

Why Firms do (not) Develop Institutional Collaborations with Local Universities?

Isabel Maria Bodas Freitas^a, Aldo Geuna^b and Federica Rossi^c

^aDISPEA, Politecnico di Torino,
& Grenoble Ecole de Management

DISPEA, Corso Duca degli Abruzzi, 24b, 10129 Torino. isabel.bodasdearaujofreitas@polito.it

^bDepartment of Economics S. Cognetti De Martiis, University of Torino,
BRICK, Collegio Carlo Alberto
& Grenoble Ecole de Management

University of Torino, Via Po 53, 10124 Torino, Italy, Tel: +39 0116703870, Fax: 0039 011 6703895;
email: aldo.geuna@unito.it

^cDepartment of Economics S. Cognetti De Martiis, University of Torino,
& Centre for Innovation Management Research, Birkbeck College, University of London

University of Torino, Via Po 53, 10124 Torino, Italy, Tel: +39 0116703870, Fax: 0039 011 6703895;
email: rossi.federica@unito.it

Abstract

Based on a representative sample of firms in the Italian region of Piedmont, we investigate the nature and size of collaborations between local firms and universities in different locations. Filling a gap in the literature on university-industry knowledge transfer, the analysis concerns both *institutional* collaborations, typically mediated by universities through their Technology Transfer Offices (TTOs), and *personal* collaborations between firms and individual academics, often involving formal and binding agreements, but carried out without the direct involvement of the university institution. The different characteristics of firms involved in these two different governance forms for knowledge transfer are explored, and compared with those of firms that do not collaborate with universities at all. With respect to the subset of firms that are involved in institutional collaborations, the paper then investigates the determinants of the choice to collaborate with local as opposed to distant universities, as well as of the amounts spent in collaborations with universities in different locations.

The analysis shows that personal collaborations with individual university researchers play an important role in regional knowledge transfer, and often involve firms with different characteristics than those that use the more widely discussed institutional channels. The former are more likely to engage in open innovation strategies and to complement their internal R&D activities with university research, while firms that use institutional channels are more likely to substitute university research for internal R&D. Both channels are therefore important and should be an object of empirical analysis and policy debate.

The analysis of the geographic dimension of institutional collaborations shows that the choice of which universities to collaborate with is strongly related to the expertise possessed by the university and to the objectives towards with the collaboration is activated. These objectives, together with firms' characteristics like performance, also very strongly influence the amounts spent in the collaborations, with technology development requiring the highest investment.

Introduction

Much policy discussion and a large number of academic papers examining university-industry relationships have been produced in recent years. One of the aspects considered is the role played by universities in regional economic development (Cook, 2004; OECD, 2006; Lawton-Smith, 2007). The literature has addressed questions such as the following: Are universities regional engines of growth? Does proximity to the university facilitate knowledge transfer? Do private research labs tend to localize near high quality university departments? However, the results are still very preliminary and, in some cases, inconsistent.

This paper contributes to the ongoing debate providing an analysis of an original dataset of 1058 representative firms (the sample has been developed and validated by the local Chamber of Commerce) located in the Piedmont region in the north west of Italy. Piedmont is one of the most advanced Italian regions with a population of about 4.5 millions inhabitants. We develop an econometric analysis of university-industry collaborations with the three local universities (University of Torino, Politecnico of Torino and University of Piemonte Orientale) and with other universities in Italy and abroad. Our analysis extends the existing literature on the role of the university in regional development, along four main lines. First of all, and most importantly, we measure both *institutional* collaborations (formal relationships with the university, probably mediated by a TTO) and *personal only* collaborations (reported by those companies that did not have institutional relationships with universities but that did have direct formal and informal collaborations with university researchers). This allows us to compare the different reasons for developing *institutional* relationships versus the reasons for developing the more traditional *personal* interactions with university researchers. Second, we focus on interactions with local universities compared to interactions with other universities in Italy and abroad. Third, we measure the intensity of university-industry collaborations on the basis of financial investment in the last 3 years, in order to avoid the usual problem of using as dependent variable the importance of the collaboration (which is a subjective measure) or the number of times in which collaborations have taken place (which is problematic because it does not distinguish between small and large collaborations). Fourth, we have tried to assess the importance of collaborations not only in science and technology but also in the social sciences and law.

In our representative sample, only 9.9% of the respondents stated that they had developed an *institutional* relationship with a university in the last three years. We also identified 83 respondents (7.9% of the sample) that had only *personal* collaborations with university researchers. The more detailed data collection focuses primarily on *institutional* collaborations. This decision is justified by the fact that most of the policies developed in recent years to support university-industry interactions at the regional level have been based upon the view that interactions need to be managed institutionally, and therefore policies have implicitly been focused only on *institutional* collaborations. Thus, an analysis clearly focused only on the *institutional* side of the contribution of the university to local development would provide the information needed for a future assessment of policy impacts.

The paper is structured as follows. In the next section, we frame our discussion in the general context of the literature on university-industry interactions and on the role of inter-organizational knowledge flows in regional development, and we briefly describe the main features of Piedmont's industrial system and its universities. Then, we present our data and the methodology used for the empirical analysis, and subsequently the results obtained. In the last section we present some concluding remarks.

Discussion and hypotheses

University industry interactions: *institutional* versus *personal* collaborations

While various studies have examined the characteristics of university-industry collaborations, there is no overall agreement on how best govern them and on their results in term of knowledge transfer and subsequent economic development. Most empirical studies have focused on high-tech industries, although more recently also other contexts have been scrutinized, and the availability of CIS-type data has permitted econometric analyses controlling for sector and technological differences. Important discrepancies in the conclusions reached are often associated with the chosen methodology: detailed interview-based case studies tend to highlight the importance of personal contact and mobility in the transfer of knowledge, while quantitative studies underscore the success of the channels managed by knowledge transfer organisations such as TTOs.

