UNIVERSITÀ CATTOLICA del Sacro Cuore

DIPARTIMENTO DI DISCIPLINE MATEMATICHE, FINANZA MATEMATICA ED ECONOMETRIA

WORKING PAPER N. 13/6

Is collaboration with universities really beneficial for firms?

Evidence from Italy

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Abstract

This paper focuses on the relationship between firms' innovative performance and different forms of academic cooperation for innovation, paying a specific attention to the role of Universities as sources of information. We build a dataset merging information drawn from two different surveys carried out by the Bank of Italy between 2007 and 2010. We show that the impact for firms of partnering with universities, in terms of the likelihood of producing a drastic innovation, is significant and increases as the level and quality of engagement increases. Thus, Universities may represent a privileged source of knowledge for firms. Whenever the commitment in terms of resources and time increase on either side, the degree of novelty of innovation increases as well.

JEL classification: O32; L24

Keywords: university cooperation; innovation; discrete choice.

1 - Introduction

This paper aims at investigating the role of universities in fostering innovation. We address this issue from two different perspectives. On the one side, we investigate if cooperation with university may positively affect the probability of innovative activity of firms. On the other side, we asses the relevance of universities as a source of information in fostering the innovative attitude of firms.

The paper is motivated by evidence that firms are becoming increasingly aware of the importance of having partners as a source of new knowledge. This awareness stems from the fact that in recent years, rapid technological change, shorter product life cycles and globalization processes, have deeply transformed the current competitive environment . These changes are inducing firms to face stronger competitive pressure which push them to develop new product, to improve productive process or to implement new technologies. Thus they need to continually advance knowledge and to innovate. At the same time, entrepreneurs recognize that technological innovations are less and less the outcome of an individual firm's isolated effort (Fisher and Varga, 2002; Drejer and Jorgensen, 2005).

Firms can acquire knowledge and technology from many external partners[1]. These include competing firms, research organizations, government laboratories, industry research associations, and universities. However, these latter are unique in terms of their potential. Universities provide a conduit for the spillover of knowledge from the academic organization, where knowledge is created and transformed, into innovative activity, in order to ultimately enhance the competitiveness of firms, industry and the country. As a result of the complementary nature of industry-university relationships, some of these collaborative activities have been instrumental in helping firms to advance knowledge and proper new technologies in many areas, especially in the scientific sector (Lundvall, 1992; Metcalfe and Ronnie, 2008).

Thus, a deep understanting of the impact of collaboration between firm and university is relevant for the policy implication it might have on the innovation system. It is worth noticing that recently policymakers are putting emphasis on both knowledge transfer and commercialization of academic research. For this reason, in most

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[1] See Ozman, 2009, for a survey of the literature.

research projects funded by the European Commission[2] is required at least one industry partner, and this requirement is becoming the norm for government-funded research in many countries. This is being accompanied by the creation of new mechanism to foster collaboration between universities and industry to facilitate technology transfer. Technology transfer offices and science parks (see Liberati et al., 2012) are being created to allow universities and firms to meet and collaborate (Hall et al., 2000; Siegel et al., 2003; Kirby, 2006).

Thus, Universities are increasingly seen as one of the engines of economics growth and they are being asked to contribute to economic development and competitiveness (Etzkowitz and Leydesdorff, 2000). This view is consistent with the "triple helix" model[3], which argues that as universities increasingly take on "industrial" roles, public sector and industrial organizations also being to take on academic roles leading to the emergence of a set of interactions of what were formerly distinct domains of activity. In other words, university needs to be directly linked to industry in order to maximize the industrialization of knowledge. As a consequence of the awareness of the crucial role that universities may play for firms' innovation and economic growth, a sizable empirical literature on university-industry interaction and technology transfer has been developed. However, given the complexity and constant flux that have been occurring in these two overlapping worlds, there have been emergent issues that remain unexplored.

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[2] *Europe 2020 Flagship Initiative Innovation Union.* European Commission. 2010

[3] "[…] the universities' assumption of an entrepreneurial role is the latest step in the evolution of a medieval institution from its original purpose of conservation of knowledge to the extension and capitalization of knowledge. As the university increasingly provides the basis for economic development through the generation of social and intellectual, as well as human capital, it becomes a core institution in society." (Etzkowitz, 2002, p.1).

This paper takes the case of Italy to investigate the role of university linkages and their impact of firms performance. Italian firms are usually characterized by a low level of innovation activity that is nowadays considered as one of the main reasons to explain the Italian slowdown in the productivity trend of the last fifteen years. The reasons usually addressed to explain this situation refer to the productivity specialization, to the firms' governance, and especially to the fact that the Italian firms are undercapitalized, reling too much on bank credit. Most of these problems have a structural character and cannot be solved in the short run. However, the possibility to engage a collaboration with research oriented partners could be a way to overcome, at least partially, these problems. Specifically, our paper aims at investigating i) the impact of collaboration in term of the novelty of innovative outcome, and ii) whether universities are important information and knowledge sources for industry.

Results may significantly change according to the definition of innovation and collaboration. In the analysis, innovation is classified according to the degree of novelty, and collaboration has been distinguished according to the effectiveness of the partnership.

We show that collaboration with universities is able to increase the probability of a substantial technological innovation. However, the type of partnership plays a relevant role. In other words, we find that the firm-university collaboration is effective in increasing the probability of technological innovation only when there exists a real interaction between partners; it means that "soft contacts" are not sufficient to affect the innovative attitude of firms. Moreover, our findings also contribute to shed some light on the paradox raised by Howells et al. (2012) according to whom it is difficult to conciliate the very low rating that firms assign to university as source of information with the impact that universities have on the innovative performance of collaborating firms. We show that universities are privileged sources of information only if the collaboration is "strict".

