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The effects of universities' proximity to industrial districts on university–industry collaboration

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ABSTRACT

There is increasing awareness that university–industry collaboration provides an important knowledge transfer channel and, thus, is a powerful driver of innovation. Universities are increasingly being asked to play incisive roles in the process of regional economic development. This paper assesses the extent to which university–industry collaboration, expressed in terms of private funding for university consulting research activities, is affected by the geographic proximity of an academic institution to an Industrial District (ID). Although the economic literature insists on the positive effects of proximity for these collaborations, empirical work on Italian ID so far shows no particular effects. This paper provides new insights into the effects of academic proximity to ID on university–industry collaboration, by presenting robust evidence that proximity to districts promotes the establishment of collaboration agreements. This sheds new light on the need for targeted policies to support local productive systems. The empirical evidence is based on an analysis of qualitative information and an econometric analysis of financial data for the whole population of Italian university departments engaged in research in the Engineering and Physical Sciences.

1. Introduction

The role of geographical proximity in firms' innovation processes has been object of a wide scientific literature on innovation and regional development. The Regional Innovation Systems (RIS) theory (Asheim & Isaksen, 2002; Cooke, 2001) and the Cluster literature (Baptista, 2000, Saxenian, 1994) share the idea that proximity between firms and private and public research institutions such as Universities is crucial in developing innovation activities. An important contribution to this theoretical debate is provided by the literature on Industrial Districts (IDs) (Becattini, 1987; 1989). IDs can be described as concentrations of — mostly small sized — firms, located in the same area and specialised in the production of the same product/s. The recent literature on IDs underlines the ability of these productive systems to develop innovation (Muscio, 2006a, 2006b) based on the contribution of several factors such as: advanced division of labour between local firms (Garofoli, 1989; Mazzoni, 2001); availability of specialised skills in the local labour market; tight interaction between local actors in a virtuous cycle of cooperation and competition; and rapid diffusion of innovations within the local system (Bellandi, 1996). For these reasons, IDs have been often considered as "local innovation systems" (Corò & Micelli, 2007; Garofoli, 2003), where proximity plays a fundamental role in the innovation process; but in these "local innovation systems" the role of the university and its proximity to firms is not clear. Some

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empirical works (Garofoli, 2002; Scarpinato, 2003) evidenced that firms located in IDs interact with the universities less than firms located outside IDs. These results can be explained taking into account that IDs firms find inside the district alternative sources of knowledge and by the difficulties that small enterprises in traditional and mature industries (as those of Italian IDs) face in interacting with Universities (Bellini and Ferrucci, 2002; Rolfo, 2000; Tödtling & Kaufmann, 2002). Therefore, this suggests that in districts, typically specialised in mature sectors, where there are few large enterprises, proximity between firms and universities does not encourage their cooperation. At the same time, there is increasing awareness in the economic literature of the importance of universities as crucial institutions for stimulating or assisting regional economic development processes. In particular, a deeper connection between academia and industry is seen as essential, since universities are expected not only to produce new knowledge, but also to contribute more directly to the economic promotion of the territory in which they operate (Laredo, 2007).

In light of these arguments, the purpose of this paper is to assess the impact of IDs' proximity to academic institutions on the intensity of university–industry relationships. We take into account the point of view of academic institutions and, on the basis of qualitative and quantitative information, test whether university–industry collaboration, expressed in terms of private funding for university consulting research activities, appears stronger in the case of geographical proximity of academic institutions to clusters of firms, such as IDs.

The paper is organised as follows: Section 2 sets the theoretical background and explains why interaction between academic institutions and IDs is an issue that should be explored in the context of university–industry collaboration; Section 3 presents our empirical results. The data on universities are analysed using descriptive statistics and econometric regression models. Section 4 discusses the results and their implications for future research.

2. Theoretical background

2.1. University technology transfer and local development

Universities are increasingly seen as essential engines of local economic development contributing to knowledge transfer processes in several ways.

University–industry collaboration, in its various forms (D'Este & Patel, 2007), is seen as a critical tool for regional development as it provides businesses with scientific knowledge that is essential for their innovation activity. These linkages allow firms to benefit from technical support and specialised expertise and access facilities that are indispensable to their research and development (R&D) activity (Grossman, Reid, & Morgan, 2001; Mowery, Nelson, Sampat, & Ziedonis, 2004).

The increasing reliance on knowledge in industry and services is generating strong incentives to develop more efficient ways to transfer the discoveries made in academia to businesses. However, universities vary enormously in the extent to which they are involved in the commercialisation of academic research (Geuna & Muscio, 2009). There is tension between the benefits to innovation of working across disciplinary and organizational boundaries vs. the risks that arise from the costs of coordination and relationship development in these collaborations (Cummings & Kiesler, 2005; 2007). Despite the overwhelming evidence that university–industry partnerships improve firms' innovation capability it is not always evident whether they are effective in improving firms' innovation economic performance (Guan, Yam, & Mok, 2005). The adoption of transferred and/or purchased technologies has both positive and negative impacts on firms, at least in the case of developing countries, and successful collaborative innovation depends on technology level as well as on effective integration of total innovation capability (Guan et al., 2005, Guan, Mok, Yam, Chin, & Pun, 2005, 2006).