One fundamental reason for the inconsistency in the results is that most of the studies have relied on imprecise measurements of the phenomenon due to the lack of standardized, validated, robust data on university-industry relationships. Some studies have only focused on data made available from TTOs or similar organisations therefore capturing only the university-managed set of interactions. Other studies have collected their own information (based on surveys of academics or/and firms). While these studies have become increasingly sophisticated in the identification of alternative communication channels, they have been limited by the implicit assumption that personal contacts were mainly informal, therefore considering all the more formal channels of knowledge transfer as university-managed. Actually, some of the respondents may well have had very formal contracts with the universities, but managed them personally without involving the university. CIS-type surveys simply ask firms whether they have relationships with universities, and their importance, without requiring them to specify the nature and governance of these relationships, again confusing university-mediated institutional relationships with personal (formal or informal) collaborations.

It is paramount to recognise that there are at least two different models of university-industry collaboration at work at the same time (Geuna and Muscio, 2009). First, based on historical developments, university-industry knowledge exchange can be governed by formal or informal *personal interactions* between university researchers and company engineers and researchers. This type of governance is the result of the participation in the same networks on the part of academic and industry personnel (Collyvas et al., 2002), and it is based on some form of trust (in some cases due to sharing the same educational background, as exemplified by alumni association in US or the “*Esprit du Corp*” of the French Grandes Écoles or of the Italian Politecnici). These interactions are usually formalized into binding contracts and agreements, but they are not mediated by university structures. Second, the last twenty years or so have seen the development (mainly spurred by public policies) of *institutional* university-industry relationships mediated by specialised units such as TTOs: universities have taken the responsibility of organising and supporting the interaction between academics and firmsⁱ.

While some of the literature (Etzkowitz and Leydesdorff 2000; Gibbons et al. 1994) has argued that the supposedly more efficient new institutional knowledge transfer model is substituting the older model and should be developed further, we think that the two models are coexistent. In countries where public policies for the support of the “institutional model” have been less intense, such as Italy, we would expect to find the two models of governance of university-industry relationships to thrive in response to different needs for knowledge exchange. Once we recognise that there are two different approaches to knowledge exchange between universities and companies it is natural to question what is the relative importance of the two models, if they are complementing or substituting each other and, most importantly, if public intervention in support of one approach is improving the overall efficiency of the system. None of these questions have been address by the literature in an exhaustive way though various attempts have been made. This paper aims to provide a contribution to answering these questions.

The Piedmont region and its universities

Piedmont is located in the north west of Italy. With a total population of about 4.4 million, it produces about 8.5% of Italian GDP. GDP per capita in PPP is 25,703 Euro (Eurostat, 2004), 120% of the average EU (27 countries). The region has a positive trade balance with about 30 billion euro of export. Almost 67% of the export goes to other EU countries, especially France and Germany.

The 410,000 companies active in the region are relatively more focused on manufacturing. Employment is consequently relatively high in manufacturing (33% vs. 63% in services). High and medium-high technology manufacturing is particularly strong, with about 12.1% of total employment compared to the EU-25 average of 6.8% (2004).

Piedmont has a strong specialisation in automotive components, Turin being the home town of Italy's main car producer FIAT. Besides some large R&D intensive firms, the industrial structure is characterised by a large number of small and medium size enterprises (SMEs) organised in traditional industrial clusters. Among the specializations present in the region, we find wool, fittings and valves for plumbing, textile and apparel, mechanics, jewellery, kitchen utensils and appliances, food&wine.

Good performance from the manufacturing sector is also highlighted in the employment statistics; the unemployment rate is relatively low at 4.7% in 2005, significantly lower than the EU average while the overall participation rate, for the 15-64 age cohort, is 64% (slightly lower than the 70% target set in the Lisbon strategy).

While Italy suffers from structural weakness in R&D investment (Italy's R&D expenditure as a percentage of GDP is 1.16 % vs. an average of 1.93 % in EU-25), Piedmont is better positioned in this respect, having the third highest value of R&D expenditure among Italian regions in absolute (total R&D expenditure) and relative terms (public expenditure in R&D as a percentage of regional GDP). In particular, Piedmont is characterized by a high incidence of private R&D expenditure as a share of total R&D expenditure: while the Italian average is 47.39%, Piedmont's share of private R&D is almost 80% (1.4 billion euro). This is largely due to some large Piedmontese firms which invest heavily in R&D, particularly FIAT (with its research centre CRF) and Telecom Italia (through its research centre TiLab). Of the 24,273 Piedmontese workers employed in R&D roles in 2004, 15,260 were employed by private firms, 6,466 in universities, 1,700 in other public bodies and 847 in private charities (Fondazione Roselli, 2007). The third Community Innovation Survey indicates that about 33% of Piedmontese companies were innovative, a few percentage points higher than the Italian average.

The universities and the many public research centres localized in the region greatly contribute to local research and knowledge production. In Piedmont there are four universities, of which three are public (Università degli Studi di Torino, Politecnico di Torino, Università degli Studi del Piemonte Orientale "Amedeo Avogadro") and one is private (Università di Scienze Gastronomiche)ⁱⁱ.