The analysis is conducted by using a unique Italian firm level database resulting from the merge of two different databases, namely the 2010 release of the Bank of Italy's Survey on Investment by Manufacturing Firms and the 2007 release of the Bank of Italy's Business Outloolk Survey of industrial and service firms. The two surveys collect information on Italian firms with more than 20 employees. The sample of firms we use is particularly suitable for our analysis. Most of research and innovation output are produced by medium and large firms (see, e.g., Frischer and Varga 2002, Chun and Mun, 2011). Among small firms, only start-ups (often university spin off) have a significant innovative activity, but they have peculiar characteristics in comparison with all other firms. In fact, they are very risky and they need some peculiar forms of financing. This entails that start-ups deserve an ad hoc analysis.

Summing up, this paper contributes to analyzing the peculiar characteristics and the relevance of collaborations between firms and universities, which is still an under explored issue. We propose that the way firms choose to collaborate with academia is crucial for understanding the different roles that academics play in industrial invention activities, both as partners and as source of information. The type of collaboration may help to explain the degree of the novelty of the resulting innovation.

The rest of the paper is organized as follows. Section 2 reviews the literature. Section 3 provides an overview of the data and variable selection. Section 4 provides some descriptive statistics and the methodology used in the empirical analysis. Section 5 discusses empirical results. Section 6 provides the conclusions.

2 - Literature Review

In recent years several theoretical and empirical analyses have been put forward to explain R&D cooperation strategies for innovation. In particular, key research areas have dealt with the issue of how universities can support and develop the innovation process (Peters and May, 2004, pp. 268–9). In this strand of the literature, we focus on two main streams of research. The first regards the impact of collaboration on the innovative performance. The second focuses on the importance of university as a source of information for firms' innovation activity.

As regards the former, research institutions (University and Research Centre) aim at providing new scientific and technological knowledge (Drejer and Jorgenses, 2005), which are relevant in producing innovation. However, knowledge from universities is transferred often informally to firms, although there are different channel of transfer, such as citations, patents and spin offs. Thus, due to the characteristics of knowledge (or knowledge transfer) industry university cooperation may not directly influence the success of a firm in the innovation process. One of the earliest papers in this literature was by Mansfield (1991). He showed that, in a random sample of 76 large American firms in seven manufacturing industries, about 10% of the product and process innovations could not have been developed without recent academic research. More recently, Monjon and Waelbroeck (2003) found that cooperation with universities (foreign rather than domestic) increases the probability of radical innovation, while spillover from universities does not. In the Korean context, Sung (2005) found that this cooperation does not affect the innovation probability of Korean firms in general. Thorn et al. (2007), using a dataset of Chilean and Columbian firms, found that collaboration between firms and universities increases the probability of introducing new products. Loof et al. (2008) showed that this kind of collaboration influences innovative performance. Levy et al. (2009) find that companies in high tech sectors, or located in foreign countries are likely to activate a multi-partner collaboration with the University, while domestic and regional companies have higher propensity to activate exclusive collaboration. Ashhoff et al. (2006) concluded that collaborations

with Universities improve the probability of innovative firms of developing new products. In contrast, some other studies find that such a collaboration is more important in affecting R&D decision-making and less important in generating tangible outputs.
Thus, the hypotheses to be tested are the following:

H1: We conjecture that some firm's specific characteristics, such as size, internationalisation and human capital endowment, influence significantly both the technological capability and capacities.

H2: We expect that that the impact for firms of partnering with universities, in terms of the likelihood of producing a drastic innovation, is positive and increases as the level and quality of engagement increases.

As far as the latter, firms should use inflows and outflows of knowledge and expand the market for the external use of innovation by collaborating with partners. In this way firms would share risks and reward, thus achieving advanced technological capabilities (Iammarino et al., 2013). The linkages to external knowledge have become obvious and important both because of substitution relationships (Schmidt, 2010; Love and Roper, 2001) and complementary relationships (Cassiman and Veugelers, 2002; Roper and Love, 2005; Roper et al., 2008 and Ganotakis and Love, 2011). Hence, a firm acquires external knowledge and employs them in the innovation process in order add value. This view is supported by the so called "open innovation model" (see, e.g., Chesbrough, 2003, Laursen and Salter 2006). It is now widely acknowledged that, as knowledge producers, universities contribute to increasing regional competitiveness and attractiveness through a range of activities, including research collaboration, technology transfer and licensing. Specifically, a key issue has become the creation, circulation and utilisation of knowledge as a result of the interplay between

universities and businesses and the optimal policy tools to foster virtuous development cycles (Mowery and Sampat, 2005).
However, firms rate universities very low as information sources and potential partner, even if their actual use and impact on firms is much higher. In general, there is a tendency to equate the low importance and relevance placed upon universities as sources of information and knowledge with the ex post impact of universities on collaborating firms. This findings has been confirmed by studies from both Europe and North America (see, e.g., Howell et al. 2012, Cosh et al. 2010).
For example, Becker (2003), using German data, found that the use of knowledge resources from universities and research institutions increases the probability of process innovations, but has no impact on the probability of product innovations, while joint R&D with universities has a positive impact on the probability of both product and process innovations. Liao et al. (2003) note that the most important sources of knowledge are customers and competitors, but they think that having a large number of sources is better. In fact, a broad range of sources may more likely to provide more information, which is expected to then create better options for identifying changes in the environment, thus leading to improved performance. Indeed, previous research showed that new product development tends to be more successful when customer needs are clearly defined rather than when innovation is based on technology, suggesting that customers will be an important source of information (Lukas & Ferrell, 2000; Mavondo, Chimhanzi & Stewart, 2005). Grimpe and Sofka (2009) identify different knowledge linkages leading to innovation decisions and success. Specifically, firms in high-tech industries tend to access universities or supplier to derive technological knowledge, while firms in low-tech industries are more likely to benefit from the knowledge provided by customers or competitors.
Thus, the hypotheses to be tested are the following:

H3: We conjecture that some firm's sources of information, such customer and suppliers, influence positively both the technological capability and capacities.

H2: We expect that the combined impact for firms of partnering with universities and sources of information, in terms of the likelihood of producing a drastic innovation, is positive and increases as the level and quality of engagement increases.

