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Abstract

This paper explores the factors affecting firms' decisions concerning whether to collaborate with universities in their region or elsewhere, and the level of investment in the collaboration. Building upon an original survey of a representative sample of firms in the Italian region of Piedmont, the paper examines the effect of firm and collaboration characteristics (including the type and diversity of each collaboration's objectives) on the location of the university partners and on the investment in university-industry collaborations. We find that firms that are smaller, less engaged in international markets, less vertically integrated, and that engage in collaborations with universities in order to solve organizational problems, tend to collaborate more with regional universities. Firms tend to invest more in collaborations focused only on R&D activities with nearby universities, though the maximum amount spent in a collaboration was with a foreign university.

Keywords: University-industry relationships, learning regions, regional innovation systems, knowledge transfer, proximity

JEL: O31; O32; L25; R12

1. Introduction

Firms' ability to access knowledge through interactions with other organizations, including universities, is increasingly considered a source of competitive advantage. In a more aggregate perspective, the ability of regional firms and universities to exchange knowledge and integrate it in their own innovation activities is thought to stimulate collective learning processes (Lawton-Smith, 2007) leading to the development of "regional capabilities", which are a source of competitive advantage for regional actors and ultimately foster regional economic development.

Existing literature shows that firms that invest heavily in R&D and put greater effort into searching for external knowledge possess the absorptive capabilities needed to learn, and to maintain linkages with universities and public research institutes (Cohen, et al., 2002; Belderbos et al., 2004; Laursen and Salter, 2004; Fontana et al., 2006). Engaging in such collaborations, however, is likely to be costly to firms, not only in terms of direct research expenditures but also in terms of the transaction costs involved in the identification of potential university partners and in the setting up, organization and monitoring of the collaboration. It is likely that such transaction costs will affect firms' choice of which universities to collaborate with.

In this study, we examine what factors affect firms' decisions concerning the amount of funds to invest in the collaboration, focusing, in particular, on the effects of geographical proximity to the university and of the type and diversity of the objectives of the collaboration. On the one hand, the greater the geographical proximity to the university, the more likely both parties are to share the same social and cultural background, which facilitates communication and in turn makes it easier to initiate and organize the collaboration (including the negotiation and set up of contracts) (Gertler, 1995; Laursen, Reichstein and Salter, 2010). The ease of communication and the possibility of frequent direct contact also make it easier for the firm to monitor engagement (thus reducing the agency costs involved in collaborating with agents whose competences are sophisticated and hence difficult to assess) and to enforce rules and penalties. It is possible that sharing the same socio-cultural background also increases trust among the parties, lowering the risk of

opportunism and further reducing the costs of contract design, monitoring and enforcement (Bouty, 2000; Inkpen and Currall, 2004; Muthusamy and White, 2005).

On the other hand, it can be argued that the higher the number of aspects of the innovative process covered by the firms' university collaborations portfolio, the greater the firm's ability to use the knowledge provided by universities in order to meet their own business needs – i.e., the greater the firm's ability to absorb academic knowledge. This might make it easier and cheaper for the firm to repackage the general knowledge outputs of its university collaborations into specific practices, tools, processes or products that are closer to the firm's own needs (Cowan et al., 2000; Foray and Steinmueller, 2003), lowering the opportunity cost of collaborating with universities. Hence, firms that engage in collaborations aimed at multiple objectives – R&D, specific testing services, organizational problem solving – may be more willing to collaborate, because the expected value of academic knowledge for the firm is higher, and to invest in collaborations, because their cost of organizing such transactions are lower.

Empirically, we examine the importance of these and other factors on the amount of financial investment in university-industry collaborations using detailed firm-level data collected through an original survey of a representative sample of firms in the Italian region of Piedmont (UIPIE survey). The empirical analysis is structured in two steps. First, we investigate the characteristics of firms that collaborate with universities in different geographical locations, distinguishing between: firms that collaborate with specific regional universities; firms that collaborate with different numbers of regional universities; firms that collaborate with universities within the region, outside the region, and both within and outside the region. Second, we explore the influence of collaboration characteristics, in terms of location of partner universities and collaboration objectives, on the firms' financial investment in university-industry collaborations.

This understanding is very important for regional policy purposes: by investigating which features of regional firms and which collaboration characteristics are associated with greater variety of collaborations with regional universities and determine greater investment in university-industry collaborations, we can derive helpful suggestions

for regional policymakers who wish to stimulate interactions between firms and universities within their regions. These interactions can promote the development of regional capabilities, which in turn can constitute important sources of competitive advantage for firms based in the area.

The paper is structured as follows. In section 2 we review the relevant literature on the geographical dimension of university-industry collaborations, and we highlight how the present analysis originally contributes to this line of research. Section 3 presents a brief overview of Piedmont's regional innovation system and Section 4 introduces the data used for the empirical analysis. Section 5 presents the methodology (section 5.1) and the empirical results (sections 5.2 and 5.3). Section 6 concludes with a summary of the main results and some policy-relevant remarks.

2. University-industry relationships and regional innovation capabilities

As innovation processes become more open and distributed, firms' successful innovation activities increasingly depend on their ability to acquire knowledge from external sources - in particular, on their ability to effectively identify the knowledge they need and to integrate it in their research, development and production activities (Kline and Rosenberg, 1986; Freeman 1987; Arundel and Geuna, 2004).

Increasing attention has therefore been paid to interactions among firms and other organizations, including universities, as sources of new knowledge and innovation; often, it is highlighted that co-localization in the same region promotes such interactions, thanks to the parties' embeddedness in a homogeneous cultural, social and institutional context that allows the transmission of both codified and tacit knowledge (Quintas, 1992; Hippel, 1987; Maskell and Malmberg, 1999). While some authors have argued that modern information and communication technologies and stronger intellectual property rights are lowering the cost of codifying knowledge and increasing firms' ability to obtain external knowledge, thus reducing the importance of proximity to access tacit knowledge (Antonelli, 1999; Roberts, 2000), others maintain that most emerging and complex technologies will always depend on tacit knowledge (Senker, 1995) implying that proximity is likely to remain crucial for interactions to foster innovation. Most studies suggest that proximity to universities

facilitates and stimulates direct interactions and exchanges among personnel, thus helping firms to keep up-to-date on scientific developments (e.g. Jaffe 1989; Feldman 1994; Henderson et al. 1998; Mansfield 1995; Cooke 2001, 2002; Arundel and Geuna 2004). Frequent interactions with universities help firms integrate new scientific knowledge into their innovation processes, which is particularly important in the case of cutting-edge technologies (Tödtling et al. 2006, 2009).

Analytical concepts and frameworks such as those of learning regions (Asheim, 1996), regional innovation systems (Cooke et al, 1997) and competence theory of the region (Lawson, 1999) emphasize that interactive learning processes, supported by regional institutions, take place among regional actors; some authors suggest that these learning processes, over time, lead to the development of regional capabilities (Foss, 1996; Lawson, 1999; Lawson and Lorenz, 1999). Since such capabilities relate to knowledge which resides in the region, and "emerge in a historical processes from the systemic interaction among firms" (Foss, 1996, p. 3), they are highly idiosyncratic and localized, and hence difficult to replicate in other regions (Lawson and Lorenz, 1999; Antonelli, 2000; Romjin and Albu, 2002); therefore, regional capabilities can become important sources of competitive advantage, making regional firms more competitive by virtue of their localization. Understanding the interactions processes that give rise to higher-order regional capabilities is of great interest to policymakers intending to strengthen potential sources of regional competitive advantage and thus to increase the regions' attractiveness to firms.

