TECHNOLOGICAL STATUS OF THE ITALIAN COMPANIES

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Abstract

This paper aims at investigating the role of different cooperation channels in enhancing the technological status of the Italian companies, as defined by Von Tunzelmann and Wang (2003). Different types of cooperation are examined along three lines: with customers and suppliers (i.e. vertical cooperation), with other firms, competitors and consultants (i.e. horizontal cooperation), and finally with universities and public research institutions (i.e. institutional cooperation). From a methodological point of view the technological status of a firm is modelled as a categorical ordered dependent variable of a generalized ordered logit model where cooperation partnerships and firm's characteristics play the role of independent variables. The findings, based on firm-level data provided by the Italian Community Innovation Survey (CIS 2008), show that cooperation channels as well as some company characteristics, such as size, human capital and internationalization, significantly impact on the technological status of Italian firms, despite important regional differences

JEL classification: 030, 031, R11

Keywords: technological status, innovative cooperation, regional system

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1- Introduction

This paper aims at investigating the role played by innovation cooperation[1] on the technological status of firms by considering different partner types, namely competitors, customers, suppliers, universities and Government laboratories.

We address this issue from two different perspectives. On the one hand, we investigate whether the cooperation with different partners may positively affect the probability of innovative activity. On the other hand, we try to assess the relevance of geographical location in fostering innovative attitudes of a firm.

The term "firm's competence" has a long tradition (for a historical overview, see Carlsson and Eliasson, 1991; Eliasson, 1990; Rasche and Wolfrum, 1994; Winter,1987). Competence is often understood as a series of processes or activities (Day, 1994; Li and Calantone, 1998; Prahalad and Hamel, 1990, Audretsch and Vivarelli, 1996; Whitley, 2002; Piva and Vivarelli, 2009), or alternatively, as a potential, or qualification, to perform activities, i.e. ''having the ability, power, authority, skill, knowledge, etc., to do what is needed'' in order to add value to products and processes. According the evolutionary approach to technological chance, the notion of capability is instead seen as the result of internal competences and of individual and collective accumulation of adaptive learning processes and new knowledge.[2] As far as these two concepts are concerned, in this paper we will adopt the definitions introduced by von Tuzelmann and Wang (2003). According to their interpretation, competences- being preset attributes- stem from inputs to produce products and services, whilst capabilities are to be considered as the outcome of flexible learning processes requiring a multiplicity of outer links and sources of innovation. As such, both of them must be related to the introduction of new processes and products. In light of this premises, we would expect innovative cooperation to enhance both technological competencies and capabilities (see, e.g., Drejer and Jørgensen, 2005).

Previous research (see, e.g., Evangelista et al., 2002) has confirmed that context-specific factors are able to influence company technological performance. As the literature on national systems of innovation indicates, technological performance cannot be explained only by looking at specific strategies. In fact, outside the firm itself, other factors and actors play an important role in favouring the diffusion and economic exploitation of knowledge. These include network relationships which are peculiar to regional innovation systems, industrial structure and organizations as well as the institutional setting, i.e. the presence of financial institutions, technical agencies and R&D public infrastructures (e.g. Lundvall, 1992, Nelson 1993, Cooke, 1992, Braczy et al 1998, Evangeslista et al, 2002).

By using firm-level data from the Community Innovation Survey for the years 2006-2008 (CIS 2008), we aim at investigating the determinants of a firm's technological status, paying particular attention to geographical location. We show that cooperation channels significantly impact on an Italian firm's technological degree, but that there are important regional differences.

The rest of the paper is organized as follows. Section 2 provides an overview of the theoretical and empirical results regarding both technological competencies and capabilities. It goes on to formulate the hypotheses to be tested by a suitable econometric model. Section 3 deals with the empirical analysis describing the data and the variables as well as the methodology used. Section 4 discusses the results and Section 5 provides some concluding remarks and their policy implications.

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[1] See, e.g., Ozman, 2012, for a detailed review of the literature.

[2] The notion of capabilities has been also dealt with by Chandler [1977, 1990, 1992].