Founded in 1404, Università di Torino is composed of 12 schools and 55 departments, covering all sciences except for engineering. In 2007/08, it had over 66,000 enrolled students and it employed over 2,000 permanent academic staff (over 3,000 if non-permanent academic staff are included), as well as over 1,500 administrative and technical staff. Founded in 1859, Politecnico di Torino has 6 schools and 18 departments. In 2007/08, it enrolled almost 24,000 students and it employed over 800 permanent academic staff (over 2,000 if non-permanent academic staff is also considered) as well as about 600 administrative and technical staff. While Università di Torino offers undergraduate and postgraduate courses in a wide range of disciplines (although, compared with other large Italian universities, its course offering is particularly oriented towards the social sciences, the humanities and medicine), Politecnico di Torino is quite narrowly specialized in engineering and architecture. Università del Piemonte Orientale, founded in 1998, has 7 schools and 12 departments, localized in the cities of Alessandria, Novara and Vercelli. In 2007/08, it had almost 10,000 enrolled

students, almost 400 permanent academic staff (over 500 if also non-permanent academic staff is considered) and about 300 administrative and technical staff. Università di Scienze Gastronomiche is a small university specialized in Food Science. In 2007/08 it had about 200 enrolled students and only 6 permanent academic staff. Available data on Piedmontese students show that almost 40% of bachelor and master graduates in 2005 specialized in science (mainly at the Università di Torino) and technology (at the Politecnico di Torino), while about two thirds of PhD students in the same year were enrolled in science and technology programmes.

Data and Methodology

We use data from an original survey (UIPIE) sent to a sample of representative firms localized in the Piedmont region. This sample has been developed and validated by the local Chamber of the Commerce, which kindly forwarded our questionnaire together with their quarterly survey on the state of the regional economy.

Firms were asked whether they had engaged in *institutional collaborations* (through contracts and agreements with university institutions) in the last three years, specifying which universities they collaborated with (universities in Piedmont, in the surrounding regions, in Italy, in Europe or outside Europe). For each university that the firm had collaborated with, the survey asked respondents to specify the objective of the collaboration (choosing between technological development, testing and analysis, organization and management, marketing, logistics and legal issues), to state the amount of money that was spent, and to assess whether the collaboration was satisfactory (choosing between four options indicating different degrees of satisfaction). Finally, non-collaborators were asked to identify their reasons for not collaborating. Firms were also asked whether they possessed an internal R&D unit.

This questionnaire was circulated in October/November 2008. We obtained 1052 valid responses (FIAT is not included among questionnaire respondents), although for some of the variables there are a few missing observations. Some additional information about the firms - such as size, industry, internal structure, and performance - was kindly provided by the Chamber of Commerce.

The objective of this paper is to analyse the role of local universities in supporting local development and innovation, paying particular attention to the model of governance of the interactions (*institutional or personal*). *Institutional collaborations* are formal relationships with the university, probably mediated by a TTO, while *personal only* collaborations are reported by those companies that did not have institutional relationships with universities but that did have formal and informal collaborations with individual university researchers. In order to address these objectives empirically, we proceed in two steps.

First, we explore the factors affecting the firms' decision to collaborate or not with universities, as well as the factors affecting the decisions to collaborate using *institutional agreements* vs. engaging in *personal only* individual collaborations with university researchers. In order to account for this selection mechanism, we run a Heckman Probit analysis on the variable *Institutional collaboration*, taking into consideration the selection effect of the earlier decision to collaborate or not with a university. In the selection equation (*no collaboration* versus collaboration either through *only personal collaborations* or with *institutional arrangements*), we used as independent variables the firms' size (variable "size") and their industrial affiliationⁱⁱⁱ, as well as the variable identifying whether the firm possesses an R&D lab or not (variable "no R&D lab"). As predictors of the firms' decision to collaborate via *institutional* rather than *personal* channels, we included firms' size, share of production exported, share of production outsourced, value added per employee, and information on whether the firm owns a R&D lab (Model 1).

The variable "exports" provides information on whether the firm exports more than 20% of production, while the variable "outsourcing" provides information on whether or not the firm

outsources more than 20% of production to other firms in Italy or abroad. The variable value added per employee (“VA_employee”) takes value 0 when such amount is less than 200,000 euros, and one when it is greater than that threshold.^{iv} The variable “no R&D lab” contains information on whether firms own a R&D lab or not, in particular it takes value one when it does not have an R&D lab^v.

Firms facing international competition are expected to have greater incentives to innovate and to develop local and international collaborations that allow the internal integration of different knowledge sources (Powell et al., 1996; Tether, 2002; Bodas Freitas et al., 2008). To measure the degree of exposition to international competition we use the export intensity of firms. Firms that outsource great parts of their production and development processes are more likely to face higher organisational challenges to integrate learning and production activities in different locations (Wang and von Tunzelmann, 2000; Brusoni et al. 2001). Therefore we would expect that they might have greater incentives to collaborate with universities to keep up to date on knowledge developments of the outsourced technologies and components. Additionally, we would expect firms with higher levels of performance and innovation to be more likely to collaborate with universities. The variable value added per employee is a measure for performance, unit product value and innovation (Crespi and Pianta, 2008). Finally, owning an R&D lab can be used as a proxy for the research competences of the firm, and consequently for the ability to learn from research collaborations with university – as a proxy for its “absorptive capacity” (Cohen and Levinthal, 1990). In the literature, large firms in high-technology sectors with R&D lab have been found to be more likely to collaborate (Monjon and Waelbroeck, 2003; Fontana et al., 2006).

Second, we analyse the reasons for firms *not to* collaborate *institutionally* with universities. We extract the principal components of the reasons acknowledged by firms for not having collaborated institutionally with universities in the last 3 years. Then, we explore how differently these reasons have affected the firms’ decision to engage in *no collaboration* at all with universities and the decision to maintain *only personal collaborations* with specific university researchers. For this purpose, we run a Probit analysis on the variable *only personal collaborations*, which takes value one when the firm engaged in personal collaborations with university researchers, and zero when the firm stated that it did not have any institutional or personal collaborations with universities. In particular, we run the same Model 1 as specified above plus three dummy variables related to the different motivations for not collaborating institutionally with universities.