Regional universities are often among the important actors involved in the interactions that sustain regional capabilities. The presence of a public science infrastructure, consisting of universities and public research institutes, is considered a key element in the innovation system (Lundvall, 1992; Nelson, 1993). However, there is still much to learn with respect to what roles regional universities play, in practice, in order to sustain local firms' innovation processes and hence in order to contribute to generating competitive advantages for the region vis-à-vis other locations. Existing studies on the role of geographical proximity in university-industry collaborations generally adopt one of two approaches.

First, numerous studies have investigated the extent to which co-localization of firms and universities (or public research laboratories) generates spatially-mediated knowledge spillovers from university research to industrial innovation, finding significant evidence in this sense (e.g. Jaffe 1989; Acs et al. 1994; Anselin et al. 1997; Henderson et al. 1998; Fritsch and Schwirten 1999; Fritsch and Slavtchev 2007; Laursen et al. 2008). With a few exceptions (Henderson et al., 1994; Beise and Stahl, 1999), empirical research suggests that knowledge spillovers from university research to firms decline with geographical distance. Most studies base their evidence on innovation surveys, citations to patents or to publications (or on matching citations from patents to publications) or on co-publication patterns, without delving into the specific processes that channel such knowledge, whether based on direct interactions or on pure spillovers from public research (D'Este and Iammarino, 2010). The contributions that have explored specifically the relative importance of different channels for university-industry knowledge transfer have consistently shown that most firms prefer to access university knowledge through open science channels, employment relationships, and through direct collaborations, and have suggested that the latter's importance has increased over time (Baldwin and Link, 1998; Link and Vonortas, 2002). Use (buying and licensing) of university-owned patents generally tends to rank low in importance for this purpose (Mowery and Sampat, 2005; Póvoa and Rapini, 2010).

Second, some studies have explored the extent to which distance matters in influencing the likelihood of knowledge transfer between universities and firms. For example, using U.S. survey data, Mansfield and Lee (1996) report that firms prefer to work with local university researchers within a hundred miles of the firm's R&D laboratory, Adams (2001) finds that private R&D laboratories consider distance to be a greater barrier when sourcing knowledge from public science than from firms, while Harhoff (1999) finds a positive relationship between new firm formation in high-tech sectors and the presence of university and other research scientists in a location. Research on the United Kingdom has shown that the research productivity of firms in science parks located near a university is higher than that of a matched sample of firms outside science parks (Siegel et al., 2003) and that academic research quality at near universities influences firms' localization decisions in industries like chemicals and pharmaceuticals, but not in others (Abramovsky et al. 2007).

Besides geographical proximity, other factors such as firm size, R&D intensity, industry, as well as the university's scientific specialization and research quality, have also turned out to be important in order to explain the frequency of knowledge transfer as well as the choice of channels through which it takes place (Agrawal and Henderson, 2002; Bekkers and Freitas, 2008; Póvoa and Rapini, 2010). However, issues related to the firms' ability to engage in collaborations with universities aimed at different objectives, indicating their ability to use diverse academic knowledge to meet their specific needs, have not been thoroughly investigated, despite the fact that the literature on the economics of knowledge development and codification has stressed how the process of conversion of general codified knowledge into specific practices, tools, processes or products is costly and time consuming (Cowan et al., 2000; Foray and Steinmueller, 2003). Moreover, whether or not the characteristics of the collaboration in terms of diversity of objectives pursued are related to the location of the university partner has been mostly neglected.

This paper, building upon an original empirical survey of a representative sample of firms based in the Italian region of Piedmont (UIPIE survey), contributes to the understanding of the regional dimension of university-industry knowledge transfer. It does so by investigating what are the firm and collaboration characteristics that are associated with a greater likelihood to collaborate with regional universities, and with greater overall investment in university-industry collaborations.

3. The regional context: Piedmont 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, and employment in this sector is consequently relatively high (33%). High and medium-high technology manufacturing is particularly strong, with about

12.1% of total employment compared to an average of 6.8% in the EU (25 countries, 2004). Good performance from the manufacturing sector is also highlighted in 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).

Piedmont has a strong specialisation in automotive components, Turin being the home base of Italy's main car producer FIAT. Among the R&D intensive companies localized in the region, many belong to the FIAT group (Alfa Romeo, Lancia, Ferrari, Maserati and Iveco), and some are well-known designers, specialized primarily, but not only, in automobile design (such as Italdesign-Giugiaro and Pininfarina). There are also some companies producing trains (such as Alsthom Ferroviaria) and aeronautics and aerospace firms (among others, Fiat Avio, Alenia Aeronautica, Alenia Spazio and Altec). Besides large R&D intensive firms, the regional 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 and wine. Well-known brands produced in Piedmont include for example Alessi, Ermenegildo Zegna, Fila, Ferrero, Lavazza, Martini-Bacardi and Marchesi di Barolo.

While Italy suffers from structural weakness in R&D investment (in the mid 2000s, Italy's R&D expenditure as a percentage of GDP was 1.1 % vs. an EU-25 average of 1.8 %), Piedmont is better positioned in this respect, having the third highest value of R&D expenditure among Italian regions in both absolute terms and as a percentage of regional GDP. The region is characterized by a high incidence of private R&D expenditure as a share of total R&D expenditure: while the Italian average is about 47%, Piedmont's share of private R&D is almost 80%. This is mostly due to some large Piedmontese firms which invest heavily in R&D, particularly FIAT (through 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, 2006). The third Community Innovation Survey

indicates that about 33% of Piedmontese companies were innovative, a few percentage points higher than the Italian average.

Fondazione Rosselli has published a set of regional scoreboard reports that map the performance of Piedmont's science and technology system and compare it with the performance of other Italian regions, of a sample of foreign regions, and with the Italian and European averages. The values, reported in Table 1, highlight that Piedmont is well placed, when compared with other Italian regions, although its position is much less favourable when compared with other foreign regions and with the EU-15 average. Piedmont has a value lower than the EU-15 average for Innovation Performance, and a value that is higher than the EU-15 average for Enabling Factors[1] (but lower than the highly innovative regions shown in the table).

Table 1: Performance of Piedmont's science and technology system

	TOTAL INNOVATIVENESS	*INNOVATION PERFORMANCE*	*ENABLING FACTOR*
Baden-W.	0.77	0.71	0.66
Bayern	0.76	0.71	0.65
Catalunya	0.34	0.40	0.46
Lombardia	0.47	0.51	0.54
Piedmont	**0.37**	**0.39**	**0.42**
Rhone-Al.	0.52	0.57	0.62
Stockholm	0.90	0.83	0.75
Campania	0.17	0.23	0.30
Emilia Romagna	0.29	0.37	0.46
Lazio	0.34	0.40	0.46
Toscana	0.22	0.35	0.47
Veneto	0.22	0.27	0.31
Italian AVERAGE	0.27	0.30	0.33
EU 15 AVERAGE	0.52	0.44	0.36
sample AVERAGE	0.45	0.48	0.51

Source: Fondazione Rosselli (2007); Data refer to 2004-2005

The universities and the many public research centres based in the region greatly contribute to local research and knowledge production. In Piedmont there are four universities, three of which 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)[2]. Founded in 1404, Università di Torino is composed of 12 schools and 55 departments. In 2007/08, it enrolled over 66,000 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

[1] These are: University-industry collaboration; Average scientific productivity; Scientific impact; Human resources employed in Science, Technology and Higher Education; Human resources employed in private innovation activities; Listing in new stock markets; Market capitalization; Number of venture capital investments; Venture capital intensity.