2 - Literature Review and Hypotheses to be tested

In this paper we will try to define the technological status of Italian firms by using the concepts of competencies and capabilities introduced before. Accordingly, Italian firms will be ranked into different classes depending on their ability to introduce enhanced inputs in the production as well as new products and services. Technological competencies and capabilities are fundamental concepts in explaining innovative performance. Von Tunzelmann and Wang (2003, 2009) assume that technological competencies are to be referred to prerequisites and resources pertaining to innovation activity, whereas technological capabilities represent the knowledge acquired through complex learning and absorption processes, ready to be integrated into new products, services and industrial processes. In this sense the concept of capabilities involve internal and external dynamic processes of new knowledge. acquisition and integration. It is important to point out that both these variables involve all the activities of a firm. For instance, a firm with an adequate endowment to perform research is a firm with internal competences, that is a firm able to obtain value from R&D and innovation investment., whereas a firm which has developed a new patent and use it to get new products is a firm with technological capabilities.

Sometimes the borderline between these two concepts is subtle, especially because they have a complementary effect over time. In the long run, a firm's competencies can develop into capabilities and these latter, in turn, can have an impact on competencies once putting capabilities into effect may requires competences reinforcement.

Recent studies have highlighted the key role played by cooperative agreements in promoting a firm's technological status, which depends crucially on technological competencies and capabilities.

In this context, the capacity to absorb knowledge through external learning processes (Cohen and Levinthal, 1990) plays a crucial role. Dynamic interactive capabilities can be viewed as the outcome of successful interaction between consumer and/or supplier capabilities and evolving producer competencies in real time. This involves various types of learning on both sides, as well as an element of mutually interactive learning[3].

Now insofar as, according to these studies, innovative cooperation could play a crucial role in enhancing both firms competencies and capabilities, and especially these latter, we will try to analyse the role played by different collaborative agreements on the technological status of Italian firms.

As is well known, firms may acquire knowledge horizontally, that is from other firms and competitors as well as vertically, that is from other suppliers and consumers, and in addition from universities or research labs.

Starting with the seminal contribution of Mariti and Smiley (1983) a large number of empirical and theoretical studies have been devoted to the understanding of innovative cooperation (e.g. Loof and Hesmati, 2002, Miotti and Schwald, 2003, Cincera et al., 2003, Belderbos et al., 2004, Loof and Brostrom, 2008, Aschoff and Schmidt, 2006). These studies often led to the result that external innovative cooperation is beneficial to innovation performance for several reasons. Innovative cooperation can internalize spillovers (Kamien et al, 1992), reduce transaction costs relative to pure market-based transactions and/or assimilate new knowledge fields embedded in the core competencies of other firms (Teece and Pisano, 1992). Partners are strategic to innovation projects. According to the industrial organization literature, the most important factors of the innovative

[3] We refer to the literature on the 'open innovation' model. See, e.g., Chesbrough, 2003 and Laursen and Salter, 2006.

cooperation strategies are incoming and outgoing spillover, whereas the management literature sees cooperation agreements as a mean to reduce and share costs and risks associated to the innovation process (see, e.g., Das and Tend, 2000). This latter phenomenon is especially true for the cooperation with customers and suppliers. In fact, if on the one hand collaboration with competitors may greatly enhance the knowledge base of a firm because competitors usually have similar needs, on the other hand, market competitors will not be very cooperative in sharing their knowledge and may be hard to deal with. Besides, a firm's appropriability, i.e. its ability to control outflows of knowledge, is better guaranteed by vertical partners (suppliers and customers) who appear, in this regard, more stable and reliable (Cassiman and Veugelers, 2002). Similar conclusions may be drawn for partnerships with public research organizations (Lhuillery and Pfister, 2008).

Now, both firms' competencies and capabilities should be influenced by some of their intrinsic characteristics, such as size, belonging to an industrial group, internationalisation and human capital endowment. In fact large firms are more likely to collaborate with other firms, and especially with institutions (Mohnen and Hoereau, 2003) because they have more availability of resources, as well as more capacity to internalize spillovers. In addition several authors as Piga and Vivarelli (2004) underlined that firms belonging to the same industrial group should have an higher propensity to develop both their competences and capabilities because they have easier access to (internal) finance and benefit from the effect of intra-group knowledge spillovers (Mairess et al (2002) and Iammarino (2012). In addition, acting in international markets spurs a firm's ability in promoting cooperative agreements and its innovative behaviour. Eventually, the higher is a firm's productivity level, the higher is its economic performance.