Third, we analyse the factors affecting the firms’ decision to *collaborate institutionally* with local universities, and to invest different amounts in these relationships. We examine the factors affecting the number of local universities – Università di Torino, Politecnico di Torino and Università del Piemonte Orientale – with which firms collaborate. In particular, we analyse how the number of local universities with which firms engaged in *institutional collaborations* relates to the characteristics of firms as well as to the objective of the collaboration. To explore this issue empirically, we run a Zero Inflated Poisson on the number of local universities with which the firm collaborated (through institutional channels) in the last three years. We run the same Model 1. The inflated model is defined by firm size, industrial activity and the presence of a R&D lab. We then run Model 3, which is the same as Model 1, plus some variables related to the number of different locations with which the firm collaborated outside the region (i.e. in the rest of Italy, in Europe and outside Europe) and to objectives of the collaboration (distinguishing between *R&D* – that is, technological development – *testing and analysis*, and *managerial issues* – that is, organization and management, marketing or logistics). We also run a Model 4, which is the same as Model 3 plus the count variable capturing information on the number of different objectives that firms had when collaborating with universities.

We then analyse the financial investment in *institutional collaborations* with universities in the last 3 years. To explore empirically how the characteristics of the firms, as well as the characteristics of the collaborations that firms were willing to develop, affected the amount firms invested in university collaborations, we run Heckman’s two-step model. The dependent variable is

the logarithm of one plus the total amount spent in the collaboration. We run the specification of Model 1, as specified above. Moreover, we run Model 5, which is the same as Model 1 plus some variables related to the objectives of the collaborations (i.e. *R&D, testing and analysis*, and *managerial issues*), the number of collaborations with universities in different locations, and whether the firm has maintained *institutional* collaborations with at least one local university. Moreover, we include the count variable capturing information on the number of different objectives that firms had when collaborating with universities. Finally we run Model 6, which is the same as to Model 5 but without the performance variable, as the level of investment might also relate to the performance level of the firms.

Which firms collaborate and how with universities?

Of the 1052 firms in our sample 104 responded that they had engaged in *institutional* collaborations with universities in the last 3 years, 83 responded that they only had *personal* collaborations with some university researchers (generally through individual consultancy contracts), and 865 responded that they did not undertake any kind of collaboration with universities. We first analyzed the differences across firms in each group.

With respect to the sample's structure, the firms that collaborate with universities are over-represented in the Food, Chemical and Mechanical sectors and only slightly over-represented in the Production of Electrical, Electronic and Communication Equipment, Production of Transportation Equipment and Other Manufacturing sectors, and in the provinces of Torino, Alessandria and Asti. They are instead under-represented in the more "traditional" Textile, Wood and Paper and Publishing sectors, and in the provinces of Biella, Novara, Vercelli and Verbania-Cusio-Ossola, where most of the traditional clusters are located.

Further, firms that collaborate with universities are over-represented in the "medium" and "large" size categories, especially the latter, and are strongly under-represented in the "small firms" category – in line with the findings of most of the literature (Mohnen and Hoareau, 2003; Arundel and Geuna, 2004; Laursen and Salter, 2004; Fontana et al 2006). If size is measured in terms of turnover, the data confirm that firms that collaborate with universities tend to be larger: they are in fact over-represented in the "between 5 and 10 million", "between 10 and 20 million" and "between 20 and 50 million" categories (interestingly, however, they are in line with the sample average in the "more than 50 million" category, indicating that very large firms do not tend to interact relatively more with universities). Finally, firms that possess an internal R&D unit tend to interact relatively more with universities. This is in line with the literature suggesting that firms that interact with universities need to possess the internal competencies and "absorptive capacity" (Cohen and Levinthal, 1990) that allows them to process and exploit scientific knowledge.

There are important differences in the characteristics of the firms using alternative modes of governance for university-industry collaborations. With respect to the sample's structure, the firms that engage in *institutional collaborations* with universities are over-represented in the Food, Chemical and Mechanical sectors, while the firms that only engage in *personal collaborations* are over-represented in the Textile, Production of Electrical, Electronic and Communication Equipment and Other Manufacturing sectors. The former are over-represented in the provinces of Alessandria, Asti and Torino while the latter are over-represented in the provinces of Biella, Torino and Vercelli.

There are also important differences in terms of size. While firms that engage in *institutional collaborations* with universities tend to be over-represented in the medium and large firms categories, firms that engage in only *personal collaborations* with university researchers are under-represented in the large firms category and are in line with the sample average in the small and medium firms categories. Also in terms of turnover, firms that engage in institutional collaborations with universities tend to be larger, as they are over represented in the categories "between 10 and 20 million", "between 20 and 50 million" and slightly over-represented in the category "over 50 million". Firms that engage in personal collaborations with university researchers are over-

represented in the categories “less than 2 million” and “between 5 and 10 million”. There seems to be, therefore, a distinction between larger firms in process industries and in mechanics, which tend to engage in institutional collaborations, and smaller firms in more traditional sectors, but also in specialized high tech sectors, which tend to engage in personal collaborations with university researchers. This is an interesting results as it contradicts one of the reasons for developing an institutionalised infrastructure of knowledge transfer that is the incapacity of small firms to interact with university researchers (see for example the original reasons for the development of the Bayh-Dole act)

Institutional versus personal collaboration with universities

In order to analyze how the different characteristics of firms influence their decision to collaborate or not to collaborate with universities, as well as the decision to undertake only formal or informal *personal collaborations* with individual researchers rather than engage in *institutional arrangements* with university, we estimate a Heckman Probit model.

