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The governance of formal university–industry interactions: understanding the rationales for alternative models

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This article develops a conceptual framework to explain the economic rationale 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.

Introduction[1]

Views of the role of universities in the economic system have changed in most advanced economies since the 1980s. 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 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).

Universities often describe these activities 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. The

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more intense engagement of universities with external stakeholders is evidenced by the 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 (Feller, 1990; Argyres and Liebeskind, 1998; AUTM, 2002).

This article examines the rationale underpinning the formal interactions between university and industry that involve an agreement among the participants about division of labour, 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, 1985; 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 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 that include university–industry liaison offices, technology licensing offices, technology transfer offices, joint industry–university research centres, academic spin-offs and 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. 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 Rothaermel *et al*., 2007; D'Este and Iammarino, 2010; Wang and Shapira, 2009; 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 few analyse the characteristics of direct personal interactions, focusing generally on academic consulting, which is often mediated by universities. At present, the literature has not fully addressed such problems 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 complements or substitutes for each other.

This paper focuses on the economic rationales underpinning the choice of governance modes. 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 survey). Data from the same region

provide the complementary perspectives of managers and inventors on both types of governance of industry interactions with universities.

The paper has three main sections. The following section introduces the two governance modes and the reasons for the availability of relatively few comparative analyses. A conceptual framework is then developed to explain the specificities and reasons for the continuing co-existence of the two governance modes. The paper then presents some empirical evidence supporting this framework and shows that several firm and project characteristics are associated with the modes of governance of formal university–industry interactions. The paper concludes with some policy implications.

Two modes of governance of formal university–industry interaction

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, 2005) 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. Interaction with universities allows firms access to a 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 well-qualified human resources.

Interactions with universities are particularly cost effective for firms. The economics of knowledge shows that the costs of knowledge production in academia 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 on the institution's reputation in the open science system, which is an independent system that confirms the ability 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 university's perspective, 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 in 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, 2011). Examples of such 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 HM Treasury, 2003).

The greater engagement of universities in third stream activities may bring 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, thereby making it more difficult for firms to appropriate the results of collaborative research with universities.

A possible side effect of increased participation in third stream activities could be the replacement of more traditional forms of interaction with industry, such as direct personal contractual relationships with academic researchers, with interactions mediated by an institutional knowledge transfer infrastructure. While some (Gibbons *et al*., 1994; Etzkowitz and Leydesdorf, 2000) argue that the supposedly more efficient new institutional knowledge transfer model is substituting for the older model and should be developed further, it could be argued 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. 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 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. In part, this is because it is generally easier to collect this type of data, as we discuss in the next section, 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, for example, HM Treasury, 2003; Bercovitz and Feldmann, 2005). However, studies that explicitly consider formal academic consulting activity as a distinct knowledge transfer channel highlight its importance (see 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 (Dechenaux *et al*., 2007; Perkmann and Walsh, 2008).

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 were 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 increasingly used 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 the university's involvement 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 the work is cheap for the firm. Although many institutional interactions are based on personal friendships between academics and commissioning firms, knowledge transfer offices are becoming proactive in looking for potential partner firms.

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 seeking to identify 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 rely on measures and data that are not directly comparable to capture the complexity of university–industry relationships.

Several empirical studies use data collected through surveys of academics 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 involving the commercialization of university knowledge (i.e. spin-offs, licences, patents) are among the least frequently used (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 collaborative research projects, including consultancies, are more important sources of income than licensing in the UK. Schartinger *et al*. (2001) highlight crucial intersectoral and inter-disciplinary differences in the intensity with which the different channels are used. Because of their broad focus, these studies provide little evidence about the governance of formal interactions and 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, 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 because of 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 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, respondents focus on business-related, accountable types of activities and sources, which usually results in comparative bias (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 partner organizations).

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 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 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.

A conceptual framework to explain the rationale 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 aims of collaboration and different perceived transactions costs and levels of uncertainty (Artz and Brush, 2000; Zang *et al*., 2007). Several authors consider that different modes of governance of organizational interactions should apply to different levels of transaction costs. Gulati and Sing (1998) show that coordination costs, which depend on the expected complexity of the activities undertaken and the expected interdependence of tasks across organizational boundaries, can be high. Efforts to reduce these costs may influence the firm's choice of governance form. Interactions in which project control and coordination costs are shared are argued to be more appropriate 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 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 transactions 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 the need for monitoring. The higher the potential monitoring costs, the more important it becomes to select 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 transactions 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 for two reasons. First, they involve high fixed costs and require the contribution of teams of researchers rather than of individuals. Second, 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 also tend 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 that 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. Because the research is short term and closer to the firm's activities, 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.

In a survey of professors in different academic fields in Germany, Meyer-Krahmer and Schmoch (1998) found that collaborative research (typically involving the university institution) is important in microelectronics, software and biotechnology, where research tends to be basic, and that contract research (which includes academic consulting) is important in production technology, a field strongly oriented towards applied R&D. Because firms tend to be involved in a range of innovation projects, we expect firms to be involved in both modes of governance. In a companion paper (Bodas Freitas *et al*., 2010), we analyse the firm characteristics associated with choice of governance mode. Firms with high levels of absorptive capacity (Cohen and Levinthal, 1990) are likely to benefit from basic research projects, which are uncertain but enhance research productivity and allow unexpected technological spill-overs (Fontana *et al*., 2006; Laursen *et al*., 2011). Other things being equal, we expect firms with high levels of absorptive capacity to engage in institutional interactions.