It is clear that a detailed study of the dynamic process underlying the development of a firm's technological status would require panel data which would allow the temporal dimension of the learning and absorbing processes to be brought to light.

This is not available with CIS data because they are not longitudinal. Thus, to accommodate this concept, in our analysis we have defined firms "with technological capability" as firms having introduced innovative input and then produced innovative output, in the form of products, services or processes[4].

In addition, when examining the relationship between innovative cooperation and technological competency and capability, attention must be paid to the role of the environment where the firms work. The empirical literature confirms that context-specific factors may influence the technological performance of regions and the regional dynamic of patterns of technological specification. In fact a firm's status is influenced by institutional context and relationship networks as well as the industrial and organizational framework. In particular, technological capabilities, which can be considered as the consequence of adaptive processes, can appear highly localized, insofar as they can be sustained by links and external sources. In this case, technological capabilities turn out to be dependent on specific characteristics (industrial, organizational and institutional) of the environment in which they work. This can engender a regional system of innovation, well explained by the interactive model of innovation which shows how cooperative relationships can be strongly influenced by local territorial mechanisms which favour polarization processes. This concept is renewed and emphasized by the open innovation model, according to which regions can be viewed as the spatial agglomerate of players such as firms, suppliers, consumers acting within regional frameworks. The peculiar characteristics of these frameworks

[4] We preserve the logical temporal sequence existing between technological competencies and capability (the former should precede the latter and not vice versa).

influence both the technological status and growth capacity of firms originating in specific regional systems.
As far as Italy is concerned, it is well known that this country is characterized by strong regional economic and technological imbalances. In this paper, the regional dimension[5] will be explored by dividing the country into four macro regions: North-east, North-West, Central and Southern Italy. This division has been made to uncover those territorial peculiarities suggested in the literature. We will show that some cooperation agreements turn out to be effective at a national level but not a local level.
The core objective of this paper is to explain the influence of the different forms of cooperation on the technological status of firms, focusing on the role played by their regional environment.

In the light of the literature reviewed above, the hypotheses to be tested in this paper are the following:

Hypothesis 1. *We expect all cooperative agreements to have a positive impact on a firm's technological status at both a national and regional level. In particular, vertical and horizontal cooperation are expected to be the most significant forms of cooperative agreements affecting a firm's technological status*

Hypothesis 2. *We conjecture that some specific characteristics, such as size, belonging to an industrial group, internationalisation and human capital endowment significantly influence a firm's technological status at both the national and regional level.*

Hypothesis 3. *We expect a firm's technological status to vary substantially from one regional areas to another, depending on their specific characteristics.*

3 – Data, Variables and Econometric Model

3.1 Dataset

The empirical analysis of the paper is based on data from the Community Innovation Survey 2008 (CIS 2008) run by the Italian National Institute of Statistics (ISTAT) which follows the OSLO manual containing the OCSE guidelines for collecting and using data on industrial innovation.
The Community Innovation Survey is a firm-level survey carried out every four years, in all EU countries and some non EU countries, in order to gather information about firm level innovation activities. The Italian CIS 2008 collected data on the 2006-2008 period from a stratified sample of enterprises with ten or more employees, operating in a wide range of sectors such as the primary sector, the engineering –based manufacturing, construction, retail and distribution, knowledge-intensive services and so on. The final representative firm sample consists of 19,904 Italian enterprises. Sample results are then extended to population by means of a suitable weighting procedure (ISTAT, 2010).
The CIS 2008 is specifically planned to investigate innovative performances and has therefore been designed to bring to the fore the main systematic features of companies and the environment they work in. It is a micro-data source which provides a set of general information on characteristics

[5] The geographical distribution of technological activities, measured by the R&D/GDP ratio, i.e. the number of patents per capita, can also be related to the economic size of different regions, which, in turn, can be proxied by their contribution to the national GDP, industrial value and exports. For a detailed analysis see Economie Regionali 2012 - Bank of Italy.

such as a firm's size, corporate group membership, turnover, employment, exports, etc,. In addition detailed information is proved regarding innovation sources and outputs. Innovative outputs include product and process innovation as well as organisational and marketing innovation. Innovation sources include public funding, innovation cooperation with different partners, such as customers, suppliers, other firms or non-commercial institutions like universities or public research institutes both at a national and an international level.

