities, scientific publications and conferences: however, this classification not only neglects many channels of knowledge transfer from universities that are discussed in the literature, it also introduces a downward bias in the ranking of the importance of university knowledge (the overall importance of university knowledge should be measured as the sum of the knowledge directly obtained from universities and the knowledge obtained from scientific publications and conferences). Moreover, since the CIS and similar surveys focus on capturing innovation-related activities, this orients respondents to focus on business-related, accountable, 'concrete' types of activities and sources, and usually results in comparative bias (i.e., respondents tend to rank the most concrete sources of knowledge as most important, and understate the importance of interactions such as personal contractual arrangements that involve individual collaborators rather than a partner organization).

Finally, when, as is most often the case, studies rely on data made available by university technology/knowledge transfer offices, they capture only the set of interactions managed directly by the university (see, e.g., Joly and Mangematin, 1996; Thursby et al., 2001). Policy often considers only statistics related to 'university and other higher education institutions', overlooking the fact that individual academic researchers may be active players in the interactions with industry.

Hence, although work on identifying knowledge transfer channels has become quite sophisticated, it has several limitations when the focus is on comparing different modes of governance of university-industry interactions.

2.3. A conceptual framework to explain the rationales for different forms of interactions

Interaction arrangements seem to reflect the concerns about and motivations for collaborating (Foray and Steinmueller, 2003). There is evidence suggesting that the governance of an interaction is associated with different perceived levels of transactions costs and uncertainty involved, and the aims of the collaboration (Artz and Brush, 2000; Zang et al., 2007).

Several authors consider that different modes of governance of inter-organizational interactions should apply in the presence of different levels of transaction costs. Gulati and Sing (1998) show that coordination costs, which depend on the expected complexity of the activities to be undertaken and the expected interdependence of tasks across organizational boundaries, can be high and efforts to reduce these costs may influence the firm's choice of which governance form to adopt. Interactions in which project control and coordination costs are shared are argued to be more appropriate for contexts where the need for coordination, integration and processing of diverse information relative to diverse subtasks, is high. Gulati and Sing suggest that this applies particularly in highly complex technological projects. On the other hand, if coordination costs are low they can be more easily managed by one or other of the partners. Appropriability considerations also play a role in the choice of governance form, with 'shared' governance structures being more relevant in conditions of weak appropriability, which carry a higher risk of opportunistic behaviour such as free riding. Other things being equal, trust between the partners reduces the risks of opportunism (Williamson, 1975) and the need for shared coordination.

Another type of transaction cost that affects interaction is the cost of monitoring the degree of commitment of partners. According to Lacetera (2009), outsourcing to an academic institution increases the commitment of research scientists to the project because it is conducted according to the norms of the scientific community and within realistic timescales, which reduces monitoring. The higher the potential monitoring costs, the more relevant a form of governance that allows scientists to operate within the framework of their academic institution.

These insights apply to the choice of governance mode for university-industry interaction. Since the content of the project around which the interaction is developed influences the extent of the transaction costs (especially coordination and monitoring costs), we would argue that certain governance modes are more appropriate for certain types of projects. Projects related to basic scientific knowledge have high coordination costs, since (i) they involve high fixed costs and require the contribution of teams of researchers rather than

of individuals, and (ii) they are characterized by high levels of codification of results, uncertainty in terms of possible application, and externalities related to the range of possible beneficiaries (Nelson, 1959), all of which leads to low appropriability (Arrow, 1962). These types of projects tend also to involve high monitoring costs because the research is complex and open ended, and monitoring the efforts and commitment of scientists is difficult. Based on these arguments, such projects are suited to institutional contracts which allow the firm to participate in the governance of the collaboration, which reduces coordination costs and ensures researchers' commitment because they are operating within the framework of their scientific institution.

Applied research projects, on the other hand, produce knowledge that is more immediately appropriable by the firm and because the research is more short-term and closer to the firm's activities, project activities and monitoring of university scientists' commitment is easier for the firm. According to the arguments presented above, these types of projects are better suited to personal contractual governance.

Consistent with this framework, Meyer-Krahmer and Schmoch (1998) in a survey of professors in different academic fields in Germany found that 'collaborative research' (typically involving the university institution) is more important in microelectronics, software and biotechnology, where research is more 'basic', and that 'contract research' (which includes academic consulting) is relatively more important in production technology, a field that is strongly oriented towards applied R&D.