3 - Data and Variables

3.1 Dataset

The dataset used in the analysis is the joint result of two different surveys carried out by the Bank of Italy: the Bank of Italy's Survey of industrial and service firms (INVIND hereafter) and the Bank of Italy's Business Outloolk Survey of industrial and service firms (SONDTEL).
The INVIND[4] represents one of the richest sources of information at firm level for Italy, and it is widely used in the literature (Banca d'Italia, 2008). The INVIND is carried out by the Bank of Italy once a year between March and April since 1984. It collects both

[4]The INVID database goes back to 1984. The questionnaire is sent to each enterprise at the beginning of each year and the questions refer to the last two years (this allows data consistency to be checked over time). The sample is stratified according to three criteria: sector of economic activity, size and geographical location. With regard to the first, the three-digit Ateco-91 classification of the National Institute of Statistics (ISTAT) is used (fully consistent with the international Standard Industrial Classification). Size refers to the number of employees; four classes are considered: 50-99, 100-199, 200-999, 1000+ employees. Due to difficulties in ensuring high quality in the data collection, small firms, defined as those with fewer than fifty employees, are excluded from the SIM sample. Firm location refers to the regions (nineteen). The presence of outliers and missing data within the sample is dealt with by means of appropriate statistical techniques.

quantitative and qualitative information about industrial firms and service firms. Similarly, the SONDTEL is carried out once a year between September and October since 1993 on the same sample of firms interviewed with the INVIND. Information are collected through telephone interview. In both cases interviewers are officials of the Bank of Italy, who tend to establish long-run relationships with firms' managers and are also responsible for the accuracy of the collected information.

Both surveys contain questions which are fixed over time, mainly concerning sales, employment and investments, and a series of questions that vary each year according to the specific issues investigated. For this reason, we focus on the 2007 release of the SONDTEL and on the 2010 release of the INVIND. The former contains questions focusing on the co-operations towards the attainment of innovations, while in the latter there is a section on the innovative attitude of firms. The 2010 release of INVIND contains information for 3.937 firms, while SONDTEL collects answers of 4,196 firms. Unfortunately, in the 2010 release of INVIND, questions on the innovative attitude of firms were asked to a random subsample of firms. For this reason the number of available information drop to 1.964. Due to the presence of missing observations merging the two dataset we end up with a sample of 1162 firms, which is the dataset used in our empirical investigation.

The choice of the Bank of Italy surveys has two main advantages. First, they contain high quality data, mainly due to the rigorous procedure followed in the collection. Second, the surveys mainly focus on medium and large firms which are those producing innovation. We do not consider young innovative companies (YICs), usually small and key actors in the process of implementation of the new technologies, which are the object of a special attention (see, e.g., Pellegrino et al., 2012).

In what follows, we proceed to describe both dependent and independent variables used in our analysis.

3.2 Dependent Variable

As Becheikh et al. (2006) point out, innovation measurement has always been a thorny task for researchers; moreover, the issue of innovation novelty has been handled in different ways (see, e.g. Lakemond and Berggren, 2006, for a comprehensive analysis). In building the dependent variable, which measures the firms' innovation activity, we follow Liker et al. (1999), and use a criterion based on the degree of novelty of the kind of innovation considered.

The respondents to the INVID Survey 2010 were asked whether they were involved in some form of innovation in the period between 2008 and 2010. More precisely, they were asked whether they have obtained patents in the period under consideration. Moreover, they had to indicate whether they were involved in one or more of the following activity: product innovations, innovation of productive processes, managerial or organizational innovations, without necessarily attaining a patent from this activities. By using the answers to these two questions, we build up a categorical ordered dependent variable (Transfer), which has three different outcomes. It takes on a value equal to 2 in case of firms developing a new product or a new production process, namely a patented innovation. In the following, these firms will be called "firms with technological capability". It is equal to 1 in case of firms developing a (marginal) new product or a process innovation not originating a new patent. In the following, these firms will be called "firms with technological capacities"[5]. Finally, it takes on value equal to 0 in the case of technologically inactive firms, i.e. the enterprises which declared neither a patent nor innovative output in the period covered by the INVID 2010. These firms will be called "inactive firms". It is worth

[5] See, e.g., Von Tunzelmann (2009) for a detailed analysis of firms' competences versus capabilities.

noticing that we have chosen not to consider managerial or organizative changes as innovative outcomes of firms, since we are mainly interested into the "technological transfer" related to co-operations. Table A1 displays the regional distribution of the three categories of firms, whereas Table A2 shows the type of collaboration established by firms with universities taking into account their geographical location.

In order to explain in detail the firm innovation activity, we build different models where the dependent variable (Transfer) is regressed on different sets of independent variables. Each of these regression models, which have some independent variables in common, is used to highlight a different aspect of the collaboration between firms and universities. Next sections will describe these models and provide a complete list of the employed independent variables.

3.3 Independent Variables

In the first regression model, we are mainly interested to investigate whether and to what extent the collaboration with academic institution is able to affect the innovative activity of firms. Thus, the specific independent variable of this regression is the firms' technological cooperation with universities. By using the answer of firms to a specific question contained in the 2007 release of SONDTEL, we build up a dummy variable, UNIV, which takes on value 1 if the firm had engaged in technological collaboration with academia in the period 2005-2007 and value equal to zero otherwise. It is worth noticing that, since collaboration is observed in the period before the innovation is realised, the degree of novelty of innovation turns out to be explained by collaboration and not vice versa. In this way, we avoid the problem of endogeneity due to reverse causality. In addition, we have to consider that usually there is a systematic delay between the beginning of collaboration and the observation of results. In fact, the technological transfer like the development of new product or process or the adoption of new technology requires some years to be implemented and to produce outcomes. Thus, using the SONDTEL 2007, we were able to track how collaboration between 2005 and 2007 influences the achievement of innovation between 2008 and 2010.