[2] Numerous public research centres, not discussed in this paper, are also present in the region.

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 Politecnico di Torino is quite narrowly specialized in engineering and architecture, Università di Torino offers undergraduate and postgraduate courses in a wide range of other disciplines (although, compared with other large Italian universities, its course offering is particularly oriented towards the social sciences, the humanities and medicine). 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 enrolled almost 10,000 students, employed 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 enrolled about 200 students and employed only 6 permanent academic staff. Available data on Pidemontese 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.

4. Data

We use data from an original survey (UIPIE) sent to a representative sample of 1058 firms based in the Italian region of Piedmont. This sample has been developed and validated by the local Chamber of the Commerce, which forwarded our questionnaire together with their quarterly survey on regional economic trends. This has ensured a very high response rate (1052 valid responses). It must be pointed out that the sample does not include the car manufacturer FIAT, the region's largest firm.

Firms were asked whether they had engaged in "institutional collaborations" (through contracts and agreements signed with either a university or a structure affiliated with a university, such as a department, school, research centre or technology transfer office) in the previous three years, with any of the following: each of the three public universities based in Piedmont (Università di Torino; Politecnico di Torino;

Università del Piemonte Orientale[3]), universities in the bordering regions of Lombardia, Liguria, and PACA/Rhone-Alpes, other universities in Italy, universities in Europe, and finally universities outside Europe. For each university that the firm had collaborated with, respondents were asked to specify the objective of the collaboration (from the options "technological development", "testing and analysis", "organization and management", "marketing", "logistics" and "legal issues"), to state the amount of money that was invested in the collaboration, and to assess whether the collaboration was satisfactory (based on four levels of satisfaction). Finally, non-collaborators were asked to identify their reasons for not collaborating.

This questionnaire was circulated in October/November 2008. Additional information about firm characteristics, such as size, industry, internal structure (investment in R&D and design, investment in the acquisition of external embodied and disembodied knowledge), and performance was provided by the local Chamber of Commerce. Of the 1052 respondents, 104 stated that they had engaged in institutional collaborations with universities in the previous three years.[4] In the rest of this paper, for sake of simplicity, we use the term collaborations to refer to "institutional" collaborations mediated by a university institution.

Compared with the set of 948 non-collaborating firms, the 104 firms that engage in collaborations with universities are more likely to belong to the more technologically intensive Food, Beverage and Tobacco and Chemical, Rubber and Plastics industries, and less likely to belong to the more traditional Textiles, Apparel and Shoes and Wood and Furniture industries. They are more likely to be based in the metropolitan province of Torino and in the province of Asti, and less likely to be based in the provinces of Novara and Vercelli. As the latter provinces are characterized by an industrial structure composed of small and medium enterprises active in traditional industries, while the province of Torino is home to the largest and more technologically advanced firms and Asti has a concentration of firms in the Food

[3] Firms were not asked about their relationships with Università di Scienze Gastronomiche, due to the latter's extremely small size and very recent origin, as detailed in Section 3.

[4] Another 83 firms responded that, while they did not have institutional collaborations with universities in the previous 3 years, in that same period they engaged in direct personal collaborations with some university researchers (generally through individual consultancy contracts). The features of the firms engaged in these two different forms of governance for university-industry relationships have been analyzed in a separate paper (Bodas-Freitas, Geuna and Rossi, 2010).

sector, this result reinforces the industry pattern. Size effects (whether measured in terms of employees or in terms of turnover) are also important, with larger firms being more likely to collaborate with universities and smaller firms less likely to do so (Bodas Freitas, Geuna and Rossi, 2010). Finally, firms that invest in internal R&D or design capabilities are more likely to collaborate with universities. This is in line with findings from other countries and regions (Mohnen and Hoareau, 2003; Arundel and Geuna, 2004; Laursen and Salter, 2004; Fontana et al., 2006), and points to the need for firms to have a sufficient level of internal competences (i.e., an adequate degree of "absorbing capacity"; Cohen and Levinthal, 1990) to be able to communicate with university personnel and exploit the knowledge transferred through the collaboration.

The 104 firms that engaged in collaborations with universities interacted at least once with universities in one of the different locations considered in 153 cases, that is 1.47 collaboration/university-location per firm, on average. As expected, the distribution of these collaborations is skewed. Only 34 of these firms (32.7%) engaged in collaborations with universities in more than one location. Only 15 (14.4%) of the 104 firms that engaged in collaborations did not collaborate with any regional university, while 89 firms (85.5%) collaborated with at least one regional university. Of the latter, only 36 firms engaged in collaborations outside Piedmont, but in no more than two other geographical areas, while the remaining 68 firms (65.4%) only collaborated with regional universities. Only one firm collaborated with all the 3 regional universities, and 15 firms collaborated with 2 of the 3 regional universities.

Most firms collaborate with universities for technological development objectives (about 63%), followed by testing and analysis objectives. However, firms also develop relationships with universities to solve problems that are not related to technology development or testing: about 21% of firms have had at least one collaboration with a university focused on addressing organizational issues. Finally, about 12% of the firms have had collaborations directed at more than one objective. No firm in the sample has collaborated with universities for all three possible objectives (in the analysis, possible collaboration objectives have been grouped into three categories: R&D, which refers to technological development activities; Test, which refers to testing and analysis activities; and Organizational, which refers to

organization and management, marketing, logistics and legal issues). Only 7 firms have engaged in collaboration with universities for R&D and Test and 5 firms for R&D and Organization, and 1 firm has engaged in coloration for Test and Organization.

5. Empirical analysis

5.1. Methodology

To undertake this research, we use data from the UIPIE survey described in Section 4 and we proceed in two steps. First, in section 5.2, we examine how collaborations with university institutions in different geographical locations are related to different firm characteristics. For this purpose, we analyze linear differences among firms that collaborate with each of the five groups of universities considered (each of the three regional universities, universities in the bordering regions of Lombardia, Liguria and PACA/Rhone Alpes, and other universities in Italy and abroad); and among firms that collaborate with different numbers of regional universities. Then, we analyse the linear differences among firms that only collaborate with regional universities, firms that only collaborate with universities outside the region, and firms that collaborate with both. In order to account for the multiple firm characteristics that may influence the pattern of collaboration with universities, we run a Multinomial logit on the same categorical variable indicating the pattern of collaboration (only with regional universities, with regional and non-regional universities and only with non-regional universities). We include all the variables related to firm characteristics, and those related to the objectives of the collaboration described in Table 2 below.