The form of governance that firms favour depends on the resources available for cooperative activities. Small firms generally do not have spare resources (financial, managerial skills, cognitive abilities) to deal with such cognitively and socially distant institutions 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 with whom they have collaborated in the past, which reduces coordination and monitoring costs. They may have the technological and codification capabilities to enable them to write water-tight contracts. We would expect such firms to be more likely to engage in personal contractual interactions.

The policy framework also matters for firms' choice 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. There is

evidence of the co-existence of these two modes of interaction in the Piedmont region of Italy.

Modes of governance of university–industry interaction: empirical evidence

This section provides some evidence of the relative importance of the two modes for the governance of university–industry interaction. It relies on data from two original surveys conducted in 2008–2009, addressed respectively to firms and inventors based in the Piedmont region of northwest Italy. In other words, their institutional, social and economic settings are identical. This allows us to control for some of the determinants of different types of interactions and to analyse whether the two models of governance are complements or substitutes for the organization of university–industry interactions in the same regional economic system.

Based on data from the UIPIE survey of Piedmontese firms [5] (Bodas Freitas *et al*., 2010), Table 1 reports the shares of firms that engaged in institutional interactions with 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. 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 who responded to the questionnaire).

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% of Piedmontese firms engaged in institutional interactions and 8% 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% 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 reported importance and use of university research. Table 3 shows that there is a positive correlation between the use of different forms of governance in formal interactions. In other words, governance modes are not mutually exclusive. Firms may participate in interactions governed in different ways. This indicates that modes of governance can be associated with the different characteristics of the innovative projects.

Table 4 uses information from the PIEMINV survey to show the effectiveness of institutional and personal contractual interactions. Percentages are computed over the number of respondents who declared experience of institutional interactions with

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

	Observations	Share (%)
Sample	1052	100
No institutional interaction	865	82.2
Institutional interaction	104	9.9
Personal interaction but no institutional interaction	83	7.9

Source: UIPIE survey.

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

TTO = Technology Transfer Office.
Source: PIEMINV survey.

universities and of 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 are likely to be governed through institutional interactions and those oriented towards the application of scientific knowledge to the firm's products and production activities are 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

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

	Institutional interactions financed through public funds	Personal contracts between company and individual university researchers	Informal, personal contacts between company and university researchers
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***

***Significance at 1% (two-tailed).
Source: PIEMINV survey.

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

Project content	Institutional interactions more effective (%)	Personal contracts more effective (%)	Both equally effective (%)
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.

preferred if the objective is to keep up to date and the knowledge exchanged is not firm-specific.

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; (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.

We find that large firms with high levels of absorptive capacity (using investment in innovation through in-house R&D or design as proxy) are likely to engage in institutional interaction with a university and that small firms are likely to be involved in personal contractual collaborations only. Bodas Freitas *et al.* (2010) pro-

Table 5. Forms of governance and firm characteristics

		Institutional interaction	Only personal contractual interaction	
		n = 104 % of respondents	n = 83 % 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	<2 m	0	31.3	***
	2–5 m	1.9	20.5	***
	5–10 m	16.3	21.7	
	10–20 m	30.8	9.6	***
	20–50 m	41.3	9.6	
	>50 m	9.6	7.2	
	Total	100	100	
R&D or design investment	Yes	58	41	***
	No	42	59	
	Total	100	100	

**Significance at 5% (two-tailed).
*** Significance at 1% (two-tailed).
Source: UIPIE survey (Bodas Freitas *et al.*, 2010).

vide 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.

Conclusions

This paper proposes a conceptual framework to explain the rationale underpinning different forms of governance in formal university–industry interactions. We focus

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 argue 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 show 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 argue also that firm characteristics affect the specific form of governance chosen to manage the interactions. Large firms and firms with higher levels of absorptive capacity are likely to engage in institutional interactions, while small firms and firms reliant on the acquisition of external knowledge and that favour more open innovation strategies based on the exchange of technological knowledge with external partners are 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 and technology interactions in the Piedmont region broadly supports the conceptual framework outlined and shows that institutional governance may be more effective for innovation projects involving basic research and, conversely, that personal contractual arrangements seem to be effective for innovation projects involving applied research and problem solving. Small firms, especially those that employ open innovation strategies, are most likely to favour personal contractual interactions. Large firms with high absorptive capacity are most 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. Rather, 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 in 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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Notes

1. This article is an abridged and radically developed version of Bodas Freitas *et al*. (2011).
2. Another trend, not explored in this paper, is the progressive increase in the number and importance of the interactions between firms and universities, compared with the relative decline in importance, since the 1990s, of the interactions between firms and public research centres. Such a trend has been noted in many European countries, including Ireland, Denmark, the UK, Iceland, Italy and Hungary, although notably not Germany (Senker *et al*., 1999).
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.
4. See the special issues of *Industrial and Corporate Change*, 2007, 16, 4; *Oxford Review of Economic Policy*, 2007, 23, 4; and *Journal of Economic Behavior & Organization*, 2007, 63, 4.
5. The UIPIE questionnaire was administered in autumn 2008 to a representative sample of 1058 firms in the Piedmont region; we obtained 1052 valid responses (a response rate of 99%). The sample was developed and validated by the local chamber of commerce, which sent out our questionnaires with its quarterly regional economic foresight survey.
6. The PIEMINV questionnaire was administered in autumn 2009 and spring 2010, to inventors with a Piedmont address who had applied for a patent to the European Patent Office in the period 1998–2005 (about 4000 patents and 3,000 inventors in Piedmont). We obtained 945 valid responses from 2583 questionnaires sent (a response rate of 36%).

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