The type and level of interaction between academia and industry seems to be strongly dependent on firm size and the sectors in which the firms operate (Calderini, Franzoni, & Vezzulli, 2007; Fontana, Geuna, & Matt, 2006; Laursen & Salter, 2004; Mohnen & Hoareau, 2003). University research produces local knowledge spillovers to firms (Breschi & Lissoni, 2001; Feldman & Desrochers, 2003), which concur to the development of innovation systems (Anselin, Varga, & Acs, 2000; Jaffe, 1989; Varga, 1998) to the extent that firms' location decisions seems to be strongly influenced by the opportunity to benefit from these positive externalities (Varga, 2000).

Secondly, universities act as the conduit enabling firms to access knowledge from the 'global pipelines' of international academic research networks (Bramwell & Wolfe, 2008) fostering their industrial patenting activity (Branstetter & Ogura, 2005; Breschi, Lissoni, & Montobbio, 2007). Interaction with universities, therefore, not only enables access to the knowledge available in the academic institution, but also exposes firms to a broader set of technologies and innovations developed elsewhere.

Thirdly, academic institutions catalyse talents in local labour markets (Betts & Lee, 2005; Florida, 1999, 2002; Gertler & Vinodrai, 2005; Senker, 1995) facilitating the transfer of tacit knowledge, a crucial component of the innovation process (Bramwell & Wolfe, 2008; Wolfe, 2005).

2.2. Demand for university knowledge from IDs

Since the mid 1990s there has been increased interest in the geographical dimension of innovation activity and the effective capability of IDs to sustain firm innovation activity (Muscio, 2006a). Interest in innovation activities within IDs has coincided with an increased focus in innovation studies on the territorial dimension of innovation and investigation of the determinants of concentrations of innovation (Baptista & Swann, 1998; Beaudry & Breschi, 2001; Breschi & Lissoni, 2001; Paci & Usai, 2000; Swann, Prevezer, & Stout, 1998). These works provided evidence that innovation activity is spatially concentrated and that local knowledge spillovers play an important role in innovation.

Italian IDs are generally composed of micro and small enterprises, managed directly by entrepreneurs, specialised in producing high quality products (Becattini, 1987, 1989; Brusco, 1989; Garofoli, 1989, 1992), District systems have reached outstanding economic performance despite their SMEs structure and have become competitive on international markets (Fortis, 2000; Fortis & Curzio, 2007; Mazzoni, 2001; Rabellotti, 1999; Saxenian, 1994; Storper, 1993). In the case of IDs, the agglomeration of specialised economic activities naturally sustains the competitive behaviour of local actors and reinforces the relationship between dynamic competition (between district firms) and product innovation (Bianchi, 1989) also fostering innovation adoption.

The IDs literature suggests several factors that increase the ability of these industrial systems to develop innovation and competitiveness. First of all, an important factor accelerating innovation processes is the availability of high technology expertise and competences (Belussi & Gottardi, 2000; Garofoli, 2002). Secondly, stable horizontal and vertical linkages between local firms generate a complex mix of trust, a shared 'language' and habits that contribute to the creation of semi-formalised networks and promotion of innovation within the ID. These networks allow firms to conduct complex operations that their individual capital, technical skills, organisation and entrepreneurial capability resources could not sustain. Thirdly, a virtuous circle of cooperation and competition between local agents leads to positive externalities and local knowledge spillovers sustaining the innovation process. The high frequency of formal and informal transactions fosters information sharing and knowledge spillovers. This promotes the collective efficiency (Garofoli, 1983, 1989; Schmitz, 1990, 1999) of the local system, in which each firm exploits the dynamic competitive advantages deriving from the existence of external economies.

The findings in the Italian literature on IDs are supported by other schools of thought. The literature on clusters has deepened analysis of the impact of spatial agglomeration on innovation activities. This line of research provided evidence of an uneven distribution of innovative activities (Saxenian, 1994) and pointed to the relevance of innovation performance in geographically concentrated industries (Best, 1991; Markusen, 1996; Storper & Harrison, 1991). According to this literature, innovation processes are enabled by relations between cluster firms and also between firms and research centres.

The RIS theory emphasises this aspect of the linkages between firms and universities even more strongly, underlining how these linkages matter for innovation (Arundel & Geuna, 2001). Territorial agglomeration provides the best context for a learning economy based on innovation; such a system promotes localised learning and endogenous regional economic development (Asheim & Isaksen, 2002). The process of forming systematic links and interactive communication among local innovating actors combines learning with upstream and downstream innovation capabilities (Cooke, 2001). This process increases the innovation capacity of the entire local system, based on similar mechanisms to those operating in Italian IDs.