Table 2. Variables used as independent and control variables related to collaboration and firm characteristics, and their descriptive statistics

	Type	*Variable name*	*Description*	*N*	*Min*	*Maxim*	*Mean*	*Std. Dev.*
Collaborations' Characteristics	Technological development	R&D	1 if the firm reports to have collaborated with universities for technology development, 0 otherwise	1052	0	1	0.06	0.24
	Testing and analysis	Test	1 if the firm reports to have collaborated with universities for test and analysis, 0 otherwise	1052	0	1	0.03	0.17
	Organizational	Organizational	1 if the firm reports to have collaborated with universities for organizational issues, 0 otherwise	1052	0	1	0.02	0.12
	Regional collaborations	Regional	Count variable of the number of regional universities with which the firm collaborates. It can take values from 0 to 3.	1052	0	3	0.10	0.35
	International Collaboration	International	1 if the firm reports to have collaborated with universities abroad (in Europe or extra-Europe), 0 otherwise	1052	0	1	0.01	0.10
	Number of geographic areas of collaboration	Areas	Count variable of the number of different locations of the university partners of firms. It can take values from 0 to 5.	1052	0	3	0.13	0.42
Firm's Characteristics	Size	Lnemp	Logarithm of the number of employees	1058	0	9.47	3.42	1.20
		Sqsize	Square of the logarithm of number of employees	1058	0	89.60	13.17	9.62
	Innovation efforts	Innov_C	1 if the firm commits efforts to internal R&D or design activities, 0 otherwise	950	0	1	0.35	0.48
	Complementary investments	Techn_Sourcing	1 if the firm invested in either acquisition of patents, external know-how or informational and data process equipment and software, 0 otherwise	915	0	1	0.37	0.48
	Export	Dexport	1 if the firm exports more than 20% of their production, 0 otherwise	1058	0	1	0.42	0.49
	Multinational	Multin	1 if the firm produces 5% or more of their product in plants outside the country	1058	0	1	0.19	0.39
	Outsourcing	Outsour	Logarithm of the share of production outsourced in Italy or abroad to subcontractors	1058	0	1	0.10	0.29
	Industry	Food	Food, Beverages and Tobacco	1057	0	1	0.10	0.30
		Textiles	Textiles, Apparel and Shoes	1057	0	1	0.15	0.36
		Wood	Wood and Furniture	1057	0	1	0.06	0.23
		Paper	Paper, Printing and Publishing	1057	0	1	0.06	0.24
		Chemical	Chemicals, Rubber and Plastics	1057	0	1	0.10	0.30
		Metals	Production of Metals and Metal Goods	1057	0	1	0.18	0.38
		Equipment	Mechanics	1057	0	1	0.15	0.36
		Electronic	Production of Electrical, Electronic and Communication Equipment	1057	0	1	0.07	0.25
		Transport	Production of Transportation Equipment	1057	0	1	0.04	0.21
		Jewellery	Jewellery	1057	0	1	0.02	0.15
		Other	Other Manufacturing companies	1057	0	1	0.08	0.27

Second, in section 5.3, we explore the determinants of the intensity with which firms pursue collaborations with universities (where intensity is measured in terms of amount of financial investment in collaboration). Since our dependent variable is truncated, as we only observe a value equal or superior to 0, we run a Tobit model on the logarithm of one plus the total amount spent in the collaboration with universities in the last 3 years. The set of independent variables used in the regression are reported in Table 2. In Appendix 1, Table A provides the correlation coefficients for the firms that reported information on their collaborations with universities. The regressors refer to characteristics of the collaboration and characteristics of the firm.

5.2. Firms' collaborations with universities: location, variety and type

Table 3 provides information on the firm's characteristics (industry, size) and on the objectives of the collaboration associated with the location of the university partner. Firms that collaborate with Università di Torino belong more frequently to the Food industry (11 firms, or 36.7% of the firms that collaborate with this university); this is not surprising, as Università di Torino performs a high share of its research in fields (Chemistry, Biology and Biotechnology, Medicine, Environmental and Life Sciences) that are of relevance to the Food and Chemical industry. Firms that collaborate with Politecnico di Torino belong more frequently to the Mechanics industry, followed by Production of Metals and Chemical industries (and are significantly less likely to belong to the Food industry). Much of the research carried out at Politecnico is of relevance to industries 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). Firms in the Chemical, Plastics and Rubber industry are significantly more likely to collaborate with Università del Piemonte Orientale and with universities in neighbouring regions (but not with universities in other Italian regions and abroad), suggesting that those universities may possess specific competences sought after by firms in this industry. Firms in the Production of Transportation Equipment sectors are significantly more likely to collaborate with distant universities, suggesting that these firms are seeking for specific technological competences. These results suggest that the firms' choice of which specific university to collaborate with is influenced by the extent to which the

field of research performed by the universities is "close" to the firms' knowledge needs.

Table 3. Distribution of collaborations across universities, by industry, size and objective of the collaboration

	Università di Torino	*Politecnico di Torino*	*Università del Piemonte Orientale*	*Universities in bordering regions*	*Other universities in Italy and abroad*
	N = 30 %	N = 68 %	N = 8 %	N = 12 %	N = 28 %
Food, Beverages and Tobacco	36.7**	4.4**	25.0	25.0	21.4
Textiles, Apparel and Shoes	0.0	7.4	0.0	0.0	3.6
Wood and Furniture	3.3	1.5	0.0	0.0	0.0
Jewellery	3.3	2.9	0.0	0.0	0.0
Paper, Printing and Publishing	3.3	7.4	0.0	0.0	0.0
Chemicals, Rubber and Plastics	20.0	13.2	37.5*	50.0***	3.6*
Production of Metals and Metal Goods	10.0	14.7	0.0	0.0	10.7
Mechanics	13.3	25.0	12.5	16.7	25.0
Production of Electrical, Electronic and Communication Equipment	6.7	8.8	0.0	0.0	10.7
Production of Transportation Equipment	0.0	7.4	12.5	0.0	17.9*
Other Manufacturing companies	3.3	7.4	12.5	8.3	7.1
Alessandria	13.3	8.8	37.5*	33.3	17.9
Asti	10.0	14.7	12.5	8.3	3.6
Biella	0.0	7.4	0.0	0.0	3.6
Cuneo	16.7	11.8	0.0	8.3	17.9
Novara	0.0	5.9	12.5	8.3	7.1
Torino	53.3	47.1	25.0	33.3	42.9
Verbania-Cusio-Ossola	3.3	2.9	0.0	0.0	7.1
Vercelli	3.3	1.5	12.5	8.3	0.0
10-49 employees	33.3	32.4	25.0	0.0**	35.7
50-249 employees	46.7	36.8	25.0	50.0	28.6
more than 250 employees	20.0	30.9	50.0	50.0*	35.7
R&D	43.3	58.8	25.0	75.0**	60.7
Test	30.0	23.5	12.5	8.3	21.4*
Organizational	20.0	13.2	25.0	25.0	10.7
Excellent	29.6	39.7	20.0	63.6*	34.8
Good	66.7	57.1	80.0	27.3*	65.2
not satisfactory in terms of timing	0.0	1.6	0.0	9.1*	0.0
not satisfactory in terms of quality	3.7	1.6	0.0	0.0	0.0
Innovative efforts					
Yes	50.0	68	50.0	17	61.0
No	50.0	32	50.0	83	39.0

significance codes: * 0.1, ** 0.5, *** 0.01
(t-test are calculated with respect to distribution of firms that interact with universities)

Firms that collaborate for R&D objectives are more likely to engage in collaborations with universities in bordering regions, while those that collaborate for Test purposes are more likely to interact with universities in other Italian regions and abroad. This suggests that firms are willing to interact with distant universities when they seek specialist technological competences and specialist services. With respect to size, large firms are more likely to engage in collaborations with universities outside the region, while small firms are less likely to do so. Firms in the province of Alessandria are statistically more likely to interact with Università del Piemonte Orientale, which

is based in Alessandria, Novara and Vercelli, suggesting that the presence of a university in the province stimulates collaborations with local firms.