Since, some of the information regarding innovative performance, such as cooperation towards innovation attainment is limited only to innovative firms, this could raise issues in terms of sample bias or selection. However we have circumvented this difficulty by taking into account all firms, both innovative and non-innovative.

The exclusion of micro firms (with less than 10 employees) does nonetheless bias the sample towards large scale firms (see also Iammarino et al. (2009)). In order to avoid this bias and taking into account that the Italian context is characterized by firms of small and medium size, we have considered only firms with less than 1,000 employees in the sample, ending up with a final sample of 19,479 firms.

3.2 Dependent Variables

Respondents to the Italian CIS(5) were asked to answer whether they had undertaken an innovative performance in the period 2006-2008 by signalling which innovative output they had brought in. More precisely, they had to indicate if they had introduced an innovative product or service (questions 11 and 12 of the questionnaire) or if they had developed new logistics systems, distribution methods or other innovative processes (questions 19, 20, 21). Firms which gave a positive answer are classified as firms with technological capabilities.

Firms were also asked to declare if they had invested in innovative input. There are some items in the questionnaire aimed at acquiring information about the introduction of product, process, marketing and/or service innovation. These items deal with internal R&D activities, external R&D acquisition, acquisition of innovation machinery and equipment, acquisition of disembodied technology in equipment, training for innovation, marketing of innovation products, design, industrial planning or other activities targeting innovation (questions 28-33). Firms answering positively to least one of the previous quoted activities, even without achieving an innovative output or even having abandoned their innovation project, are classified as firms with technological competencies. In addition, firms declaring neither innovative output nor investment in innovative inputs, are classified as technologically inactive firms in the period under consideration by the Italian CIS5.

Accordingly, since our dependent variable measures a firms' technological status (Ts), by using the answers to the above questions, we can build up a categorical ordered dependent variable, which may have three different outcomes. It takes a value equal to 2 in cases of firms having technological capabilities. It equals 1 in cases of firms having technological competences, and finally, it takes on a value equal to 0 in the case of technologically inactive firms.

3.3 Independent Variables

We focus here on the two main variables of interest, namely collaboration with different partners and the role played by different macro regional areas in fostering innovation.

This is why in a first model (Table 4) we investigate whether and to what extent the collaboration with different partners affects the technological status of firms. The CIS data set shows company collaboration, either formal or informal, with parent firms, competitors, suppliers of materials or machinery, clients or customers, consultants and public research organizations (i.e. universities and other public research institutions). Hence, seven dummies are created for these cooperation partners, namely Coopk, k=1,…,7, where k=1 is for partner firms operating within the same business group, k=2 is for suppliers, k=3 is for clients, k=4 is for competitors, k=5 is for consultants, k=6 is for universities, and k=7 is for other public research. Moreover, since firms may simultaneously have different types of innovation partnerships, all the seven dummies are included in the regression model. Consequently, the marginal coefficient should be interpreted as the marginal effect of having one more partner type[6].

Collaborations may differ depending on industry type of. There are certain sectors where firms present a higher level of innovation and R&D practice. Therefore, our analysis also includes five sectorial dummies Sd_j, j=1,...,5. These are the technological manufacturing sector, the non-technological manufacturing sector, the technological service industry, the non-technological service industry and other non-technological sectors. The sectorial classification of firms has been carried out by using the NACE classification codes

In a second model (Table 5), we shift our attention to a slightly different issue. We concentrate on the local components of technological status, i.e. we are interested in investigating the regional components of firms. In this respect, using CIS data for regional analysis is not straightforward and reveals some limitations. The major problem lies in the choice of the geographical units for analysis. In fact, while some administrative regions correspond to functionally defined areas, others are both extensive and economically quite heterogeneous, frequently including different local subsystems. In order to obtain reasonably homogeneous macro regions in line with standard classification, the twenty Italian regions have been aggregated into four macro regions: North West (including Piemonte, Lombardia, Valle d'Aosta and Liguria), North East (including Veneto Trentino Alto Adige, Friuli and Emilia Romagna), Middle (including Toscana, Umbria, Marche and Lazio), and South (including Abruzzi, Molise, Campania, Puglia, Basilicata, Calabria, Sicilia and Sardegna). Even though this subdivision is mainly geographic, when the regions are ranked at an aggregate level by economic performance indicators, the findings show that the most developed and richest regions are the northern ones, followed by the central regions. The southern regions have the lowest performance results. Hence four dummies are created for these macro regions Rgj, j=1,…4, where j=1 for the North West, j=2 for the North East, j=3 for the Middle, j=4 for the South.