The literatures on clusters and RIS are based on analyses of productive systems and advanced sectors (aerospace, biotechnology, high tech, etc.) where the main actors are large groups of medium and large enterprises, as well as groups of small firms. The relations between firms and universities are facilitated by the actions of firm managers and their abilities to interact with research centres. IDs, on the other hand, are characterised by small and micro enterprises and a very low number of medium and large firms (Muscio & Scarpinato, 2007); in this context, building linkages between universities and firms is quite difficult. Then, if, on the one hand, the ID literature stresses on the importance of firms' proximity for economic (and innovation) performance, on the other hand it says very little about the roles of academic institutions and their proximity to districts in the innovation process. Case-specific empirical evidence seems to show that only a small percentage of district firms collaborates with universities (Scarpinato, 2003): in the Lombardy region of Italy, for example, innovative firms in IDs are less likely to interact with universities than other firms (Garofoli, 2002; Muscio, 2006b). This empirical evidence is coherent with other works showing the low propensity of small firms in traditional sectors to cooperate with universities (Bellini & Ferrucci, 2002; Rolfo, 2000; Tödtling & Kaufmann, 2002).

However, IDs may represent important 'potential markets' for university research since they are based on a large pool of innovation oriented firms (Muscio, 2006a) that are geographically concentrated and specialised in the production of the same product (or range of products): these characteristics could generate similar knowledge, innovation and technology needs and improve the chances of success of using a collective approach in innovation activity. In the light of these arguments this paper investigates whether proximity between academic institutions and IDs promotes university–industry collaboration. We investigate whether the presence of an ID can affect the likelihood of collaborations being established between universities and firms and their intensity. We argue that IDs proximity to academic institutions increases their capability to specialise their research activity and services, therefore generating better opportunities to establish collaboration agreements.

Research hypothesis. *university proximity to IDs has positive effects on knowledge transfer activities.*

3. Empirical analysis

3.1. Description of the data

The test of the research hypothesis is based on the empirical analysis of qualitative and quantitative information on university knowledge transfer activity and business funding. First we analyse the responses to a qualitative questionnaire administered to Italian university departments. We carried out an exploratory analysis of qualitative information collected via a web survey,[3]

[3] The survey was carried out by Gruppo di Ricerche Industriali e Finanziarie (GRIF) "Fabio Gobbo" — Università Luiss Guido Carli (Roma) as part of the research project 'The Governance of Technology Transfer in Italy', funded by the Italian Ministry of University and Research (MIUR), Progetto FIRB: 'A Multidimensional Approach to Technology Transfer'.

Table 1
University departments classified by scientific area.

Code	Scientific area	MIUR data		Survey data	
		n.	Percent	n.	Percent
MAT	Mathematics, Computer Science, Physics	140	11.86	34	17.35
CHEM	Chemistry	59	5.00	26	13.27
BIO	Biology	122	10.34	24	12.24
MED	Medicine	450	38.14	33	16.84
AGR	Agriculture and Veterinary	126	10.68	32	16.33
ARCH	Civil Engineering and Architecture	130	11.02	15	7.65
ENG	Industrial Engineering	153	12.97	32	16.33
TOTAL		1180	100.00	196	100.00

Source: Authors' calculation based on MIUR data.

conducted during the period June–September 2007 that targeted university departments in Italy engaged in research in the engineering and physical sciences (EPS). The survey investigated technology transfer activity and the drivers and barriers to university–industry collaboration agreements signed during the period 2004–07. Questionnaires were addressed to the department directors of 1047 EPS departments. We received 197 completed questionnaires, a response rate of 18.8%. We compare the qualitative information collected via the survey for those university departments located near IDs to those that are not near IDs.

Secondly, we tested our research hypothesis against the analysis of financial data from the whole population of university departments in Italy engaged in research in EPS. The data were provided by the Italian Ministry of University and Research (MIUR) and included financial data for the 2007–08 financial year, which identified 1,180 EPS departments located in 65 public universities (5 of them polytechnic universities) located in 54 municipalities. We provide descriptive statistics for departments located near IDs and not near IDs and then conduct an econometric analysis aimed at identifying the determinants of private funding raised by university departments. We use private research funding raised by departments as a proxy for university–industry collaboration. In the econometric exercise we control for the effects of departments' proximity to IDs.

Table 1 reports the distribution of Italian departments across seven EPS scientific areas. Most of these departments are in the field of Medicine, which counts 450 units and represents 38% of the total population. Industrial engineering accounts for 13% and Biology, Agriculture & Veterinary, and Civil Engineering & Architecture account for around 10% each. Over the four-year period 2004–07 there was a substantial increase in research staff (+12%) employed in Italian universities, especially at the junior level (+19% assistant professors). Table 1 also reports the distribution of the departments contacted via the questionnaire survey across seven EPS scientific areas and shows that this is a very representative sample.[4]

3.2. Empirical results

This section provides empirical evidence on the differences in technology transfer activities between those university departments located near an ID and those that are not. We investigate the characteristics of university departments involved in those activities and determine whether proximity to a district influences the amount of private funding that these departments will raise and highlight the drivers of and obstacles to technology transfer.