As different firms tend to have involvement in different types of innovation projects, we expect the two modes of governance to differ across firms with different characteristics. In a companion paper (Bodas Freitas et al., 2010) we analyse in more detail the firm characteristics associated with the choice of governance mode. Firms with high levels of absorptive capacity (Cohen and Levinthal, 1990) will 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). Other things being equal, we would expect firms with high levels of absorptive capacity to be more likely to engage in institutional interactions.

Firms may favour different forms of governance depending upon the resources available for cooperative activities. Small firms generally do not have excess resources (financial, managerial skills, cognitive abilities) to deal with cognitively and socially distant institutions such as universities, and find it difficult to initiate and organize university-firm

collaboration. We would expect small firms to be more likely to interact through personal contracts with individual academics.

Firms that rely on sourcing technology from external organizations (via collaborations, licensing of intellectual property, etc.) are more likely to have the capabilities required to search for knowledge providers, and their search costs will be lower for personal contractual interactions. They may be part of a network of trusted academics which whom they have collaborated in the past, which reduces coordination and monitoring costs. They may be more likely to have the technological and codification capabilities to enable them to write ‘water-tight’ contracts. Therefore, all else being equal, we would expect such firms to be more likely to engage in personal contractual interactions.

The policy framework also matters for firms’ choices of governance models for university-industry interactions: for example, public funds to support university to industry knowledge transfer that are restricted to university-mediated interactions may be an important determinant of the firm’s choice to set up an institutional collaboration. In countries where policies to support the institutional model are recent, e.g. Italy, we would expect both models of governance of university-industry relationships to exist, and respond to different knowledge exchange needs. Section 3 provides some evidence of the co-existence of these two modes of interaction in the Piedmont region of Italy, and discusses several determinants of the relative use of the two models, within the framework presented in Section 2.3.

3. Modes of governance of university-industry interaction: Empirical evidence

This section provides some evidence on the relative importance of the two modes of governance of university-industry interaction described above. We rely on data from two original surveys conducted in 2008-2009, addressed respectively to firms and inventors, all of whom are based in the Piedmont region in north-west Italy. In other words, their institutional, social and economic settings are identical. This is important because it allows us to control for some of the determinants of different types of interactions and analyse whether the two models of governance are complementary or substitutes for the organization of university-industry interactions in the same regional economic system.

Based on data from the UIPIE survey⁵ of Piedmontese firms (Bodas Freitas et al., 2010), Table 1 reports the shares of firms that engaged in institutional interactions with

⁵ The UIPIE questionnaire was administered in autumn 2008 to a representative sample of 1,058 firms in the Piedmont region; we obtained 1,052 valid responses. The sample was developed and validated by the local

universities, that engaged only in personal contractual interactions with individual university researchers and firms that did not interact at all during the period 2006-2008.

Table 1. Co-existence of governance mode for university-industry interactions (firms)

	<i>Observations</i>	<i>Share (%)</i>
Sample	1,052	100
No institutional interaction	865	82.2
Institutional interaction	104	9.9
Personal interaction but no institutional interaction	83	7.9

Source: UIPIE survey

Based on data from the PIEMINV survey of Piedmontese inventors,⁶ Table 2 presents the shares of inventors and the channels of knowledge-transfer under different governance modes (shares are computed using the 945 inventors that responded to the questionnaire).

chamber of commerce, which sent out our questionnaires with their quarterly regional economic foresight survey.

⁶ The PIEMINV questionnaire was administered in autumn 2009 and spring 2010, to the population of inventors with a Piedmont address, that had applied for a patent to the European Patent Office (EPO) in the period 1998-2005 (about 4,000 patents and 3,000 inventors in Piedmont). We obtained 945 valid responses from 2,583 questionnaires sent (response rate 36%).

Table 2. Co-existence of governance mode for university-industry interactions (inventors)

	not used (%)	used but of little importance (%)	used and very important (%)
university-industry interactions			
• institutional interactions financed by company	70.8	15.4	13.7
• institutional interactions financed by public funds	72.6	15.0	12.3
• personal contracts with individual academics	72.9	14.6	12.5
• informal personal contacts	71.4	19.1	9.5
'open science' channels:			
• scientific articles	38.5	26.2	35.3
• conferences and scientific seminars	46.0	32.7	21.3
• other publications	36.7	33.9	29.4
'commercial' channels:			
• interactions with university TTOs	76.6	16.2	7.2
• contacts with university spin offs	84.4	10.6	5.0
• university patents	76.8	17.1	6.1
• sharing facilities	80.5	11.5	8.0
'employment' channels			
• company staff in university	94.7	4.4	0.9
• university staff in company	80.5	12.3	7.3
• student internships	62.1	24.0	13.9
• hiring of graduates	57.6	21.1	21.3
• joint supervision of graduate students	71.1	16.6	12.3