A second regression model is finalized to explain to what extent different types of cooperation set up between firms and universities may influence the firm's innovation activity. One of the main issue stressed in this paper is that cooperation is really effective only if it involves firms and universities in a deep exchange of information, whereas other forms of shallow contacts may be not sufficient to produce a significant technological transfer. We address this issue distinguishing three different forms of collaboration. A first cooperation agreement is that of firms which have financed R&D and participated to the innovation process with universities; a second cooperation type is that of firms which have acquired consultancy from university; then, we consider the case of firms which have organized stages for students. Accordingly, firms are classified in three different categories relating to the type of their collaboration with universities: firms finance R&D (i=1), acquire consultancy (i=2), and host stage (i=3). On the basis of this classification, we build three different dummy variables (TYPE_COLLi, i=1,..3) which assume value 1 when a specific occurrence takes place and zero otherwise.

Then, we run a third regression model in order to assess the relevance of university as source of information and knowledge to drive firms' innovation activity[6]. According to Howells et al. (2012), firms usually rank universities very low among information sources and potential partners, but their actual role and their impact on firms innovation performance is much higher. For this purpose, we use a

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[6] See, e.g., Amara and Landry (2005).

specific question in the 2007 survey where firms were asked to classify different sources of information according to their relevance in affecting their innovative behaviour and thus results. Four different answers were possible: very effective, quite effective, low effective and no effective In Table A3 the firms' answers have been grouped into two classes "not/little relevant" and "fairly/ very relevant.) Along with university and research centres the other possible sources of information are: intra mural information, clients, suppliers, competitors, consultants, Universities and public research centres, and exhibitions. The specific set of independent variables of this model is a set of seven dichotomous variables, INFO_SOURCEi, whose value is 1 when the source of information is very/quite relevant for a firm, and 0 otherwise.

As a further investigation of the role of university and research centre in affecting technological innovation of firms, we run a forth regression model exploiting the additional information about the collaboration between firms and universities. More precisely, we construct a set of dummy variables (INFOSOURCE_TYPECOLLi, i=1,2,3,4) which allow us to distinguish the following cases: i = 1 if there exists only an information flow between university and a firm; i = 2 if there exists an informative flow between firm and university and the firm hosts students stage; i = 3 if there exists just a collaboration but not an informative flow; and i = 4 if the firm both collaborates and uses university as a source of information.

In the next two paragraphs we provide a complete list of all the independent variables related to firm's characteristics as well as their sectorial belonging and geographical location, which are employed as independent variables in all the regression model introduced above.

3.3.1 Firms characteristics

Firm size (*Fs*): according to Schumpeter (1943), large firms have the wherewithal (large scale production and capacity, marketing infrastructure, finance and R&D expertise) to exploit new technology. Large firms have both the availability of resources and the possibility to internalize spillovers . Thus, large firms are generally more likely to collaborate with other firms, and especially with institutions (Mohnen and Hoereau, 2003). This positive relationship has been demonstrated for several European countries (Miotti and Sachwald, 2003; Lopez, 2006). Moreover, Segarra (2008) observed that small and innovative Spanish firms find very difficult to get partners. However the evidence is still controversial, in fact, it is arguable that small firms have greater flexibility in adjusting employees to innovation projects and benefit from less complex management structures in implementing new projects. As indicator of the firm size we consider the log of the firms' sales, which is a continuous variable.

Aging (*Ag*): aging is computed as difference between the current year and the constituent year reported by the firm; Colombo et al. (2004) and Colombo and Grilli (2005) pointed out that – at least in some sectors – young firms may be at the core of the innovation process.

Affiliation to a business group (*Bg*): Group affiliation can influence a firm's propensity to be engaged in successful innovation and cooperate with an increasing number of partners (see, for instance, Piga et al., 2004; Dachs et al., 2008). Mairesse et al. (2002) underlined the expected innovative benefits gained from an easier access to (internal) finance and the effect of intra-group knowledge spillovers for firms that are members of industrial groupings. Similarly, Iammarino et al. (2013) pointed out that a firm's technological status benefits from the relationships within a group. However, whether group affiliation increases collaboration with universities is still disputed. Belderbos et al (2004b) found that it does increases R&D cooperation with customers and suppliers, but not with universities and public research institutions.

Internationalization (*In*): global competition can spur innovation and capabilities, while technologically inactive firms are doomed to exclusion from the international arena (e.g. Archibugi and Iammarino, 1999; Narula and Zanfei, 2003). Moreover, firms that sell large parts of their production abroad are also more likely to be engaged in R&D collaboration (Dachs et al. 2008). Thus, at a firm level, a valid measure of export attitude (i.e. the level of internationalization) is the presence of the firm in foreign markets. In our analysis, 20% of the sample refers to highly export oriented firms (more than two third of their production are exported), while another 28% exports more than one third of the production. Internationalization is a dummy variable which is equals 1 if the firm has sold its goods or services in a foreign country.

Human Capital: human capital is seen as complementary to innovation, constituting per se a firm competence and generating a super-additive effect in terms of both innovative and economic performance (see, for example, Machin and van Reenen, 1998; Piva and Vivarelli, 2004; Piva et al, 2005). It can also be used as a measure of absorptive capacity. As argued by Cassiman and Veugelers (2002), Piga et al. (2004) and Lambertini et al. (2004), firms with high levels of absorptive capacity are better prepared to join other partners in innovative projects. In order to specify the level of the human capital, we introduce two variables, namely PHD and BLU_COLLAR. The former takes value equal to one in case the firm hired employees with a degree, the latter is continuaous variable which assumes values between 0 and 1.

Propensity to innovate: university collaboration is just one of the strategy a firm may adopt to innovate. We cannot exclude, a priori, other strategies that could be implemented to attain innovation like, for example the *internal R&D* (*IR&D*), *the acquisition of software (As) and the acquisition of patents* (*Ap*).