In this paper, we use the definition of IDs proposed by ISTAT.[5] On the basis of the 2001 census, ISTAT identifies a high number of districts in 156 geographical areas, employing 4,929,721 workers. ISTAT identifies the following industry specialisations for Italian IDs: food manufacturing; publishing and printing; machinery; jewellery; leather; rubber and plastics; domestic products; and textiles. We mapped the Italian administrative provinces (NUTS3 in the Eurostat classification of European territorial units) and crosschecked the geographical locations of university departments against the ISTAT classification of IDs in Italy. From the 1180 university departments considered we identified 731 departments in administrative provinces with at least one ID (62%) and 449 departments in provinces with no IDs (38%).

Table 2 compares average industry funding for departments located close to an ID to funding to departments that are not close to IDs.. The first row in Table 2 reports average values for departments in universities close to IDs specialised in any kind of industry. The results of the analysis show that the aggregate level of industry funding for research is much higher in departments located near an ID (Euro 270,040 vs. Euro 193,780). We ran an independent sample *t*-test to test the equality of the means (the results are reported in Column 3).[6] The results of the *t*-test reject the hypothesis of equality of means when departments are

[4] When we classify departments represented in the sample according to SA and size of academic institution we can see that the differences between the weights of each typology of department and the corresponding total population, in most cases are less than 3%.

[5] The criteria used by ISTAT to identify Italian IDs are based on the conditions established in 1993 by the Ministry of Productive Activities (now Ministry of Economic Development, MSE). These conditions focus on Local Labour Systems (LLS), which are groups of neighbouring communes where labour mobility is self-contained. MSE classifies LLS that meet the following conditions, as IDs: a) employment share in manufacturing activities above the national average; b) employment share in small and medium sized enterprises (SME) above the national average; c) employment share in the main manufacturing activity above the national average; d) employment share in SME in the main manufacturing activity above the national average.

[6] If the p-value associated with the *t*-test is small (<0.05), this is evidence that the null hypothesis should be rejected in favour of the alternative (Ho being the equality of means). In other words, there is evidence that the means are significantly different at the significance level reported by the p-value. If the p-value associated with the *t*-test is not small (>0.05), there is not enough evidence to reject the null hypothesis, i.e. the means are not different.

Table 2
Average industrial funding to departments (2007).

	Location of departments		
	Near a district	Not near a district	*t*-test
All district industries	270.04	193.78	**
Food manufacturing	264.04	237.98	
Publishing and printing	339.31	238.02	
Machinery	294.45	215.94	**
Jewellery	192.57	242.59	
Leather industry	218.69	246.14	
Rubber and plastics	200.53	243.23	
House products	275.04	226.15	
Textiles	254.56	234.37	
Observations	731	449	

Value expressed in thousand Euros.
Independent samples *t*-test: *significant at 5%; **significant at 1%.
Source: Authors' calculation based on MIUR data.

Table 3
Frequency of collaboration agreements (2004–07).

Frequency and type of collaboration agreements		Location of departments		
		Near a district	Not near a district	*t*-test
Number of collaboration agreements signed in the last 3 years		23.72	14.33	*
Type of collaboration agreements				
1	Creation of new physical facilities	0.60	0.37	
2	Consultancies and contract research agreements (research by university)	15.74	8.86	*
3	Collaborative research agreements (research by both)	2.75	2.25	
4	Training programmes	2.34	1.52	
5	Meetings and conferences	3.55	2.62	
Observations		119	63	

Classification adapted from D'Este, Nesta, and Patel (2005).
Independent samples *t*-test: *significant at 5%; **significant at 1%.
Source: Authors' calculation based on survey data.

grouped based on their proximity to any kind of district. In other words, a low p-value (less than 0.05) for this test means we should reject the null hypothesis in favour of the alternative of different levels of funding. We can then conclude that industry funding to research departments located near an ID is statistically higher than the amounts received by departments not near an ID.

We also compare average levels of private funding based on district data disaggregated for different industry specialisations. Rows 2–9 in Table 2 show that, with the exception of proximity to districts specialised in manufacturing machinery, funding levels are not statistically different.[7] In the case of machinery manufacture funding levels are much higher for departments located near an ID. We can conclude that proximity research departments and IDs positively affects private funding to departments, and thus technology transfer activities, at the aggregate level and in the specific case of manufacture of machinery, which is a major national export. In some other cases, such as proximity to districts focused on food manufacturing, publishing and printing, house products, and textiles, there is a positive — although not statistically different — difference in the funding received by departments located near to and not near to a district. In other cases, such as the jewellery, leather and rubber and plastics sectors, proximity can have a negative effect on technology transfer activities, but the estimated differences in funding levels are not statistically significant.