Source: PIEMINV survey

The results of these two surveys are consistent in showing that personal contractual interactions are almost as frequent as institutional cooperation. Thus, an exclusive focus on the latter overlooks an important part of the phenomenon. The manager survey (Table 1) shows that in 2006-2008, 10 per cent of Piedmontese firms engaged in institutional interactions and 8 per cent in personal contractual interactions only (we do not know whether firms that participated in institutional interactions also engaged in personal contracts). Among the inventors surveyed (Table 2), about 28 per cent reported institutional interaction with a university and collaboration through personal contracts. As expected, surveying inventors

rather than firms (where the respondent is the manager) increases the importance and use of university research.

Table 3 shows that there is a positive correlation between the use of different forms of governance of formal interactions. In other words, governance modes are not mutually exclusive. Firms may participate in interactions governed by different forms. This indicates that modes of governance can be associated with the different characteristics of the innovative projects.

Table 3. Forms of governance for interaction: Pearson correlation coefficients

	<i>Institutional interactions financed through public funds</i>	<i>Personal contracts between your company and individual university researchers</i>	<i>Informal, personal contacts between your company and university researchers</i>
institutional interactions financed by the company	0.544***	0.417***	0.321***
institutional interactions financed through public funds		0.417***	0.355***
personal contracts between company and individual university researchers			0.382***

Note: *** Significance at 1% (2-tailed)

Source: PIEMINV survey

Table 4 uses information from the PIEMINV survey to show the effectiveness of institutional and personal contractual interactions for specific industrial knowledge development goals. Percentages are computed over the number of respondents that declared experience of institutional interactions with universities and personal contracts with individual university researchers. The results suggest that personal contractual interactions are particularly important for firms wanting to solve problems related to product development and production activities, and to identify students to recruit. In the case of non-competitive basic-research, institutional interaction is preferred or is at least as relevant as personal contractual arrangements. Both personal contractual and institutional interactions are used to update knowledge and to get new ideas for product development, although there is a bias towards personal contracts in the latter case. Hence, the choice of governance for contracts

with a university seems to be related to the type of knowledge being developed and shared. These results are broadly in line with the conceptual framework presented above, which proposes that projects oriented towards basic scientific knowledge development are more likely to be governed through institutional interactions and those oriented more to the application of scientific knowledge to the firm’s own products and production activities are more likely to be governed through personal contractual interactions.

Hence, personal contractual interactions seem to be advantageous for immediate business activity because they provide access to the best graduates, and to ideas for new product development. Institutional interactions are preferred if the objective is to keep up to date on new knowledge developments, which reinforces the view that they involve projects where the knowledge exchanged is more general and less firm-specific.

Table 4. Effectiveness of institutional and personal interactions with university according to the content of the project.

<i>Project content:</i>	<i>Institutional interactions more effective (%)</i>	<i>Personal contracts more effective (%)</i>	<i>Both equally effective (%)</i>
Non-competitive (basic research) projects	32.2	21.3	34.2
To keep up to date on new knowledge developments	28.2	17.3	41.1
Applied research projects to develop new products	14.2	50.4	25.8
Applied research projects for production Activities	12.2	49.3	25.1
To identify the best students for recruitment	20.7	42.2	26.9
To get ideas for new product development	15.3	34.2	37.3

Source: PIEMINV survey. Question: ‘In order to reach the following objectives, which is more effective: collaborations with a university or personal contracts with individual university staff?’

From the UIPIE survey, which was addressed to local firms rather than inventors, we can identify three distinct subsamples of firms: (1) those with only institutional interactions, (2) those with only personal contractual interactions, and (3) those with involvement in both modes of interaction. The data show that firm characteristics (and strategies) can play important roles. Table 5 provides some descriptive statistics of the differences between firms

that engaged in institutional interactions with a university, and those that used personal contractual interactions with individual university researchers, in the three years before the survey.