As far as the internal R&D is concerned, it can be defined as that set of creative work undertaken within the business that increases knowledge for developing new and improved goods or services and processes. In-house R&D activities improve the firms' absorptive capacity (Cohen and Levinthal, 1989; Catozzella and Vivarelli, 2007). In order to consider these activities, we include a dummy variable which equals to 1 if the firm engaged internal R&D during the period of analysis and 0 otherwise. Moreover, investment in innovative activities often implies both the acquisition of patent as well as computer hardware and software. As from Pellegrino et al. (2012), the external acquisition of technology in its embodied component (machinery and equipment) turns out to be most important factor for innovation both for mature and new firms. In order to take into account this variable, we introduce a dummy variable which equals to one if the firm engaged in these kind of acquisitions.

3.3.2 Economic sectors and location

Collaborations may differ depending on the type of industry. There are sectors where firms present higher levels of innovation and R&D practice. Therefore, the analysis includes Ateco 2007 sectorial dummies (see Table A4 for a detailed description) in order to control for the different sectorial technological opportunity and appropriability conditions.

Moreover, among the main controls, firm's location is especially interesting. Spillover effects are among the main sources of innovation that the theory has enlightened. R&D is frequently carried out by firms located in agglomerated areas, either metropolitan areas or industrial districts. Due to data limitation, we use macro-area dummies instead of a direct measure of geographic proximity to reflect firm location. Our database cover 21 regions across Italy, and this analysis re-groups them into four main areas. We use four dummies, each of them assuming value of 1 if a firm is located in the corresponding area and 0 otherwise. It is found that 24,1% of all firms are located in the North West area, 16,7% in the North East area, 24,9% in the Centre and 34,3% are located in the South and in the Islands.

Table B1 shows the complete list of the variables used in the analysis here carried out.

4 – Descriptive Statistics and the econometric strategy

4.1 - Descriptive Statistics

In our sample, out of the total 1162 firms, 470 (40,4 per cent) are non-innovative firms, while 692 (59,55 per cent) are innovative firms. In particular, we consider as innovators both firms that introduced new or significantly improved goods or services and/or the processes used to produce or supply all goods or services (28,5 per cent) and firms that obtain patents from the innovation activity (31.1 per cent). Among these firms, the cooperation with academia, in the period 2005-07 was used by 37.5 per cent of them. A third of the companies (33.9 per cent) which co-operated with universities did so by taking part into specific research and funding entire projects, almost a third (28.7 per cent) bought consultancy services and 37.4 per cent of them just hosted internship students (see Table A2). These data do not allow for differentiating the type of internship hosted by companies, however, it is likely that internship often constitute the training period for skilled labour. Although the phenomenon of academic collaborations is not negligible, the majority of Italian companies have no contact with universities. Moreover, in the majority of cases relationships with institutions were carried out on an individual basis.

Table A3 shows the relative importance of different source of information for innovative activities in the period 2005-07. Sources internal to the company or the group where considered fairly/very important by 71.39 per cent of the firms, followed by relationship with clients, exhibitions and meetings, private consultant, suppliers. Research centres and Universities have been judged important just from 17,54 per cent of the firms. Thus, these data indicate that universities rate very lowly as a source of information and knowledge[7].

As far as the characteristics of firms in the sample, most of them are small (about 67 per cent of the firms have less than 150 employees) only 12.9 per cent are large (with more than 500 employees), and the remaining 20.1 per cent are medium enterprises. In the whole sample, 15,4% of the firms refers to highly export oriented firms (more than two third of their production is exported), while another 18 per cent exports more than one third of the production. Firms are fairly aged: only 21,7 per cent of the observations refers to firms less than 19 years old.

The sector of activity is important, too (see Table A4 for a detailed composition of the sample). Almost 30 per cent are science based, followed by Food and beverage (12 per cent) and by wholesale and retail trade (11 per cent).

4.2 The econometric model

This section sets up the empirical models used in the analysis. In accordance with the nature of the dependent variables, ordered logistic regressions[8] were run[9]. The specification of each these models is given here below

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[7] This findings has been confirmed by studies form both Europe and North America (see, e.g., Freel and de Jong, 2009; Cosh et al., 2006; Cosh and Hughes, 2010; Howell et al., 2012).

[8]Given that the dependent variable is an ordered one, we opted for the ordered logistic model. However, multinomial logistic regressions were also run with the cate-

$$y_t = \beta_1 x_i^* + \boldsymbol{\gamma}' x + \boldsymbol{\delta}' \boldsymbol{z} + \boldsymbol{d}' \boldsymbol{\omega} + \varepsilon_i$$

(1)

where

y_t is the categorical ordered variable Transfer, x_i^* represents the variable which is peculiar to each of the four regression models. In particular,

$$x_i^* = \begin{cases} \text{the dummy UNIV in the first regression model} \\ \text{the dummy TYPE\_COLLi in the second model} \\ \text{the dummy INFO\_SOURCEi in the third model} \\ \text{the dummy INFOSOURCE\_TYPECOLLI in the fourth model} \end{cases}$$

x is the vector whose elements are the firm's characteristics, namely

x'= (*Fs, Ag, Bg, In, Phd, BLUE_Collar,, IR&D, As, Ap*)

where the symbols have been introduced before.

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gory of technologically inactive firms as the reference (category 0). The results from the multinomial, and the estimated predicted probabilities of both the multinomial and the ordered logistic models, supported our choice of the latter, as the probability distribution between the two estimation methods is not substantially different. Furthermore, a Brant test to verify the parallel regression assumption (also called the proportional odds assumption) was performed after the ordered model. The test compares slope coefficients of the J-1 binary logits implied by the ordered regression model. This test can only be computed if all the independent variables in the ordered model are retained in all the implied binary models. For this reason, it was not possible to compute the test in all the regional models, nevertheless – where feasible – the test provided evidence that the parallel regression assumption has not been violated.

[9] Equivalent results hold in the unreported multinomial logit regressions, where the coefficients for firms with technological competences (category 1) are in general smaller and/or with lower significance levels than those for firms with technological capabilities (category 2).

z is the vector of the sectorial dummy variables, ω is the vector of the macro-regional dummies, $\beta_1, \gamma', \delta', d'$ are coefficients to be estimated and ε_i is an error term.

As already explained, the first regression model, corresponding to specification (1) with x_i^* =UNIV, measures the impact of collaboration with academic institutions on the firms' innovative activity.