These results raise the question of whether the district industry specialisation has any effect on demand for technology transfer from university departments specialised in different EPS scientific areas. We want to establish whether there is scope for science policy initiatives aimed at fostering local economic development to influence the research specialisation of academic institutions towards the industry specialisation in the local area.

We use questionnaire data to derive qualitative information on the drivers of and barriers to university–industry collaboration. We are interested in assessing whether there are any differences in the factors motivating universities to sign collaboration agreements with firms, between departments located close to and far from IDs. We want also to determine whether proximity to a large pool of firms specialised in the same industry has an effect on the barriers to technology transfer.

The higher propensity of departments near IDs to collaborate with industry is confirmed by the results of the analysis of survey data. Table 3 shows that departments located near districts in 2004–07 took part in an average of 23.72 collaborations, whilst those distant from IDs signed an average of 14.33 collaboration agreements.

[7] It was not possible to report a comparison of the effects of proximity on university funding disaggregated by department main research area because of the limited number of observations in some research areas.

Table 4
Promoters of university–industry collaborations.

Who established the first contact in collaborations?		Location of departments			
		Near a district		Not near a district	
		n.	Percent	n.	Percent
1	TTO of own university	13	11.11	2	4.00
2	Other TTO	3	2.56	1	2.00
3	Department	49	41.88	25	50.00
4	Other Department/University	13	11.11	5	10.00
5	Professor	99	84.62	39	78.00
6	Firm	60	51.28	19	38.00
7	Industry association	11	9.40	4	8.00
Observations		117	100.00	50	100.00

Source: Authors' calculation based on MIUR data.

The area of collaboration most affected by proximity to districts is contract research, which involves departments conducting contract research activity. Departments close to districts engaged were involved in 11.02 collaborations over the period 2004–07; other departments were involved in 5.41 collaborations.

Table 4 reports the main categories of promoters of collaboration agreements, for the two groups of departments identified above. Departments in the proximity of districts are more likely to engage in collaborations promoted by university professors (84.62% vs. 78%) and firms (51.28% vs. 38%). Proximity to a district increases the opportunity for academic researchers to engage in face-to-face interactions and develop personal professional networks with businesses. This is supported by the greater relevance of technology transfer offices (TTO) in establishing collaborations for universities located close to IDs (11.11% vs. 4%). Muscio (2010) highlights that, in the wake of the positive experience of northern European countries and with the support of targeted government initiatives, academic institutions in Italy are rapidly increasing their involvement in technology transfer and setting up TTO. However, Muscio (2010) and IPI (2005) provide evidence of the marginal contributions of TTOs to the establishment of university–industry collaborations. Whilst this study does not allow us to confirm or reject this claim, we can conclude that the homogeneity of the local industry base provides more homogeneous demand for innovation services and better opportunities for TTOs to specialise in supporting local companies.

3.3. Econometric analysis

This section provides empirical evidence on the determinants of the capability of university departments to raise private funding. In particular, we investigate whether and to what extent proximity to an ID increases access to industry funding. Table 5 presents information on the variables used in the regressions. We consider as dependent variables indicators of private funding to university departments and as regressors indicators of departmental sources of revenue, department and university characteristics, and geographic indicators. Table 6 reports some descriptive statistics for the variables included in the regressions. As a large part of the departments have no private funding, our dependent variable is partly continuous with a positive and large probability mass at zero. Hence, we model such a response variable in order to account for the presence of a corner solution outcome. Therefore we estimate two main regression models. First, a Probit model to predict the effect of the independent variables on the probability or not of the department being able to raise any private funding in the current year. In the Probit model, the dependent variable is a binary variable that is equal to 1 if the department received any private funding in the reference year, and 0 otherwise. Second, a Tobit model[8] estimates the impact of the presence of a district in the administrative province of the university department on the amount of private funding collected.[9]

The Probit regression estimates the probability of obtaining private funding in 2008. The Tobit regression estimates the amount of private funding in 2008 and takes into account the amount of public and university funding in 2007. In both regressions we use a 1-year lagged (2007) regressor of the dependent variable, in order to account for persistence in the process of attracting private funding and control for the impact of other sources of funding received in the previous financial year (2007).

The results of this set of regressions are reported in Table 7. As expected, there is some path dependence to accessing private funding. For both the Probit and Tobit regressions the parameters for the lagged variable measuring past private funding levels (F_PRIVATE_07) are positive and highly significant. In other words, obtaining private funding greatly increases both the probability and the amount of future funding from business. In the Tobit regression, both EU and MIUR funding for research have positive impact on business funding. Not surprisingly, the overall effect of internal university transfers (F_UNI_07) is not

[8] Both the random effects Probit and random effects Tobit are fitted by using Butler and Moffitt's method with a 32 point Hermite quadrature. See Butler and Moffitt (1982) for details of the estimation technique.