Finally, concerning firms' evaluation of their collaborations with university, half of the collaborations are rated as "good" and a further third as "excellent". The only exceptions are collaborations with universities in neighbouring regions, which are more likely to be rated as "excellent" (but also as "not satisfactory in terms of timing").

Table 4. Differences between firms according to the number of different regional universities they collaborate with

		one	*two or three*	
		N= 73	N = 16	
		%	%	
Province	Alessandria	15.1	6.3	
	Asti	16.4	6.3	
	Biella	6.8	0.0	
	Cuneo	12.3	12.5	
	Novara	4.1	6.3	
	Torino	39.7	62.5	*
	Verbania-Cusio-Ossola	1.4	6.3	
	Vercelli	4.1	0.0	
Size	10-49 employees	38.4	18.8	
	50-249 employees	42.5	31.3	
	more than 250 employees	19.2	50.0	***
Other collaborations	Universities in bordering regions	9.6	12.5	
	Other universities	11.0	43.8	***
	Only regional universities	80.8	56.3	**
	Both regional and non-regional	19.2	43.8	**
Objectives	R&D	64.4	56.3	
	Test	31.5	25.0	
	Organizational	9.6	43.8	***
	Test & Organizational	0.0	6.3	**

Note 1: significance at: * 0.1, ** 0.5, *** 0.01

We focus now on firms that collaborate with regional universities. Table 4 provides information on the significance of the linear differences across firms with different number of regional university partners. Firms that collaborate with two or three regional universities are more likely to be large and to be based in the metropolitan province of Torino. These firms are also more likely to collaborate with universities outside the region, to engage in collaborations that involve organizational issues, and to collaborate for a combination of Test and Organizational objectives. This may indicate that firms that seek university support for a variety of problems, which could signal greater absorptive capacity, are more likely to collaborate with a greater number of regional universities (as well as with universities outside the region).[5]

[5] Consistently with these descriptive results, a set of Zero-Inflated Poisson models run on the number of collaborations with regional universities suggest that larger firms, with lower export intensity, and

In order to account for the multivariate effects of the different variables, we run a Multinomial logit on the categorical variable that identifies whether the firm only maintains collaboration with regional universities, with both regional and non-regional universities of only with non- regional ones. Results are reported in Table 5.

Table 5: Multinomial Logit model of the pattern of collaborations with universities: only with regional universities, both with regional and non-regional universities and only with non-regional universities.

	Both regional and non-regional collab. vs. Only regional collab.	*Only non-regional collab. vs. Only regional collab.*	*Only non-regional collab. vs. Both regional and non-regional collab.*
Lnempl	-3.082	2.867	5.949**
	(2.283)	(2.325)	(2.938)
Sqsize	0.406*	-0.259	-0.665**
	(0.240)	(0.266)	(0.318)
Dexport	0.0736	1.540**	1.467
	(1.142)	(0.757)	(1.162)
Outsour	-0.147	-0.0478	0.0989
	(0.151)	(0.0311)	(0.150)
Multin	-0.257	-0.0670	0.190
	(2.218)	(1.214)	(2.605)
Innov_C	0.520	0.412	-0.107
	(0.859)	(0.869)	(1.203)
Tech_Sourcing	0.751	-0.343	-1.094
	(0.728)	(0.883)	(1.004)
R&D	3.871***	-0.0183	-3.889
	(1.497)	(1.799)	(2.458)
Test	3.168***	-0.227	-3.395
	(0.970)	(1.914)	(2.249)
Organizational	2.644**	-17.05***	-19.69***
	(1.220)	(2.690)	(2.860)
Intercept	0.569	-9.902*	-10.47
	(5.334)	(5.719)	(7.143)
Industry dummies	Significant		
Observations	91		
Df	39		
Pseudo R2	0.38		
Log pseudolikelihood	-51.4		

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

Firms that collaborate only with regional universities are less likely to collaborate for R&D, Test or Organizational activities, when compared to firms that collaborate with

firms that engage in collaborations with universities aimed at a greater variety of objectives are more likely to maintain collaborations with a higher number of regional universities.

regional and non-regional universities. Instead they are more likely to collaborate for Organizational issues than firms that collaborate only with non-regional universities. Firms that collaborate only with universities outside the region tend to be larger in size (up to a threshold, there is a quadratic relationship) compared to firms that collaborate with both regional and non-regional universities. In addition, firms that only collaborate with universities outside the region are more open to international markets, when compared to firms that only collaborate with regional universities. Finally, firms that collaborate only with universities outside the region are less likely to develop collaborations aimed at solving organizational issues.

These results suggest that firms engage in university collaborations characterized by low geographical proximity when they have little need for support with organizational issues. Instead, firms that have both regional and non-regional collaborations, compared to those that collaborate only regionally, are more likely to be engaged in a portfolio of collaborations with different objectives focused on R&D and also on other activities, which may support the absorption of external knowledge. Firms that collaborate with regional universities (either only regional or both regional and non-regional) are more likely to do so for organizational problem solving than those that only collaborate with non-regional ones. This may suggest that organizational issues are more context-specific and therefore firms prefer collaborations with geographically closer universities.

5.3 Investment by Piedmontese firms in collaboration with universities

To examine whether geographical proximity and the objective of the interaction affect the level of firms investment in university collaboration we estimate a Tobit model as follows:

$$Ln(1+TotEXP) = \alpha + \beta X_i + \gamma Y_i + \chi Z_i + \varepsilon \qquad (1)$$

where the dependent variable is the logarithm of total amount spent in collaborations with universities in the last three years, X_i is a vector of variables capturing the objectives of the collaboration, Y_i a vector of variables measuring geographical proximity and Z_i is a vector of control variables.

The dichotomous variables *R&D*, *Test* and *Organizational* capture information on whether the firm collaborates for purposes of technological research and development, for testing and analysis activities and for the solution of organizational issue (i.e. organization, managerial, marketing, logistics issues) respectively. We expect *R&D* followed by *Test* to be more expensive activities than the solution of organizational problems.

To account for the combined use of different types of collaborations and consequently for the number of aspects of the innovative process that the portfolio of university collaborations cover, we include two variables indicating whether the firm collaborates with universities for more than one objective (*R&D&Test*, *R&D&Organizational*). A greater number of different objectives addressed through collaboration with universities may signal greater ability (willingness) on the part of the firm to interact with universities in order to address different business needs. This may indicate that it is easier for the firm to absorb the knowledge outputs of university collaborations, by decreasing time and costs of reproducing that knowledge into specific practices, tools, processes or products (Cowan et al.,2000; Foray and Steinmueller, 2003). Therefore, we expect these firms to find it easier to collaborate with universities and hence to invest more in the collaboration.

The count variable *Regional* counts the number of regional universities with which the firm collaborates, while the dichotomous variable *International* reports whether or not the firm has engaged in collaboration with international partners. With these two variables we try to capture whether firms recognise, in their decision of how much to invest in collaboration with universities, the importance of geographical proximity in reducing transaction costs. Additionally, as a control, we include the variable *Areas* that reports the number of different geographical areas in which the universities are located (the region Piedmont, bordering regions of Lombardia, Liguria, Val d'Aosta and PACA/Rhone Alpes, other Italian regions and abroad). The number of geographical areas can be a proxy for the geographical width of the collaborative network of the firm. We expect that the wider the firm's network of collaborations, the higher the amount it will need to spend in order to maintain and use these collaborations. In principle, this variable could take value from 0 to 5, however our

firms did not engage in collaborations with universities in more than 3 geographical areas.