Table 5. Forms of governance and firm characteristics

		<i>Institutional interaction</i>	<i>Only personal contractual interaction</i>		
		n = 104	n = 83		
		% of respondents	% of respondents		
Sector	Food, Beverages and Tobacco	15.4	9.6		
	Textiles, Apparel and Shoes	5.8	14.5	**	
	Wood and Furniture	1.9	4.8		
	Paper, Printing and Publishing	4.8	2.4		
	Chemicals, Rubber and Plastics	17.3	9.6		
	Production of Metals and Metal Goods	12.5	15.7		
	Mechanics	19.2	14.5		
	Production of Electrical, Electronic and Communication Equipment	6.7	12		
	Production of Transportation Equipment	6.7	4.8		
	Other Manufacturing companies	9.6	12		
	Total	100	100		
	Size	10-49 employees	36.5	71.1	***
		50-249 employees	40.4	25.3	**
more than 250 employees		23.1	3.6	***	
Total		100	100		
Turnover	less than 2m	0	31.3	***	
	2-5m	1.9	20.5	***	
	5-10m	16.3	21.7		
	10-20m	30.8	9.6	***	
	20-50m	41.3	9.6		
	over 50m	9.6	7.2		
Total	100	100			
R&D or design investment	Yes	58	41	***	
	No	42	59		

Total	100	100
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Note: *** Significance at 1% (2-tailed), ** Significance at 5% (2-tailed); * Significance 10% (2-tailed)

Source: UIPIE survey (Bodas Freitas et al., 2010)

In line with the arguments presented in section 2.3, we find that larger firms with higher levels of absorptive capacity (proxied by investment in innovation through in-house R&D or design) are more likely to engage in institutional interaction with a university and that small firms are more likely to be involved in personal contractual collaborations only. Bodas Freitas et al. (2010) provide evidence that firms whose interactions with university are supported by personal contracts with university researchers tend to invest more than firms that collaborate institutionally in knowledge acquisition through patents and know-how, and are more likely to adopt ‘open’ innovation strategies based on the exchange of technological knowledge with external partners than firms that do not collaborate at all. Thus, contractual personal interactions with specific university researchers seem to play a role in the absorption of externally acquired knowledge and in the integration of knowledge and know-how developed in collaboration with other partners.

4. Conclusions

This article proposed a conceptual framework to explain the rationales underpinning different forms of governance of formal university-industry interactions. We focused on direct university-industry interactions — personal contractual and institutional — rather than purely commercial relationships based on the exchange of intellectual property or personnel and student exchanges.

We have argued that formal university-industry collaborations can be governed by personal or institutional contracts, and that the choice of the mode of governance is related to the knowledge content of the project. Following Gulati and Singh (1998) and Lacetera (2009), we showed that for shared governance, institutional interaction is more appropriate when coordination and monitoring costs are high and appropriability conditions are weak, which is typical of projects developed around basic scientific knowledge. More ‘unilateral’ forms of governance, such as personal contractual collaborations, are more appropriate for projects characterized by lower coordination and monitoring costs and high appropriability conditions, typical of projects developed around applied knowledge. We argued also that firm characteristics affect the specific form of governance chosen to manage the interactions: larger firms and firms with higher levels of absorptive capacity are more likely to engage in

institutional interactions, while smaller firms and firms more reliant on the acquisition of external knowledge which favour more open innovation strategies based on the exchange of technological knowledge with external partners, are more likely to engage in personal contractual interactions.

Our data, collected from surveys of R&D managers and inventors in Piedmont, suggest that personal contractual interactions are as important as institutional arrangements and that both are complemented by informal contacts. The evidence on science-technology interactions in the Piedmont region broadly supports the conceptual framework outlined, and shows that institutional governance may be more effective for innovation projects with a high basic research content and conversely, that personal contractual arrangements seem to be effective for innovation projects concerted with mainly applied research and problem solving. Smaller firms, especially those that employ open innovation strategies, are more likely to favour personal contractual interactions, while large firms with high absorptive capacity are more likely to engage in institutional contracts.

This study has important implications for policy makers. Both personal contractual and institutional governance models are important for collaboration and knowledge transfer between university and industry, with personal arrangements more appropriate for small companies. These results are somewhat paradoxical since most policy support for the development of institutional forms of governance of university-industry relationships is based on the belief that academia is unable to respond to the applied knowledge needs of small companies. Instead, personal contractual interactions with individual academics, which do not directly involve the university, appear to be more effective in facilitating the transfer of knowledge especially to small firms, and providing firms with knowledge relevant to their business, technology and production needs.

Both personal contractual and institutional interactions need to be considered when examining the contribution of universities to economic development. Instead of focusing only on support for institutional interactions (which are often too cumbersome, too costly and too inflexible for small firms), policy should try to stimulate personal contractual interactions through appropriate regulation of part-time professorships and consulting. This would provide incentives for firms to organize contracts with individual academics when this form of interaction would be more effective for knowledge transfer.

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