3.3.1 Firms' characteristics

Employment (Ep) denotes a firm's size in terms of (logarithm) employee numbers (continuous variable). 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. Not only do large firms have access to more resources, but they also have the capacity

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[6] In a further specification, we differentiate between foreign and domestic partners in line with Iammarino et al. (2009). However, given the characteristics of the cooperation variable, this distinction appears irrelevant to the Italian context, where the economy is characterized by strong localism and marked industrial districts (i.e. concentrated networks from a geographical standpoint). The local component clearly dominates, the non-local, in all types of collaboration.

to absorbe 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). Segarra (2008) observed, on the other hand, that small and innovative Spanish firms have great difficulty finding partners. However the evidence here is still controversial, in fact, it could be argued that small firms have greater flexibility in adjusting employees to innovation related projects and benefit from less complex management structures in implementing new projects.

Group (Gr) is a dummy variable denoting a firm as part of a business group. Recent analyses have shown that being part of a group tends to influence a firm's propensity to engage in innovation (see, for instance, Filatotech et al., 2003, Piga and Vivarelli, 2004) and increase the number of cooperating parterns (Piga et al., 2004, Dachs et al., 2008). In addition Mairesse et al. (2002) underlined the expected innovative benefits gained from 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. (2012) pointed out that a firm's technological status benefits from its relationships within a group. However, whether group affiliation increases collaboration with universities is still disputed. Belderbos et al (2004b) found that it does increase R&D cooperation with customers and suppliers, but not with universities and public research institutions.

Internationalization (In) is a dummy variable which takes value 1 if the firm exports products or goods to foreign markets. As is well known, worldwide competition stimulates innovation and excludes inactive firms from the global playing field (e.g. Archibugi and Iammarino, 1999, Narula and Zanfei, 2003). This effect, in turn, should spur cooperation agreements aiming at innovation (see Dachs et al 2008).

Productivity level (Pl) is a continuous variable which is measured as the ratio between the turnover and the number of employees in each firm. The productivity level, measured in terms of labour productivity is emblematic of a firm's competences insofar as it improves both innovative and economic performance (e.g., Acemoglu, 1998, Machin and Van Reeneen, 1998, Piva and Vivarelli 2004, Piva et al, 2005).

3.3.2 Descriptive Statistics and Econometric Model

Table 1 displays the list of the variables employed in the analysis carried out as well as some descriptive statistics. First of all, it should be noted that only a small number of firms have technological competencies at an aggregate level (the 14% referred to in the sample).

[Table 1]

At the regional level (Table 2) the situation is very similar. This supports the conjecture that these firms somehow represent an intermediate form of innovative behaviour (see also D'Este et al., 2011) and sits comfortably with the decision to distinguish the three categories of firms according to their technological status. As expected, firms with higher technological status are concentrated in the Northern regions.

[Table 2]

Table 3 shows the portion of firms belonging to each class of technological status across the different sectors. Firms with technological competencies and capability tend to belong to the

Engineering-based manufacturing and knowledge intensive service, whereas technologically inactive firms operate in the construction, retail & distribution as well as in other services.

[Table 3]

From a methodological point of view, a firm's technological status has been modelled as a categorical ordered dependent variable of a generalized ordered model (Gologit) where cooperation partnerships, firm's characteristics and sectorial dummies play the role of independent variables. At a first stage this model has been estimated by using all the firms in the sample and, at a second stage, taking firms based on their specific macro regions (regional models) as defined in the paragraph 3.3. Table 4 shows the estimates of the gologit model for all the firms in the sample

[Table 4]

while Table 5 shows the gologit estimates for firms belonging to the four regional areas: North West, North East, Middle and South.

[Table 5]

The justification and the explanation of the econometric specifications used for analysis here carried out can be found in the Appendix.