The second model, corresponding to specification (1) with $x_i^* =$ TYPE_COLLi, estimates which kind of collaborations are more likely to affect the innovation activity of a firm

The third model, corresponding to specification (1) with $x_i^* =$ INFO_SOURCEi, quantifies the role played by information sources on innovation, i.e. the knowledge spillover, independently of the existence of a collaboration agreement.

Finally, the fourth model, corresponding to specification (1) with $x_i^* =$ INFOSOURCE_TYPECOLLi, measures the joint effect of the different types of collaboration and university information on the firms' innovation activity.

5 - Econometric Results

Table B2 reports the marginal effects obtained with the first model specification. As expected, the variable "collaboration with universities" UNIV is statistically significant at 1% and it shows that it increases by 37 percent the probability that the firm is in a higher modality of the dependent variable TRANSFER. Hence, technological collaboration with academia is relevant to promote the firms' innovation performance. Table B3 shows the results obtained

after splitting collaboration between firms and universities in three possible forms. The strict collaboration with universities, which we identify in the funding of the research carried out in universities (TYPE_COLL1) is really effective to increase firms' likelihood of obtaining innovative output. In fact its marginal effect is equal to 0.687 per cent and it is statistically significant at 1%. Also obtaining advice from universities proves to be useful for this purpose, although its marginal effect is smaller with a 5% level of statistical significance. In contrast, looser forms of collaboration, such as having offered internships to college students (TYPE_COLL3), turns out to be useless to increase the probability to obtain a patented innovation or to enhance the innovation process.
Table B4 and B5 shows results of regressions were we have tryed to assess the role of universities as a source of information for firms. When we consider all possible sources of information for firms (Table B4) it turns out that exhibitions, namely networks ,are the most important channel through which firms acquire new information. They are followed by universities, private consultants and clients which are all significant at 10 per cent. Our findings suggest that firms seem to place a great deal on their vertical forward and backward linkage networks in term of access points for knowledge and information about innovation. In contrast, firms see universities as a less relevant source of information. This result is in line with Howell et al., 2012, according to which firms find it difficult to access information from universities, because the latter are not typical partners in the normal activity of firms. This suggests that once firms have come in contact with universities the information flows that they draw can be useful in contributing to the process of innovation of firms. This hypothesis is tested in the last regression. Results reported in table B5 show that universities play a crucial role in enhancing the firms' innovation only when firms establish a collaboration; more important when the collaboration brings together a flow of information

(INFOSOURCE_TYPECOLL4), the marginal effect is greater and the degree of statistical significance of the parameter increases. Thus, although universities may not be initially a favoured partner, when collaboration occurs with academia it has a very significant impact on innovation.

Also some firm's characteristics prove to be effective in promoting innovation effort. These variables are in-house R&D, the acquisition of patents and software. All these variables are significant at the 1% level in the whole set of regressions. They are in line with the conclusion of other empirical studies (Fritsch and Lukas 2001, Berlder et al. 2004) and confirms the results of Fischer and Varga (2002). In particular, in-house R&D seems to reinforce the firm's absorptive process: Catozzella and Vivarelli (2007) find that internal R&D is the most important determinant of innovative output, allowing for higher complementarity effects between diversified innovative inputs. Indeed, firms that invest in internal innovation activities, may accumulate the required ability to develop projects involving external institutions, such as Universities.

Also firms' size and the internationalization (which are significant at the 5% level) have a positive impact in enhancing the innovative behaviour of firms.

As far as the firm dimension, it is relevant to improve the firm's technological transfer and reinforces results by Fischer and Varga (2002), who find size to be an important factor for innovation. Compared to large firms, SMEs have more difficulties in entering cooperative networks and developing new R&D linkages, due to lower financial resources and little accumulation of experience in technical knowledge (Chun and Mun, 2011). Although small firms could overcome these constraints by joining cooperative agreement, firm's size may still hamper the capability and the competence necessary to obtain innovate output due to the lack of the necessary human resources and management skills required to engage in cooperative activities.

Moreover, a high degree of openness – as highlighted by the magnitude of the coefficients of the Internationalization variable – stimulates the production of innovative output.
Finally, the level of the human capital, and more precisely the number of employees with a PhD title, is also important even if this variable has a lower impact than the others (it is significant at the 10% level).
Looking at the control variables, we see that belonging the Textile, Chemical and Transport and Communication sectors hinders the firms' ability to innovate. The same happens for firms which are located in South and Island.

6 – Concluding Remarks

Universities are seen as increasingly important players within national and regional innovation systems. Policy-markers' attention is being faced on their economic impact and how this can be manipulated and supported to develop great economic benefits. Our results indicate that collaboration with universities is important because it improves the probability of innovative outcomes. Specifically, universities have a more significant impact than any other type of collaborative partner in this respect, since agreements with universities are relevant to improve firms' technological status. More precisely, on the one hand, such agreements are significant in stimulating the innovative performance so that it is possible the development of an entirely new product or production process that allows firm to obtain a patent (i.e. a "drastic innovation"). On the other hand, collaboration with public research is less useful whenever we consider either a progressive product innovation, i.e. a marginal improvement to the components or subsystems of a product, or a process innovation, i.e. the adoption of a new or appreciably improved methods of production. In summary, the main contribution of this paper is to shed light on how collaboration facilitate product innovation achievements as well as increase their degree of novelty. Thus, the study conclude that there is a complex interaction between use, impact and value that firms hold in respect of their collaborative relationships with universities within an innovation system. The practical value of these findings lies in a better understanding of how the configuration of a collaborative agreement affects its own performance. Therefore, firms must be aware of the importance of the type and continuity of collaboration to develop the firms' competitive advantage.