[9] We use a 1-limit Tobit model, because some 18% of observations in our sample are censored at 0.

Table 5
Variable used in the regressions.

Variable	Definition	Data source
Departments' source of revenue		
F_PRIVATE	Amount of funding from research contracts and consultancies from public and private organisations raised in the last financial year (2007 or 2008). This source of funding does not account for funding from research programmes that do not allow income distribution to research staff	MIUR
F_PRIVATE_Y	F_PRIVATE (yes/no)	MIUR
F_EC	Research funding from the EC (2007)	MIUR
F_MIUR	Research funding from MIUR (2007)	MIUR
F_UNI	Research funding from own university (2007)	MIUR
F_OTHER_PA	Research funding from other public administrations (2007)	MIUR
University characteristics		
SIZE_UNI1-4	Size of the academic institution where the department is located. University size is expressed in terms of number of students: 1 small (<10,000); 2 medium (10,000-15,000); 3 large (15,000-40,000); 4 mega (>40,000)	MIUR (2007)
EPO_MNGMT	Presence at the university of an office managing European patents. Normally this task is carried out by offices for valorisation of research results or by TTOs. These offices have the mission of supporting research staff in commercializing the results of scientific research establishing collaborations and mediating between agents.	MIUR
POLYTECH	Location of the department in a polytechnic university (4 in Italy)	University website
Departments' characteristics		
P_RESEARCH	Number of research staff (full professors, associate professors, assistant professors)	MIUR
P_RESEARCH_OTHER	Number of other research staff involved in research activities (technical staff, PhDs, research officers)	MIUR
RES_RATING	Research rating published by MIUR in 2007, based on the evaluation of research output carried out over the period 2001–03. This composite indicator takes into account peer review evaluations of research activity carried out at academic institutions (patents, impact factor of journal articles, etc.)	CIVR VTR (MIUR, 2007)
— Scientific areas	Predominant departmental scientific research area	MIUR-CINECA
— a12	SA Mathematics, Computer Science and Physics	
— a3	SA Chemistry	
— a5	SA Biology	
— a6	SA Medicine	
— a7	SA Agriculture and Veterinary	
— a8	SA Civil Engineering and Architecture	
— a9	SA Industrial Engineering	
Indicators of local demand for technology		
LOCAL_EPO	Number of European patents granted to industrial researchers resident in the administrative province where the department is located during the period 2000-06	PATSTAT database elaborated by Centro KITES, Università Bocconi
LOCAL_ MANUF	Number of medium-large sized manufacturing companies in the administrative province where the department is located	ISTAT 2001 Census
GEO_S, GEO_C, GEO_N	Geographical location of the department respectively in Southern, Central and Northern Italy	
ID	Presence of an ID in the administrative province where the department is located	ISTAT

significantly different from zero. In fact, university transfers are used to provide general purpose resources or resources already allocated to departments for the next year/s.[10]

University characteristics have little impact on business funding to departments. Location of the department in a medium-sized university (SIZE_UNI2) decreases the probability of obtaining and the volume of business funding with respect to large universities. Location in a polytechnic university and the existence of an office to manage European patents both have no effect on funding.

We find no evidence of a significant effect of research performance on business funding to universities. Mansfield (1995) provides evidence that universities conducting higher quality research, which are located close to innovating companies, make a greater contribution to industrial innovation. Firms tend to trade off faculty quality against geographic proximity, particularly in the case of applied R&D. There is evidence also that innovative firms favour research produced by high quality research universities that publish in peer-reviewed journals (Bruno & Orsenigo, 2003; Hicks, Breizman, Hamilton, & Narin, 2000; Pavitt, 2001). In the present study we use a research performance indicator to control first for whether high quality research generates valuable

[10] Internal transfers of resources seem to have no effect on a department's capability to attract funding from industry because, apart from monies formally assigned to research activities, in most cases this funding is designed to cover expenses such as hardware and software purchases, and attendance at conferences and scientific meetings. The per capita amounts of these transfers are typically capped at well below the amount required to finance structured research activities, which are likely to attract firms and promote collaboration.

Table 6
Descriptive statistics.