Furthermore, we include a set of control variables capturing information on the organizational and market characteristics of firms. We expect the amount invested in collaboration with universities to depend on the size of the firm; hence, we control for size effects by including the variables *Lnempl* and *Sqsize* which report the logarithm of number of employees and its square. The variable *Innovation Capabilities (Innov_C)* provides information about whether firms invest in internal R&D or design activities. This can be used as a proxy for the firm's research competences and, consequently, for the ability to learn from research collaborations with a university – as a proxy for absorptive capacity (Cohen and Levinthal, 1990) – which we expect to be positively related to the amount invested in collaborations. The variable *Technology Sourcing (Tech_Sourcing)* captures information on whether the firm invests in the acquisition of external embodied and disembodied knowledge, in particular patents, know-how and information and processing software and hardware. The degree to which firms are open to external knowledge can be expected to influence the firms' decision to collaborate and the amount invested in collaboration with a university (Laursen and Salter, 2004; Fontana et al., 2006). To measure the degree of exposure to international competition we use the export intensity of firms, and whether the firm has multinational activities. The variable *Dexport* provides information on whether the firm exports more than 20% of production. The variable *Multin* contains information on whether the firm owns production activities abroad that represent more than 5% of total output. We would expect that firms involved in international competition would have a greater incentive to innovate and to develop local and international linkages and collaborations that allow the internal integration of different knowledge sources (Powell et al., 1996; Bodas Freitas et al., 2008). Therefore, we expect the amounts invested in collaborations to be positively affected by international competition. The variable *Outsour* provides information on the level of production outsourced (logarithm of production outsourced to other firms in Italy or abroad). Firms that outsource more of their production and development processes are more likely to experience greater organizational challenges in integrating learning and production activities developed in other locations (Brusoni et al., 2001). Outsourcing also implies the development of relational (network) skills that can be

used in other forms of cooperation. Therefore, we would expect that firms that outsource heavily would have greater incentives to invest in collaborations with universities to keep up to date with the knowledge involved in the outsourced technologies and components, and also better capacity to manage collaborative relationships with outside partners. Finally, we control for industry effects by including industry dummies (other manufacturing is the reference category).

Table 6. Tobit model of the logarithm of total investment in collaborations with universities.

	Considering objectives of collaboration portfolio individually				Considering the combination of the collaboration objectives			
	Model 1 (Enter)	Model 2 (Enter)	Model 3 (Enter)	Model 3 (Backward Method)	Model 1 (Enter)	Model 2 (Enter)	Model 3 (Enter)	Model 3 (Backward Method)
Lnempl	0.145	0.891	2.119 [a]	2.159*	2.133	7.405***	7.532***	7.697***
	[1.126]	[1.169]	[1.341]	[1.323]	[3.168]	[1.781]	[1.587]	[1.708]
Sqsize	0.055	-0.022	-0.184	-0.184	-0.0673	-0.726***	-0.805***	-0.823***
	[0.123]	[0.127]	[0.156]	[0.143]	[0.351]	[0.175]	[0.167]	[0.180]
Dexport	-0.358	-0.050	-0.052		2.426 [a]	1.718 [a]	1.077 [a]	1.126 [a]
	[0.608]	[0.654]	[0.600]		[1.586]	[1.051]	[0.731]	[0.744]
Outsour	-0.025*	-0.025	-0.002		-0.0864*	-0.048	0.011	
	[0.016]	[0.023]	[0.019]		[0.0460]	[0.048]	[0.023]	
Multin	1.226 [a]	1.303 [a]	1.067 [a]	0.860	2.465	1.501	0.868	0.902
	[0.777]	[0.886]	[0.803]	[0.665]	[1.836]	[1.656]	[1.101]	[0.777]
Innov_C	0.825	0.768	0.513		1.282	0.810	0.183	
	[0.681]	[0.657]	[0.565]		[1.388]	[0.802]	[0.597]	
Tech_Sourcing	-0.473	-0.785	-0.938 [a]	-0.864	-1.867	-1.872*	-1.637**	-1.506**
	[0.597]	[0.612]	[0.578]	[0.643]	[1.459]	[1.026]	[0.719]	[0.717]
R&D	15.204***	13.304***	10.412***	10.376***	22.83***	10.024***	6.291***	6.055***
	[0.577]	[1.124]	[1.611]	[1.151]	[1.501]	[1.279]	[1.086]	[0.874]
Test	12.400***	10.271***	7.821***	7.877***				
	[1.065]	[1.550]	[1.905]	[1.199]				
Organizational	8.350***	5.055 [a]	3.160	3.056*				
	[2.571]	[3.247]	[2.713]	[1.647]				
Areas			3.132**	3.218***			5.981***	6.071***
			[1.300]	[0.834]			[1.326]	[0.843]
Regional		2.451**	1.604	1.568*		10.268***	5.203***	5.209***
		[1.165]	[1.000]	[0.820]		[1.137]	[1.141]	[0.863]
International		0.687	-1.344	-1.472		9.206***	1.687	1.673
		[1.961]	[1.987]	[1.478]		[1.698]	[2.566]	[1.877]
R&D & Test					0.806	-1.998	-2.856*	-2.872*
					[1.762]	[2.636]	[1.663]	[1.688]
R&D & Organizational					-4.658**	-13.556***	-11.429**	-11.628***
					[2.105]	[2.347]	[5.136]	[2.355]
Intercept	-6.872***	-8.374***	-10.065***	-10.250***	-16.23**	-23.043***	-21.133***	-22.430***
	[2.383]	[2.690]	[2.756]	[2.984]	[6.436]	[4.087]	[3.489]	[4.053]
Industry dummies	Signif.	Signif.	Signif.	Signif.	Signif.	Signif.	Signif.	Signif.
/sigma	2.880***	2.806***	2.569***	2.584***	6.961***	3.765***	2.858***	2.883***
	[0.349]	[0.326]	[0.321]	[0.257]	[0.839]	[0.415]	[0.218]	[0.290]
Observations	875	875	875	875	874	874	874	874
Uncensored	61	61	61	61	60	60	60	60
Left-censored	814	814	814	814	814	814	814	814
F Test	66.52***	62.24***	57.39***	.	21.60***	46.32***	81.70***	.
Df	F [20, 855]	F [22, 853]	F [23, 852]	17	F [20, 854]	F [22, 852]	F [23, 851]	18
Chi-Square test				492.55***				471.75***
Log pseudolikelihood	-178.7	-174.6	-167.8	-168.6	-264.6	-194.5	-172.1	-173.1
Pseudo R2	0.569	0.579	0.595	0.594	0.354	0.524	0.579	0.577

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

Table 6 reports the Tobit estimates. Results suggest that firms tend to spend more in collaborations with regional universities (the dummy variable for regional collaboration was always significant and positive, not reported here); and that firms spend more the greater the number of regional universities with which they collaborate (*Regional*), suggesting that geographic proximity facilitates interaction, probably because the agency and transaction cost of university-industry collaborations are lower at regional level. In addition, the number of different geographical locations in which firms have university partners (*Areas*) significantly explains the amount spent in collaborations with universities: the wider the geographical network of university collaborations, the higher the investment. Instead, the presence of collaborations with universities abroad (*International*) does not significantly explain the amount of investment in university collaboration.