Appendix A – Descriptive Statistics

Table A1. **Regional distribution of the categorical dependent variable: number of firms and relative percentage (in brackets), net of missing.**

	North-West	North-East	Centre	South
Technologically inactive firms (value 0)	89 (31,78%)	59 (30,41%)	109 (37,72%)	213 (53,38%)
Firms with technological competences (value 1)	82 (29,28%)	53 (27,32%)	83 (28,72%)	113 (28,32%)
Firms with technological capabilities (value 2)	109 (38,92%)	82 (42,27%)	97 (33,56%)	73 (18,29%)
Total	280	194	289	399

Table A2. **Regional distribution of the type of collaboration: number of firms and relative percentage (in brackets).**

Type of collaboration with Universities	**North-East**	**North-West**	**Centre**	**South**
Financing of research	38 (13,57%)	26 (13,34%)	46 (15,92%)	35 (8,77%)
Purchase of consultancy services	43 (15,35%)	22 (11,34%)	28 (9,69%)	30 (7,52%)
Offered student internship	35 (12,5%)	22 (11,34%)	40 (13,84%)	63 (15,79%)
Nothing	161 (57,5%)	117 (60,31)	170 (58,82%)	266 (66,67%)
Missing	3 (1,07%)	7 (3,61%)	5 (1,73%)	5 (1,25%)
Total	280	194	289	399

Table A3. Firms' information sources.

Information Source	**Not / little relevant**	**Fairly /very relevant**	**N. observation (missing excluded)**
Intra mural	28,61	71,39	1.115
Suppliers	70,80	29,20	1.106
Clients	59,28	40,72	1.105
Competitors	83,53	16,47	1.099
Consultants	70,50	29,50	1.105
Reserch centre and/or Universities	82,46	17,54	1.106
Expo, meetings publications	66,31	33,69	1.107

Table A4. Economic sectors.

Sectors	Number	Share
Food and Beverage	139	11,96
Textile, clothing, leather, shoes	104	8,95
Chemicals, rubber and plastics	98	8,43
Energy and Extraction	74	6,37
Engineering	346	29,78
Other manufacturing	91	7,83
Other non-manufacturing	31	2,67
Wholesale and retail trade	128	11,02
Hotels and restaurants	21	1,81
Transport and communication	88	7,57
Other business and household services	42	3,61

Table A5: Firms' characteristics.

Firms characteristics	mean	Standard deviation
Firm Size (Fs)	178,9	1372,2
Belonging to a Group (Bg)	44,9	49,8
Internationalization (In)	69,6	46,0
Age (Ag)	36,6	24,9
Acquisition of new human capital (XXX)	16,0	36,6
Acquisition of software (As)	60,2	49,0
Acquisition of patents (Ap)	10,1	30,2
BLUE_COLLAR	62,6	26,4

Appendix B – Econometric Estimations

Table B1: List of variables.

Name	Description	Nature
Dependent variable		
	Technological transfer of the firm	Categorical ordered (N=1162)
Transfer= 0	Technologically inactive firms	(N=470)
Transfer= 1	Firms with technological competences	(N=331)
Transfer= 2	Firms with technological capability	(N=361)
Independent/control variable in different specif.		
UNIV	**Collaboration with Universities**	Dummy (N=485)
TYPE_COLLi, i=1,…3	**Type of collaboration with Universities**	
TYPE_COLLI1	Firms financed and participate to R&D project	Dummy
TYPE_COLLI2	Firms acquired consultancy	Dummy
TYPE_COLLI3	Firms organized/host stage for students	Dummy
		Dummy
INFO_SOURCEi, i=1…7	**Information Source**	
INFO_SOURCE1	Intra-mural	Dummy
INFO_SOURCE2	Suppliers	Dummy
INFO_SOURCE3	Clients	Dummy
INFO_SOURCE4	Competitor	Dummy
INFO_SOURCE5	Private consultant	Dummy

INFO_SOURCE6	Public research institutes - universities	Dummy
INFO_SOURCE7	Exhibition	Dummy
INFOSOURCE_TYPECOLLi, i=1…4	**Relationship between information sources and collaboration**	
INFOSOURCE_TYPECOLL1	There exists information flow between industry and firm	Dummy
INFOSOURCE_TYPECOLL2	There exists information flow and firm hosts students stages	Dummy
INFOSOURCE_TYPECOLL3	There exists just collaboration but not an informative flow	Dummy
INFOSOURCE_TYPECOLL4	There exists collaboration and university is source of information	Dummy
	Firms Characteristics	
Fs	Firm Size	Continuous
Bg	Belonging to a Group	Dummy
In	Internationalization	Dummy
Ag	Age	Continuous
PhD	Acquisition of new human capital	Dummy
As	Acquisition of software	Dummy
Ap	Acquisition of patents	Dummy
BLUE_COLLAR	Share of Blue Collar	Continuous

Table B2 - **Determinants of firms' technological transfer.**

Ordered logit estimate.
Categorical ordered dependent variable: 0 = technologically inactive firm; 1 = firm with product/process innovations; 2 = firm with the ability of licensing/patenting

	Coefficient		Standard Error
Collaboration with Universities	0.376	***	(0.139)
Firms' Characteristics			
Bluecollar	-0.368		(0.313)
Firm's size	0.130	**	(0.054)
Internal R&D	0.643	***	(0.15)
Purchase of Patent	0.949	***	(0.248)
Purchase of Software	0.478	***	(0.126)
Phd	0.315	*	(0.181)
Belonging to a Group	-0.012		(0.149)
Age	-0.001		(0.003)
Internationalization	0.794	***	(0.154)
Sectors			
Textile, clothing	-1.552	***	(0.321)
Chemical, Rubber	-0.789	**	(0.392)
Energy and Extraction	-0.085		(0.25)
Engineering	-0.247		(0.282)
Other manufacturing	-0.065		(0.266)
Other non-manufacturing	-0.329		(0.221)
Wholesale, retail trade	0.23		(0.276)
Hotels and restaurant	-0.848	*	(0.454)
Transport and comm.	-1.437	***	(0.317)
Household services	-0.724		(0.538)

Regions			
North East	0.141		(0.194)
Centre	-0.128		(0.177)
South and Island	-0.493	***	(0.186)
Observations	1119		
Pseudo R2	0.1622		

* 10% significant, ** 5% significant, *** 1% significant .