	Variable	Obs	Mean	Std. dev.	Min	Max
Dependent variables	F_PRIVATE_Y	1225	0.855	0.353	0	1
	F_PRIVATE_08	1209	243.910	412.950	0	4163
University funding	F_PRIVATE_07	1155	220.113	409.698	0	4743
	F_EC_07	1159	72.965	216.854	0	4062
	F_MIUR_07	1159	158.640	304.092	0	4000
	F_UNI_07	1159	124.412	199.590	0	1984
	F_OTHER_PA_07	1159	92.905	247.171	0	4246
University indicators	SIZE_UNI1	1217	0.079	0.270	0	1
	SIZE_UNI2	1217	0.075	0.263	0	1
	SIZE_UNI3	1217	0.435	0.496	0	1
	SIZE_UNI4	1217	0.411	0.492	0	1
	EPO_MNGMT	1225	0.851	0.357	0	1
	POLYTECH	1225	0.057	0.232	0	1
Department indicators	P_RESEARCH_07	1225	30.864	22.531	0	220
	P_RESEARCH_OTHER_07	1225	33.304	30.236	0	261
	RES_RATING	1205	0.762	0.155	0	1
	a12	1189	0.119	0.324	0	1
	a3	1189	0.051	0.221	0	1
	a5	1189	0.105	0.307	0	1
	a6	1189	0.380	0.486	0	1
	a7	1189	0.106	0.308	0	1
	a8	1189	0.109	0.312	0	1
	a9	1189	0.129	0.335	0	1
Geographical indicators	LOCAL_EPO	1225	11.444	17.517	0	59
	LOCAL_MANUF	1225	13730.890	11822.490	1322	47266
	GEO_S	1225	0.313	0.464	0	1
	GEO_C	1225	0.288	0.453	0	1
	GEO_N	1225	0.399	0.490	0	1
	ID	1225	0.614	0.487	0	1

intellectual property that can be passed to industry and second for whether research performance provides a signal to industry of the best university departments. We find that research overall performance (RES_RATING) has no significant impact on business funding to universities but we do not have information that allows us to test the impact on funding of research quality on the frequency of interactions and the applicability of the research.[11]

Bruno and Orsenigo's (2003) findings for the impact of department size on industry funding are confirmed only with respect to the probability to access business funding. The coefficient of the variable measuring the number of researchers (P_RESEARCH_07) is positive and significant confirming that departments need to develop critical mass in research activities in order to be able to attract business funding. Departments with larger numbers of research staff will benefit from greater visibility, greater research specialisation and more efficient procedures for the management of collaborations.

The analysis of the impact of geographical location on the department's capability to raise business funding provides mixed results. The Tobit and Probit regressions show that localisation in southern Italy (GEO_S) affects the ability to establish a collaboration agreement with industry and affects the ability to raise private funding, but not its amount. Academic institutions in southern Italy appear disadvantaged with respect to institutions located elsewhere in the country, probably as an effect of the weaker productive structure. Location in central Italy, on the other hand, significantly decreases the amount of business funding to departments and the impact of the proxy for local absorptive capacity for research services on the amount of private funding raised by departments is negative and significant. For likelihood of university–industry collaborations (LOCAL_EPO) the effect of location in central Italy appears neutral. The same holds for proximity to a large number of medium–large businesses (LOCAL_MANUF).

From a geographical perspective, what really matters for university–industry collaboration and university access to private funding is proximity to an ID. Presence of an ID in the area surrounding the department positively affects the probability of obtaining business funding and, most importantly, the amount of business funding obtained. We conclude that departments' location in the proximity of an ID enables access to a greater concentration of enterprises specialised in the same industry (the department's 'potential market') and provides the opportunity to offer better-targeted research and consultancy services. Moreover, in such a case industry–university relations intermediaries such as industry associations, services centres and industry consortia could have better chances of channelling firms' innovation needs to academic institutions. In fact firms territorially concentrated in districts are likely to have similar technological needs and generate a common local demand for innovation and training services.

[11] We also used the number of PRIN (Research Programmes of Relevant National Interest) projects granted to departments by MIUR in the last three years as a proxy for research quality: the econometric results did not change significantly.

Table 7
Cross-sectional Tobit and Probit regressions.

	(1)	(2)	(3)
	Probit	Probit marginal effects	Tobit
F_PRIVATE_07	0.005	0.000	0.885
	(0.001)***	(0.000)***	(0.023)***
F_EC_07	0.001	0.000	0.040
	−0.001	0.000	(0.019)**
F_MIUR_07	0.000	0.000	0.079
	−0.001	0.000	(0.038)**
F_UNI_07	0.000	0.000	0.013
	−0.001	0.000	−0.061
F_OTHER_PA_07	0.001	0.000	0.003
	(0.001)**	(0.000)*	−0.038
SIZE_UNI1	0.014	0.001	−32.781
	−0.248	−0.012	−30.706
SIZE_UNI2	−0.637	−0.054	−59.134
	(0.249)**	−0.035	(34.841)*
SIZE_UNI3	0.135	0.006	−5.954
	−0.146	−0.007	−17.997
EPO_MNGMT	−0.249	−0.01	−30.918
	−0.165	−0.006	−23.049
POLYTECH	0.445	0.015	17.857
	−0.342	(0.008)*	−34.872
P_RESEARCH_07	0.011	0.001	0.567
	(0.005)**	(0.000)*	−0.518
P_RESEARCH_OTHER_07	0.000	0.000	0.471
	−0.003	0.000	−0.359
RES_RATING	−0.967	−0.046	−16.73
	−0.796	−0.040	−115.798
a3	0.617	0.017	41.216
	(0.289)**	(0.007)**	−37.774
a5	0.549	0.017	20.437
	(0.218)**	(0.007)**	−31.655
a6	0.455	0.02	50.027
	(0.180)**	(0.010)**	(26.559)*
a7	0.784	0.021	62.621
	(0.285)***	(0.008)**	(36.663)*
a8	0.536	0.017	83.417
	(0.258)**	(0.008)**	(33.661)**
a9	0.923	0.024	160.185
	(0.307)***	(0.009)***	(31.991)***
LOCAL_EPO	−0.012	−0.001	−2.031
	−0.009	0.000	(1.078)*
LOCAL_MANUF	0.000	0.000	0.002
	(0.000)**	(0.000)*	−0.001
GEO_S	−0.537	−0.033	−31.106
	(0.222)**	(0.019)*	−28.320
GEO_C	−0.128	−0.007	−55.048
	−0.208	−0.011	(25.443)**
ID	0.381	0.021	47.313
	(0.169)**	(0.012)*	(22.056)**
CONSTANT	0.569		−39.532
	−0.755		−108.699
Observations	1132		1128
Pseudo R2	0.168		0.694