Firms that have collaborations aimed at R&D and technological development (*R&D*) tend to make the highest investment in university-industry relationships. Collaboration for technological development is more expensive than collaboration activities directed at providing testing and analysis services followed by organizational problem solving (organisation, marketing, logistics, legal issues). In columns 5-8 we focus on those firms that collaborated for more than one objective; due to the small number of observations, we can only include a subset of variables. Contrary to our expectation, firms that collaborate not only in R&D but also in R&D & Test and R&D & Organizational invest less in collaborating with universities, especially R&D & Organizational.

Concerning the control variables, the estimates indicate a positive effect of firm size (*Lnempl*) and, contrary to our expectations, a negative impact (though the significance is weak) of sourcing technology from outside (*Tech_sourcing*). The more a firm relies on outside technological information the less it spends in collaborations with universities; this may indicate either a substitution effect among alternative external sources of information or the fact that technological sourcing from outside the firm may be correlated with lower absorption capacity and therefore higher difficulty in interacting with university research. Finally, industrial dummy variables are

significant and important indicating important differences in research cost (or willingness to invest in research) across industries.

Overall, collaboration portfolios with higher geographic proximity, focused on technology development and involving universities from different geographical areas are more likely to involve higher financial investment. Larger firms that are less involved in technology sourcing are also more likely to invest higher amounts in collaborations with university.

6. Conclusions

This paper explored the factors that affect firms' decisions concerning whether to collaborate with universities within and outside the region, and how much to invest in these collaborations. Empirically, we have examined these issues using data collected through an original survey of a representative sample of companies located in the Piedmont region of Italy.

Our evidence suggests that geographic proximity is instrumental in order to reduce transaction costs, and consequently it is associated with greater investment in the collaborations. Indeed, firms are often more likely to collaborate with universities from their own province, suggesting that the presence of a local university acts as an attractor for collaborations. Only large firms with considerable internal resources and a high level of absorptive capacity can afford to engage only in collaborations characterized by low geographical proximity (i.e. collaborations characterized by higher transaction costs). Instead, firms that are less endowed with internal resources (smaller, less vertically integrated, less export-oriented) exploit the advantages of geographical proximity.

However, geographic proximity is unlikely to be the only factor involved in the choice of which specific university to collaborate with: such choice in fact appears driven by the competences of the university (i.e. whether or not they are specific to the firm's needs) and by the objective of the collaboration. Firms tend to seek technological support and specialist services – such as testing and analysis - from universities even in distant locations, while collaborations around organizational

issues take place preferentially with regional universities, suggesting that organizational competences are more context-specific.

From a policy perspective, these results suggest that the competences that the regional universities possess, and the scientific research fields that they specialize in, are crucial in attracting collaborations from regional firms. Therefore, the development of a strong university research base in scientific fields that are close to the sectors of activity of regional industry is likely to be crucial in order to stimulate regional university-industry relationships and to eventually create a regional competitive advantage. It must be pointed out that these academic competences are not necessary linked to technological development and to the hard sciences. A considerable share of university-industry collaborations in fact involve the provision of services from academia to industry, in the form of testing and analysis and of consultancies around organization, logistic and marketing issues, and the latter are particularly sought from regional collaborations. Interestingly, firms that collaborate on organizational issues are more likely to collaborate with a greater number of different regional universities, so university-industry collaborations aimed at organizational issues tend to be regionally oriented rather than oriented to a specific local university.

References

Abramovski, L., Harrison, R., Simpson, H. (2007) University research and the location of business R&D, Economic Journal, 117, 3, 114-141.

Acs, Z., Audretsch, D., Feldman, M. (1994) R&D spillovers and recipient firm size. The Review of Economics and Statistics, 76: 336–340

Adams, J.D. (2001) Comparative Localization of Academic and Industrial Spillovers. NBER Working Paper Series 8292. NBER: Cambridge.

Agrawal, A., Henderson, R. (2000) Putting Patents in Context: Exploring Knowledge Transfer from MIT. Mimeo, Massachusetts Institute of Technology, Cambridge, MA.

Anselin L, Varga A, Acs Z (1997) Local geographic spillovers between university research and high technology innovations. Journal of Urban Economics 42: 422–448

Antonelli, C. (1999) The Microdynamics of Technological Change. Routledge, London.

Antonelli, C. (2000) Collective knowledge communication and innovation: the evidence of technological districts, Regional Studies 34, 535–547.

Arundel, A., Geuna, A., 2004. Proximity and the Use of Public Science by Innovative European Firms. Economics of Innovation and New Technology 13, 559-580.

Asheim, B. T. (1996) Industrial districts as 'learning regions': a condition for prosperity, European Planning Studies 4, 379–400.

Baldwin,W., Link, A., 1998. Universities as research joint venture partners: does the size of the venture matter. International Journal of Technology Management 15(8): 895–913.

Beise, M. and Stahl, H. (1999) Public Research and Industrial Innovations in Germany. Research Policy, 28, 397–422.

Belderbos, R., Carree, M., Lokshin, B. and Veugelers, R. (2004) Heterogeneity in R&D cooperation strategies, International Journal of Industrial Organization, 22: 1237-63.

Bodas Freitas, I.M, T. Clausen, R. Fontana and B. Verspagen, (2008) Formal and informal external linkages and firms' innovative strategy. A cross-country comparison. UNU-Merit Working paper Series 65; Working Paper 20081113 on Innovation Studies, University of Oslo.

Bodas-Freitas, I., Geuna, A. and F. Rossi (2010), The Governance of University-Industry Knowledge Transfer: Why small firms do (not) develop institutional collaborations? Dipartimento di Economia "S. Cognetti de Martiis", Università di Torino, Working Paper 13/2010.

Bouty, I. (2000): Interpersonal and interaction influences on informal resource exchanges between R&D researchers across organizational boundaries". Academy of Management Journal, 43(1)

Bruneel, J., D'Este, P., Neely, A., Salter, A. (2009) The search for talent and technology, AIM research paper.

Brusoni, S., Prencipe, A., Pavitt, K. (2001). Knowledge Specialisation, Organisational Coupling, and the Boundaries of the Firm: Why Do Firms Know More Than They Make?. Administrative Science Quarterly, 46, 597-621

Chesbrough, H.W. (2003) 'Open innovation: The new imperative for creating and profiting from technology'. Boston, MA: Harvard Business School Press.

Cohen, W., Levinthal, D. (1990) Absorptive capacity: a new perspective on learning and innovation, Administrative Science Quarterly 35, 128–152.

Cohen,W.M., Nelson, R.R., Walsh, J.P. (2002) Links and Impacts: The Influence of Public Research on Industrial R&D. Management Science, 48, 1–23.

Cooke P (2001) Regional innovation systems, clusters, and the knowledge economy. Industrial and Corporate Change 10: 945–974

Cooke P (2002) Knowledge economies. Clusters, learning and cooperative advantage. Routledge, London

Cooke, P., Uranga, M. and Etxebarria, G. (1997) Regional innovation systems: institutional and organizational dimensions, Research Policy 26, 475–491.

D'Este, P., Iammarino S. (2010), The Special Profile of University-Business Research Partnerships. Papers in Regional Science, 89 (2), 335-350

Feldman MP (1994) The geography of innovation. Kluwer Academic Press, Amsterdam

Fondazione Rosselli (2007) Scoreboard regionale dell'innovazione, Torino.

Fontana, R., A. Geuna, and M. Matt, 2006. Factors affecting university-industry R&D projects: The importance of searching, screening and signalling. Research Policy, 35, 309-323.