The Hypothesis of Parallel Regression is satisfied.

Sectors: Food and Beverage is the reference case; Regions: North-West is the reference case.

Table B3 - The Role of the kind of cooperation with universities on firms' technological transfer.

Ordered logit estimate. Categorical ordered dependent variable: 0 = technologically inactive firm; 1 = firm with product/process innovations; 2 = firm with the ability of licensing/patenting

	Coefficient		Standard Error
Financed a R&D Project	0.687	***	(0.217)
Acquired consultancy	0.460	**	(0.213)
Host stage for students	0.025		(0.19)
Firms' Characteristics			
Bluecollar	-0.307		(0.313)
Firm's size	0,140		(0,054)
Internal R&D	0.631	***	(0.15)
Purchase of Patent	0.903	***	(0.254)
Purchase of Software	0.518	***	(0.128)
Phd	0.249		(0.179)
Belonging to a Group	-0.022		(0.149)
Age	-0.001		(0.003)
Internationalization	0.801	***	(0.155)
Sectors			
Textile, clothing	-1.627	***	(0.327)
Chemical, Rubber	-0.645		(0.393)
Energy and Extraction	-0.011		(0.252)
Engineering	-0.203		(0.287)
Other manufacturing	-0.023		(0.268)
Other non-manufacturing	-0.321		(0.224)
Wholesale, retail trade	0.278		(0.275)
Hotels and restaurant	-0.804	*	(0.471)

Transport and comm.	-1.380	***	(0.317)
Household services	-0.648		(0.540)
Regions			
North East	0.1		(0.194)
Centre	0.109		(0.181)
South and Island	-0.474	***	(0.189)
Observations	1107		
Pseudo R2	0.1669		

* 10% significant, ** 5% significant, *** 1% significant .

The Hypothesis of Parallel Regression is satisfied.

TYPE_COLL4 indicating "no collaboration with university" is assumed as a reference case; Sectors: Food and Beverage is the reference case; Regions: North-West is the reference case.

Table B4 - Relevance of the source on information of firms' technological transfer.

Ordered logit estimate . Categorical ordered dependent variable: 0 = technologically inactive firm; 1 = firm with product/process innovations; 2 = firm with the ability of licensing/patenting

	Coefficient		Standard Error
Intra-mural	-0.057		(0.15)
Suppliers	-0.184		(0.147)
Clients	0.250	*	(0.137)
Competitor	0.050		(0.184)
Private Consultant	0.263	*	(0.145)
Universities	0.323	*	(0.182)
Exhibithions	0.284	**	(0.144)
Firms' Characteristics			
Bluecollar	-0.369		(0.319)
Firm's size	0.151	***	(0.056)
Internal R&D	0.678	***	(0.162)
Purchase of Patent	0.908	***	(0.265)
Purchase of Software	0.475	***	(0.135)
Phd	0.377	**	(0.189)
Belonging to a Group	0.015		(0.155)
Age	-0.002		(0.003)
Internationalization	0.771	***	(0.157)
Sectors			
Textile, clothing	-1.591	***	(0.329)
Chemical, Rubber	-0.818	**	(0.399)
Energy and Extraction	-0.127		(0.258)

Engineering	-0.254		(0.302)
Other manufacturing	-0.05		(0.27)
Other non-manufacturing	-0.384	*	(0.231)
Wholesale, retail trade	0.242		(0.292)
Hotels and restaurant	-0.943	*	(0.497)
Transport and comm.	-1.481	***	(0.331)
Household services	-0.729		(0.557)
Regions			
North East	0.06		(0.202)
Centre	-0.2		(0.183)
South and Island	-0.579	***	(0.194)
Observations	1060		
Pseudo R2	0.1727		

* 10% significant, ** 5% significant, *** 1% significant .

The Hypothesis of Parallel Regression is satisfied.

INFOSOURCE0 denoting firms which don't collaborate is assumed as reference case; Sectors: Food and Beverage is the reference case; Regions: North-West is the reference case.

Table B5 – Relevance of the joint effect of the different types of collaboration and university information on the firms' innovation activity firms' technological transfer.

Ordered logit estimate.
Categorical ordered dependent variable: 0 = technologically inactive firm; 1 = firm with product/process innovations; 2 = firm with the ability of licencing/patenting

	Coefficient		Standard Error
Information flow	-0.089		(0.204)
Information flow and stage	0.558		(0.362)
Just collaboration	0.478	**	(0.224)
Collaboration with Universities as main source of information	0.534	***	(0.203)
Firms' Characteristics			
Bluecollar	-0.372		(0.315)
Firm's size	0.124	**	(0.054)
Internal R&D	0.713	***	(0.155)
Purchase of Patent	0.910	***	(0.269)
Purchase of Software	0.538	***	(0.13)
Phd	0.314	*	(0.185)
Belonging to a Group	-0.037		(0.152)
Age	-0.002		(0.003)
Internationalization	0.842	***	(0.156)
Sectors			
Textile, clothing	-1.617	***	(0.323)
Chemical, Rubber	-0.791	*	(0.408)
Energy and Extraction	-0.114		(0.254)
Engineering	-0.292		(0.296)
Other manufacturing	-0.117		(0.265)

Other non-manufacturing	-0.465	**	(0.226)
Wholesale, retail trade	0.175		(0.282)
Hotels and restaurant	-1.033	**	(0.468)
Transport and comm.	-1.493	***	(0.327)
Household services	-0.556		(0.558)
Regions			
North East	0.089		(0.199)
Centre	-0.219		(0.182)
South and Island	-0.595	***	(0.190)
Observations	1077		
Pseudo R2	0.1730		

* 10% significant, ** 5% significant, *** 1% significant .
The Hypothesis of Parallel Regression is satisfied.
INFOSOURCE_TYPECOLLI0 denoting firms which do not collaborate is assumed as reference case.; Sectors: Food and Beverage is the reference case; Regions: North-West is the reference case.

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