Robust standard errors in parentheses.

4. Concluding remarks

Several strands of the scientific literature emphasise that university–industry collaboration is an important driver of successful innovation and, consequently, fosters sustained economic growth. Policy makers face the dual challenge of encouraging firms to rely on the knowledge produced in academia and persuading universities to be more open to interaction with the private sector. In such a context, universities are also requested to re-think their role within the economic and social system, making it more direct and effective.

This study of the variables that facilitate private funding of university research departments provides some new and interesting insights into university–industry interaction. Three things seem to be important for the capability of universities to attract private funding. First, the experience of departments in building relations with businesses: departments that obtained private funding in the past are more likely to continue to be able to attract private finance. Second, the ability to achieve a critical mass of research in a

given sector, in terms of visibility and results is important. Third, the proximity of the university to an ID increases the capability to obtain business funding.

Although the empirical evidence shows that individual district firms, which in Italy are usually very small and lack the skills and managerial organisation required to manage relationships with academic institutions, are less likely to rely on universities to solve their technological problems, the ID as a whole can offer unique opportunities for universities to identify and satisfy firms' innovation needs, and provide opportunities for intermediate agents to manage these relationships.

Research specialisation in scientific areas close to the industry specialisation of the ID is generally of little significance insofar as it is the entirety of the local production system, its *milieu* and its complexity that is important. The ability to cooperate and the capacity of districts firms to use the research results, and the presence of intermediate actors capable of interpreting business needs and aggregating demand, are also features of IDs that favour the emergence of university–industry relations.

Once these links are in place, this encourages departments to seek new financial resources from firms, whilst positive collaboration experience and knowledge dissemination in the local area encourages firms to consider university departments as valuable partners.

This has an impact on the instruments to be adopted in designing innovation policies in contexts like IDs. As discussed in literature, establishing links between small enterprises and universities is a difficult process as small businesses are reluctant to contact academic institutions to find solutions to their innovation problems, whilst as evidenced here, university departments have realised that IDs are an important potential market for their technological solutions. Therefore, funding firms' innovation efforts is not sufficient to promote university–industry collaborations: in order to promote business confidence in academic institutions public policies should be addressed, instead, at the promotion of projects supporting local productive systems, run by intermediaries, universities and small group of firms. This, especially in the case of IDs, is likely to start imitation processes that will generate new collaboration options between academia and local firms. In particular, the complementarity between public and private research funding to universities implies that if public funds are made available to departments for the creation of test facilities, specialised research teams and the acquisition of equipment, firms can free ride on these university facilities insofar as they can derive higher expected internal rates of return of their R&D investments through further projects at lower incremental costs. The more these assets are sector and filière-specific, the higher the increase in the expected marginal rates of return for firms located in IDs, due to the propagation of spillover effects. Hence, the main policy implication that can be derived is that public funding to universities should be increased in order for technology and knowledge transfer to be fostered. More specifically, public funding for research projects should be granted at the local level, identifying the eligible research fields seconding the natural vocation and the peculiarities of the local industrial system. Moreover, our paper underlines that universities' (as well as departments') size positively affects the capability of building and consolidating university–industry collaborations, inasmuch as a critical mass must be reached in order for the spillover effects to start spreading, which implies that specific policy measures aimed at favouring the merger between universities serving the same area or at least at avoiding their further fragmentation are highly desirable.

Finally, the results presented in this paper highlight the need for further research into how IDs evolve when collaboration with a university has been established. It is clear that much of the potential benefit to IDs from stronger university–industry linkages remains to be exploited; for example, this collaboration could enable the evolution of IDs into technological districts. Such transformations will be crucial in the global context, where many low value added national industries are being subjected to huge international competitive pressure from economic systems where the productive factors are substantially cheaper.

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