Foss, N. J. (1996) Higher-order industrial capabilities and competitive advantage, Journal of Industrial Studies 3, 1–20.

Freeman, C. (1987) Technology Policy and Economic Performance: Lessons from Japan. London: Pinter.

Fritsch M, Schwirten C (1999) Enterprise-university co-operation and the role of public research institutions in regional innovation systems. Industry and Innovation 6: 69–83

Fritsch M, Slavtchev V (2007) Universities and innovation in space. Industry and Innovation 14: 201–218

García-Aracil, Adela and De Lucio, Ignacio Fernández (2008) Industry-University Interactions in a Peripheral European Region: An Empirical Study of Valencian Firms, Regional Studies, 42: 2, 215 — 227

Gertler, M. S. (1995) "Being there": proximity, organization, and culture in the development and adoption of advanced manufacturing technologies, Economic Geography 71: 1–26.

Harhoff, D. (1999). Firm formation and regional spillovers - evidence from Germany, Economics of Innovation and New Technology, vol. 8, pp.27–55.

Henderson R, Jaffe A, Trajtenberg M (1998) Universities as a source of commercial technology: A detailed analysis of university patenting, 1965–1988. The Review of Economics and Statistics LXXX: 119–127

Henderson, R., Jaffe, A.B., Tratjenberg, M. (1994) Numbers Up, Quality Down? Trends in University Patenting 1965–1992. Presentation to CEPR/AAAS Conference University Goals, Institutional Mechanisms and the Industrial Transferability of Research, Stanford University, March 18–20.

Hippel, E. von. (1987) Cooperation Between Rivals: Informal Know-How Trading. Research Policy, 16, 291–302.

Inkpen, A. C. & Currall, S. C. (2004), The coevolution of trust, control and learning in joint ventures, Organization science, 15(5) Sept-Oct 2004

Jaffe AB (1989) Real effects of academic research. The American Economic Review 79: 957–970

Kline, S. and Rosenberg, N. (1986) An Overview of Innovation. In Landau, R. (ed.) The Positive Sum Strategy. Washington, DC: National Academic Press.

Laursen, K., Salter, A. 2004. Searching Low and High: What types of firms use universities as a source of innovation? Research Policy 33, 1201-1215.

Laursen, K., Reichstein T., Salter, A 2010.Exploring the Effect of Geographical Proximity and University Quality on University–Industry Collaboration in the United Kingdom. Regional Studies. Forthcoming.

Lawson, C., Lorenz, E. (1999) Collective learning, tacit knowledge and regional innovative capacity, Regional Studies 33, 305–317.

Lawton Smith, H., 2007. Universities, innovation and territorial development: A review of the evidence, Environment and Planning C: Government and Policy, 25, 1, 98-114.

Link, A.,Vonortas, N., 2002. Participation of European Union companies in US research joint ventures, Working Paper.

Lundvall, B. A. (Ed.) (1992) National Systems of Innovation. Pinter, London

Mansfield E (1995) Academic research underlying industrial innovations: Sources, characteristics, and financing. The Review of Economics and Statistics 77: 55–65

Mansfield E, Lee J-Y (1996) The modern university: Contributor to industrial innovation and recipient of industrial R&D support. Research Policy 25: 1047–1058

Maskell, P. and Malmberg, A. (1999) Localised Learning and Industrial Competitiveness. Cambridge Journal of Economics, 23, 167–175.

Mohnen, P., Hoareau, C. 2003. What type of enterprise forges close links with universities and government labs? Evidence from CIS 2. Managerial and Decision Economics 24, 133-145

Mowery, D., Sampat, B. 2005 The Baye-Dole Act of 1980 and University-Industry Technology Transfer: A Model for other OECD Governments? Journal of Technology Transfer, 30, 115-127.

Muthusamy, S.K., White, M.A. 2005. Learning and Knowledge Transfer in Strategic. Alliances: A Social Exchange View, Organization Studies, 26 (3).

Póvoa, L., Rapini, M. 2010 Technology transfer from universities and public research institutes to firms in Brazil: what is transferred and how the transfer is carried out, Science and Public Policy, 372, 147-159

Powell W., K. Koput and L. Smith-Doerr (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. Administrative Science Quarterly 41, 116-145.

Quintas, P. (1992) Academic-Industry Links and Innovation: Questioning the Science Park Model. Technovation, 12, 161–175.

Roberts, J. (2000) From Know-How to Show-How? Questioning the Role of Information and Communication Technologies in Knowledge Transfer. Technology Analysis and Strategic Management, 12, 429–443.

Romjin, H. and Albu, M. (2002) Innovation, networking and proximity: lessons from small high technology firms in the UK, Regional Studies 36, 81–86.

Rossi, F. and Geuna, A. (2009) Posizionamento degli Atenei Torinesi nel panorama nazionale, in Impatto degli Atenei sull'Area Metropolitana, Fondazione Rosselli, Torino.

Senker, J. (1995) Tacit Knowledge and Models of Innovation. Industrial and Corporate Change, 2, 425–447.

Siegel, D.S., Westhead, P. and Wright, M. (2003) Assessing the Impact of University Science Parks on Research Productivity: Exploratory Firm-Level Evidence from the United Kingdom. International Journal of Industrial Organization, 21, 1357–1369.

Tödtling F, Lehner P, Kaufmann A (2009) Do different types of innovation rely on specific kinds of knowledge interactions? Technovation 29: 59–71

Tödtling F, Lehner P, and Trippl M (2006) Innovation in knowledge intensive industries: The nature and geography of knowledge links. European Planning Studies 14: 1035–1058

Appendix 1

Table A. Correlation coefficients among firms that engaged in *institutional* collaborations with universities

	Size	Sqsize	Dexport	Outsour	Multin	Innov_C	Tech_Souring	Local	Areas	RD	Test	Organization	Multi-purposeness	Diversity
Size	1													
Sqsize	0.986**	1												
Dexport	0.349**	0.327**	1											
Outsour	0.189	0.181	0.153	1										
Multin	0.135	0.113	0.261**	0.507**	1									
Innov_C	0.244*	0.239*	0.083	0.074	-0.088	1								
Tech_Sourcing	0.415**	0.401**	0.210*	0.113	0.142	0.295**	1							
Local	0.24*	0.27*	-0.08	0.071	0.024	0.036	0.219*	1						
Areas	0.445**	0.492**	0.131	-0.098	-0.092	0.185	0.222*	0.291**	1					
RD	0.123	0.111	-0.057	0.97	-0.062	0.15	0.284**	-0.023	0.146	1				
Test	-0.29**	-0.3**	0.093	-0.152	-0.098	-0.07	-0.265*	-0.05	-0.07	-0.61**	1			
Organizational	0.369**	0.391**	0.059	0.087	0.102	-0.047	0.069	0.467**	0.277**	-0.302**	-0.234*	1		
Multi-purposeness	0.197*	0.149	0.135	0.037	-0.051	0.02	0.072	0.354**	0.4**	0.218**	0.247*	0.319**	1	
Diversity	0.058	0.065	0.130	-0.056	0.012	-0.119	-0.158	0.298**	0.160	-0.719**	0.660**	0.548**	0.492**	1
International	0.092	0.128	0.158	0.063	0.071	0.01	-0.153	-0.182	0.372**	-0.1	-0.005	0.13	0.087	0.078

Note: 104 firms