The results of Model 1, shown in Table 1, suggest that either form of collaboration with universities, through *institutional agreements* or *personal collaborations* with individual researchers, are more likely in large firms with R&D labs, especially those not active in textile industries. Moreover, it suggests that *Institutional collaborations* rather than *only personal collaborations* are more likely in firms with no R&D lab and lower export intensity. When we use sectoral rather than industrial dummies results are slightly different. Larger firms with R&D labs are more likely to engage in collaboration with university, and also more likely to engage in *institutional collaborations* rather than *only personal collaborations*. In particular, firms active in product engineering industries are more likely to establish *institutional collaborations* rather than maintaining only *personal collaborations* with some specific university researchers.

Table 1. Heckman Probit Model Estimation of Institutional and Personal Collaboration with Universities

Institutional versus Personal collaborations			Institutional and Personal Collaboration		
Size	0.09	(0.12)	Size	0.42***	(0.1)
No R&D lab	0.39***	(0.14)	No R&D lab	-0.58***	(0.13)
Export	0.01	(0.10)	Food	0.222	(0.20)
VA_employee	-0.04	(0.10)	Textiles	-0.48**	(0.25)
Outsourcing	0.20	(0.21)	Wood	0.000	(0.2)
_cons	0.74**	(0.37)	Paper	0.184	(0.23)
			Chemical and Plastics	-0.097	(0.16)
			Metals	-0.156	(0.19)
			Electronic	-0.253	(0.28)
			Equipment	-0.099	(0.21)
			Transport	-0.129	(0.16)
			_cons	-0.74**	(0.33)
/athrho	-15.733	(5.366)			
rho	-1	(0)			
Observation	770				
Censored obs	679				
Uncensored obs	91				
Wald chi2(5)	75395.65***				
Log pseudolikelihood =	-295.78				
Wald test of indep. eqns. (rho = 0):	5.74**				
chi2(1)					

Thus, collaboration with universities either through *institutional arrangements* or *only personal collaborations* with some researchers, are more likely among more “capable” firms, i.e. large firms with their own R&D labs, as it had already emerged from the descriptive statistics. However, when it comes to the decision of the form of governance of this relationship, low-exporting firms with no R&D lab seem more likely to decide for *institutional collaborations* rather than *only personal collaborations* with university researchers.

Reasons for not collaborating with universities

In the survey, respondents were asked to identify some reasons for not having developed *institutional collaborations* with universities in the last 3 years, choosing among seven options, listed in the first column of Table 2 below. In order to understand the main factors underlying the firms’ decision not to collaborate institutionally with universities, we extracted the principal component factors of these data.

Results, shown in Table 2, suggest that reasons can be divided into three different groups, explaining 57.7% of total variance. Factor One includes reasons related to the fact that the firm has difficulty in establishing institutional contacts with universities, and consequently it engages in *other forms of collaboration*, such as personal collaborations with individual researchers and collaborations with other research centres that are not universities. Factor Two refers to *financial reasons* not to collaborate institutionally with universities. Factor Three refers to *industrial know-how* reasons, that is, the firm develops the know-how it needs internally, or it accesses it from other industrial partners.

Table 2. Rotated Loading factors of reasons for not having participated in institutional collaborations with universities in the previous 3 years

	1	2	3
The firm has no need for collaborations	0.049	-0.733	-0.276
The firm already has the advanced internal competences it needs	0.25	-0.062	0.619

The firm acquires the necessary knowledge from other partner firms	0.032	0.226	0.733
The firm collaborates with external non-university research centres	0.679	0.012	0.231
The firm may be interested in collaborating with universities, but it lacks the resources for this kind of investment	0.13	0.804	-0.081
The firm only engages in collaborations with individual researchers (payment is made directly to the researcher or to his/her own firm)	0.621	-0.074	0.298
The firm finds it difficult to contact universities	0.717	0.353	-0.293
Share of Variance explained	20.6%	19.5%	17.6%

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

Therefore, firms had different motivations not collaborate institutionally with universities. To better understand the differences between the 865 firms that did not undertake any form of collaboration with universities and the 83 firms that engaged on *only personal* collaborations with university researchers, we run a Probit Model. The dependent variable is the dichotomous variable *no institutional collaboration but engagement in personal collaborations* with university researchers^{vi}. We estimated Model 2 using the same regressors included in Model 1 plus the three dichotomous variables based on the three factors^{vii}.

The results of the Probit estimation^{viii} (Table 3) suggest that firms that engage in *only personal collaborations* with specific university researchers are more likely than no-collaborators to acknowledge the importance of in-house and industrial partners' specific industrial know-how, as well as to find it difficult to contract with university and to use of other forms of collaboration. In terms of industrial affiliation, firms in the Production of Metals and Chemicals industries are less likely to collaborate at all with universities, when compared to other manufacturing.

Compared with *non-collaborators*, firms that engaged only in *personal collaborations* with some specific university researchers are more likely to emphasise, as reasons for not engaging in institutional forms of collaboration with university, the use of other forms of collaboration and the importance of in-house and industrial partners' specific industrial know-how. That is, relative to those firms that do not collaborate with universities at all, those firms that rely only on personal collaborations seem to adopt more "open" innovation strategies based on the exchange of knowledge with external partners (including individual academics).

Table 3. Probit Model Estimation of Personal Collaboration with Universities

	Personal collaborations versus no collaboration	
Size	-0.13	(0.22)
Export	-0.06	(0.25)
No R&D lab	-0.16	(0.24)
Outsourcing	0.17	(0.36)
VA_employee	0.13	(0.21)
Food	-0.75*	(0.39)
Textiles	-0.73**	(0.35)
Wood	-0.97*	(0.52)
Chemical and Plastics	-0.96**	(0.41)
Metals	-1.25***	(0.37)
Equipment	-0.60	(0.37)
Electronic	-0.67	(0.44)
Transport	-0.70	(0.48)
Other forms of collab.	0.76***	(0.18)
Financial reasons	-0.24	(0.24)
Industrial know-how	0.34*	(0.19)
_cons	-0.31	(0.66)
Observations	351.00	
Wald chi2(16)	53.49***	
Log pseudolikelihood	-99.81	

Pseudo R2	0.18
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Characteristics of institutional collaborations: proximity with the university and size of the financial investment

We focus on the determinants of the firms' decision to collaborate institutionally with local universities, as well as on the level of financial investment in institutional collaborations with universities.

The 104 firms that engaged in institutional collaborations with universities had 153 collaborations in different locations, that is 1.47 collaborations per firm, on average. As expected, the distribution of these collaborations is skewed. Only 34 of these firms (32.7%) engaged in *institutional collaborations* with universities in more than one location.

We have classified collaborations into 5 classes, according to the location of the university: collaborations with the three local universities in Piedmont (1) with Università di Torino, (2) Politecnico di Torino and (3) Università del Piemonte Orientale; (4) collaborations with universities in neighbouring Regions (Liguria/Val d'Aosta/Rhone-Alpes/Paca e Lombardia); (5) collaborations with other universities in Italy and abroad. Of the 104 firms that engaged in *institutional collaborations* with universities, 15 firms (14.4%) did not have any collaborations with the 3 local universities, while 89 firms (85.5%) collaborated with at least one local university. Of the latter, 68 firms (65.3%) only collaborated with local universities. Only one firm collaborated with all the 3 local universities, and 15 firms collaborated with 2 of the 3 local universities.

In terms of industrial activity, size and presence of a R&D lab, firms that collaborate with the Università di Torino belong more frequently to the Food industry (11 firms, or 36.7% of the firms that collaborate with this university), while firms that collaborate with Politecnico di Torino belong more frequently to the Mechanics industry (17 firms, or 25% of the firms that collaborate with this university), followed by Production of Metals and Chemical industries (10 and 9 firms respectively). Collaborations with firms in specific industries appear to be to some extent driven by the nature of the research performed within the universities (in fact, as we discuss below, most collaborations take place for the purposes of technological development). Università di Torino performs a high share of its research in fields that are of relevance to the Food and Chemical industry (Chemistry, Biology and Biotechnology, Medicine, Environmental and Life Sciences, departments which also perform test and analyses of food products), while much of the research carried out at Politecnico is of relevance to sectors like Mechanics, Production of Metals and Production of Electrical, Electronic and Communication Equipment (the highest shares of publications by Politecnico researchers are in the fields of Engineering, Physical Sciences and Computer Science; Rossi and Geuna, 2009).

The highest numbers of collaborations with universities in neighbouring regions involve firms in the Food and Chemical industries while collaborations with distant universities are more frequent in the Mechanics and Production of Transportation Equipment industries.

Firm size is important in influencing firms' likelihood to collaborate with distant universities. It is especially large firms that engage in collaborations with more distant universities, while smaller firms tend to focus on local collaborations. This may be due to the fact that distant collaborations are more costly to maintain. Collaborations with Politecnico di Torino involve companies with a R&D lab, more than collaborations with the Università di Torino and the Università del Piemonte Orientale. This is probably due to the technological nature of the collaboration: a very large share of the firms collaborating with Politecnico di Torino, in fact do so for purposes of technological development. While this remains the primary motive for collaboration for all the universities, the universities that have a strong specialization in the social sciences (Università di Torino and Università del Piemonte Orientale) also attract a high share of collaborations whose objectives concern managerial issues (and, in the former case, testing and analysis).

If we analyze the number of institutional collaborations with local universities according to the objectives of the collaboration, we find that collaborations with local universities tend to predominantly involve technological development (56.4% of collaborations with local universities) and testing and analysis (27.4%).

To examine how firms' decision to engage in *institutional collaborations* with the three local universities relates to the characteristics of the firms and to the objectives of the collaborations, we estimate three Zero Inflated Poisson models (Models 1, 3, 4). The dependent variable is the number of local universities with which the firm had collaborated institutionally in the last 3 years. Table 4 reports the results.

Model 1 suggests that larger firms are more likely to maintain institutional collaborations with a higher number of local universities. Model 3 and 4 suggest that large firms with smaller export intensity, in particular those developing collaborations with universities aimed at a wider variety of objectives (R&D, testing and analysis and managerial purposes) are more likely to have *institutional collaborations* with a higher number of local universities^{ix}.

Table 4. Zero Inflated Poisson Model Estimation of the number of local universities with which firms have *institutional collaborations*

	Number of local institutional collaborations			
	Model 1	Model 3	Model 4	
Export	-0.38 (0.33)	-0.72** (0.34)	-0.81** (0.35)	
VA_employee	0.23 (0.31)	-0.10 (0.37)	0.10 (0.38)	
No R&D lab	-0.11 (0.35)	0.19 (0.56)	0.30 (0.56)	
Outsourcing	0.10 (0.48)	0.57** (0.26)	0.55** (0.26)	
Size	0.72*** (0.23)	0.16 (0.37)	0.18 (0.37)	
NonRegional collaborations		0.37 (0.32)	0.50 (0.33)	
R&D		2.2*** (0.36)	0.05 (0.90)	
Test&Analyses		1.8*** (0.42)	-0.50 (1.03)	
Organisation		1.81*** (0.40)	-0.83 1.20	
N_focus			2.37** (0.95)	
_cons	-2.77*** (0.73)	-3.98*** (0.86)	-4.23*** (0.88)	
Inflated Model				
Size	-31.53 (1661.43)	-36.07 (6004.02)	-34.62 (4515.33)	
No R&D lab	48.13 (2172.25)	69.38 (9388.29)	69.78 (13018.33)	
Food	-15.96 (1472.06)	-38.19 (31181.60)	-3.28 (35706.90)	
Textiles	79.27 (4071.25)	104.35 (15246.62)	137.87 (19570.72)	
Wood	-15.48 (1472.06)	-36.19 (30063.92)	-2.29 (39217.81)	
Paper	-29.76 (4702.03)	-36.47 (10645.76)		
Chemical and Plastics	31.08 (2027.38)	34.79 (6952.91)	68.83 (10696.48)	
Metals	16.09 (1525.45)	1.42 (7168.59)	35.66 (8884.55)	
Equipment	-15.19 (1472.06)	-20.77 (6383.86)	-2.00 (46456.27)	
Electronic	0.05 (2414.18)	0.92 (6699.89)	34.84 (9440.08)	
Transport	80.46 (4760.78)	104.76 (16704.75)	136.86 (19574.66)	
_cons	-48.93 (3011.14)	-84.53 (14295.40)	-122.17 (25243.57)	
Vuong test of zip vs. standard Poisson	3.47***	4.28***	4.24***	
Observations	511	511	511	
Non Zero observations	39	39	39	
Zero observations	472	472	472	
LR chi2	13.21**	111.85***	115.84***	
Df	5	9	9	
Log likelihood	-125.115	-75.799	-74.343	

In order to explore the factors affecting the level of financial investment in *institutional collaboration* with university, we estimate two Heckman selection models. The dependent variable is the logarithm of total amount spent in the collaboration. Table 5 reports the results.

Model 1 and 5 suggest that firms with high performance invest more in collaboration with universities. Model 6 indicates that firms with lower performance, and those involved in collaboration focused on *managerial* issues and on *testing and analysis*, are likely to engage in less expensive collaborations with university. This result implies that technological development is more expensive than collaboration activities directed at solving managerial issues.

The presence of collaborations with universities in the region does not significantly explain either the amounts spent on the collaborations nor the number of locations in which firms maintain collaboration with universities^x. Results were robust to the use of sectoral rather than industrial dummies.

The results provide support to the widely held view that firms with high performance - especially those firms that collaborate for technology development rather than for the development of management solutions - invest more in collaborations with universities. Firms with higher performance are expected to be in better financial position to invest; at the same time, for these firms, investments in technological development are crucial to maintain present performance.

Table 6. Heckman selection model of the logarithm of total investment in *Institutional* collaborations with university.

	Model 1	Model 5	Model 6
Size	1.41 (0.89)	1.14 (1.01)	0.47 (0.73)
Export	0.24 (0.71)	0.27 (0.81)	0.55 (0.55)
No R&D lab	-0.44 (0.74)	-0.07 (0.69)	0.04 (0.55)
VA_employee	1.3** (0.58)	1.28** (0.54)	
Outsourcing	0.70 (1.37)	1.53 (1.42)	2.01 (1.43)
Number Locations		0.13 (0.40)	-0.06 (0.39)
R&D		-1.07 (2.05)	-1.04 1.64
Test&Analyses		-1.92 (2.07)	-2.38 (1.71)
Organisation		-2.52 (2.87)	-3.79* (2.10)
N_focus		2.44 (1.79)	2.72* (1.61)
Local collaborations		-0.65 (0.92)	-0.33 (0.74)
_cons	2.17 (3.94)	2.45 (3.79)	6.99** (3.18)
	Selection Model		
Size	0.73*** (0.15)	0.73*** (0.15)	0.64* (0.13)
No R&D lab	-0.32 (0.21)	-0.32 (0.21)	-0.23 (0.19)
Food	0.46 (0.37)	0.46 (0.37)	0.19 (0.33)
Textiles	-0.89* (0.54)	-0.89 (0.54)	-0.76* (0.40)
Wood	-0.11 (0.51)	-0.11 (0.51)	-0.38 (0.48)
Paper	0.06 (0.44)	0.06 (0.44)	-0.16 (0.40)
Chemical and Plastics	-0.33 (0.41)	-0.33 (0.41)	-0.31 (0.35)
Metals	-0.25 (0.39)	-0.25 (0.39)	-0.34 (0.33)
Equipment	-0.23 (0.36)	-0.23 (0.36)	0.05 (0.29)
Electronic	-0.55 (0.53)	-0.55 (0.53)	-0.72 (0.50)
Transport	-0.05 (0.49)	-0.05 (0.49)	-0.18 (0.45)
_cons	-2.25*** (0.54)	-2.25*** (0.54)	-2.03 (0.47)
lambda	2.58 (1.37)	1.99 (1.45)	0.29 (1.18)
rho	0.96	0.92	0.22
sigma	2.67	2.16	1.34
lambda	2.58 (1.37)	1.99 (1.45)	0.29 (1.18)
Observations	782	782	794
Censored	753	753	753
Uncensored	29	29	41
Wald chi2	43.34***	49.97***	51.09****

df	7	13	12
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Conclusions

We have analysed the collaboration patterns of Piedmontese firms with universities, in particular with local universities. Using data from a survey to a representative sample of local firms, we find that the majority of firms (82.2%) did not collaborate at all with universities, 9.9% developed *institutional collaborations* with universities and 7.9% of firms had *only personal collaborations* with specific university researchers, while they did not engage in any institutional agreement with universities.

While most of the literature on university-industry knowledge transfer focuses on collaborations mediated by university institutions, and while the focus on such institutional collaborations drives public policy interventions, our data show that in Piedmont university-industry knowledge transfer very often takes place through personal collaborations between firms and individual academics. Both forms of governance of university-industry relationships are important in the region, and they seem to involve firms with different characteristics, both in terms of size (smaller firms are more likely to engage in personal collaborations with academics), sector of activity (where firms in more traditional sectors and in high technology sectors are more likely to engage in personal collaborations), turnover and province. Also, firms that engage in personal collaborations appear to be supporting open innovation strategies based on multiple forms of collaborations with external partners and on the integration of internal and external R&D, while firms that engage in institutional collaborations often substitute university research for their own internal R&D. It is therefore very important to include these personal collaborations, formal and informal, between firms and academics, when studying university-industry technology transfer and when devising public policies in order to support it.

Focusing on the interactions with specific universities, as expected, Politecnico of Torino (being the engineering / technology university) plays an important role, both in terms of the number of firms that have developed collaborations with it, and of the total amounts that these firms have invested in the relationships. Interestingly, also other Italian universities outside Piedmont (but not those in Lombardy, Liguria and Val d'Aosta, the regions nearest to Piedmont) play a major role: a few firms collaborate with these universities, but they invest in these collaborations the highest average amounts. The specific choice of which university to collaborate with appears to be strongly influenced by the objectives of the collaboration and by the nature of the research that is carried out within the universities, that is, firms seek local universities that present expertise in the areas that are relevant to the collaboration's objectives.

The maintenance of institutional collaborations with a higher number of local universities is particularly important for larger firms which supply mainly domestic markets; it is also associated with a high number of objectives of collaboration. In particular, collaboration with local universities seems essential for firms that aim at collaborating for the development of management solutions. To a certain extent, this finding implies that management solutions are culture- and region-specific because they need to match the firm's specific markets and technologies as well as to be familiar with the local institutions regulating/influencing the firm's activities.

Finally, exploring the level of financial investment in collaboration with universities, we find that the firms that spend the most in collaboration with universities are those with higher performance, involved in collaborations for technological development. Collaboration for technological development tends to be more expensive than collaboration for the development of management solutions or for undertaking of tests and analyses. Moreover, results propose that firms with higher performance may be in better financial position to invest, as well as that investments in technological development are crucial for them to maintain present performance.

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Acknowledgements

We would like to thank Piedmont's Chamber of Commerce for helping in the collection of the data. Specifically we thank Barbara Barazza for her support and comments. The creation of the UIPIE database used in this analysis was supported by the project IAMAT coordinated by Fondazione Rosselli.

Footnotes

ⁱ In a small number of cases, such as Stanford of KUL, the creation of the institutional infrastructure for knowledge exchange between universities and firms was due both to the need for institutional support expressed by academics who were highly involved in these interactions, and to the university's desire to regulate and benefit from industry contracts. In most cases, instead, it is the result of policy actions oriented to the creation of structured third stream activities within the university (see the case of the UK for a very active set of policies in this direction).

ⁱⁱ Numerous public research centres are also present in the region, however they are not discussed in this paper as we focused our analysis only on universities.

ⁱⁱⁱ The industries to which firms in our sample belong are: Food, Beverages and Tobacco (variable "food"), Textiles, Apparel and Shoes ("textiles"), Wood and Furniture ("wood") Paper, Printing and Publishing ("paper"), Chemicals, Rubber and Plastics ("chemical and plastics"), Production of Metals and Metal Goods ("metals"), Mechanics ("equipment"), Production of Electrical, Electronic and Communication Equipment ("electronic"), Production of Transportation Equipment ("transport"), Other Manufacturing companies ("other"). In some analyses, these industry variables have been aggregated into "sectoral" variables, as follows: fundamental industries, comprising Chemicals, Rubber and Plastics (variable "fundamen"), complex industries, comprising Production of Transportation Equipment ("complex"), product engineering industry, comprising Mechanics ("prodeng"), science-based industries, comprising Production of Electrical, Electronic and Communication Equipment ("science"), and finally other industries, comprising Food, Beverages and Tobacco; Textiles, Apparel and Shoes; Wood and Furniture; Paper, Printing and Publishing; Other Manufacturing companies ("others").

^{iv} There are about 390 missing observations for value added per employee. Firms for which we have information on value added per employee are slightly larger and tend export and outsource a slightly bigger share of their production.

^v There are about 230 missing observations for R&D lab. Firms that answered the question as to whether they had an own R&D lab are likely not to have collaborated, to be smaller and export less, and to have faced more financial restrictions to collaboration.

^{vi} The variable takes the value 0, when the firms did not collaborate with universities (neither through institutional nor through personal collaborations), and 1 when the firm did not collaborate institutionally with university but it engaged in personal collaborations with specific researchers.

^{vii} We created 3 categorical variables summing the variables that loaded high in the factors. In order to avoid endogeneity, we excluded from Factor One, the variable relating to having only personal collaborations with university researchers

^{viii} When we use sectoral rather than industry dummies, results suggest that firms that maintained *only personal collaborations* were more likely than *non-collaborators* to find it difficult to contract with universities and to use other forms of collaboration and less likely to be prevented from engagement in *institutional collaboration* due to financial reasons. Firms active in fundamental process sectors are more likely to be among *non-collaborators* rather than among the group that engaged only in *personal collaborations* with specific university researchers.

^{ix} When we use the sectoral rather than the industrial dummy variables, significance and sign of independent variables are unchanged.

^x When we run a Tobit Model, results suggest that firms with large share of production outsourced, involved both in collaboration with universities in different locations as well as in several different collaboration objectives, in particular technological development, and involved in collaboration in the region are more likely to invest more in collaborations with universities.