4 - Technological capabilities and cooperation patterns: econometric results

Looking at both Table 4 and 5, we see that all the variables related to firm characteristics are highly significant at 1% level in enhancing the technological status of the individual firms involved. This is clear when we refer to the gologit estimation results of Table 4 and is in line with the theoretical expectations discussed above and hypothesis H1, both at national and regional level.

Firm size shows positively in both panels of the gologit estimation. This means that a firm's dimension is relevant not only in improving its technological status from inactive to active, but also In turning technological competencies into technological capabilities, even if with lesser impact in the latter.

Likewise, human capital and the degree of internationalization affect a firm's innovative status. Both variables have a positive impact on the improvement of technological status at every level. However, while internationalization proves to be effective in turning inactive firms into firms with capacities rather than capacities into capability, the impact of human capital is constant across the different modalities of technological status (i.e. it satisfies the parallel lines assumption).

Being part of a corporate group, on the other hand, appears to be a bar to the innovation activities of the Italian firms. This could be due to a firm's position in the group or to the policy of the group leaders, which may run contrary to a specific firm's interests. This is not uncommon in the case of Italian firms since they are characterized by small size, and thus have a marginal weight inside a group.

As far as the independent variables concerning cooperation partners are concerned, both the horizontal and the vertical ones are significant at an aggregate level for undertaking innovation activities. In particular, cooperation with other firms, suppliers and competitors also proves to be effective to turning technological competencies into capacities (see the positive sign and the magnitude of the coefficients in the second panel of the gologit estimation results), whereas cooperation with clients and consultants proves to be effective only in improving the technological status of innovative firms.

Moving on to institutional cooperation, we can see that agreements with universities are relevant in improving a firm's technological status. More precisely, partnerships with universities are significant in stimulating innovative performance and thus increasing their competencies. So enhancing their status from inactive to active firms. Cooperation with public research, on the other hand, is only useful in improving technological competencies and capabilities.

Analysis at the national level also highlights the influence of a firm's environment (in terms of its regional location) on its technological status. The regional location turns out to be a bar to innovation activities for firms located in the Centre or in the South compared with those in the North-West, which is the chosen reference macro-region. Location in the north increases the probability of improving a firm's technological status, whereas the same doesn't hold true for firms operating in other regions. This result justifies our decision to investigate regional location, since it may have an important role in moulding the competences and capabilities of technological firms.

It comes as no surprise that the sectorial dummies turn out to be significant, but the impact is greatest in the chosen reference category which is engineering-based manufacturing. More specifically, operating in a non-engineering-based manufacturing sector does not represent a stimulus for the innovation activity of firms.

To obtain a deeper understanding of the regional characteristics of innovation activities, we implement four different gologit estimations, one for each of the Italian macro regions.

The results are reported in Table 5. As can be noted, the general hypothesis H1 is also confirmed at the regional level. A firm's specific characteristics turn out to be significant in all cases and with the sign discussed above. The only exception is the South, where human capital is significant only at 5% and with a smaller impact. Turning our attention to the cooperation variables, as Table 5 shows, the results differ slightly from region to region according to specific regional contexts. These differences concern both the magnitude and significance of the different cooperation linkages.

Vertical innovative cooperation (i.e. cooperation with clients and suppliers) has a stronger positive impact in turning innovative firms into firms with technological competences rather than developing capacities into capabilities (see the first panel of the gologit estimation results), in most regions. This applies especially in the South where the magnitude of the coefficient is very high. Referring to the second panel of the gologit estimation, we observe that cooperation with suppliers appears as the sole significant factor in developing technological capacities into capabilities.

Horizontal cooperation (i.e. cooperation with competitors, other firms and consultants) surprisingly, also turns out to be significant in most regions.

In the North-Western Italian macro-region, firms are likely to display improved technological status by collaborating with competitors, and other firms.

The results are similar in the case of the North-East, where cooperation with consultants also turns out to be significant, even if with lesser effect, in shifting a firm's technological status from inactive to active. The same holds true for collaboration with other firms.

In the Centre the effect of these cooperation variables is the same for each modality of the dependent variable (in these cases the assumption of parallel lines is satisfied). In particular, while cooperation with competitors and consultants is useful for enhancing both capacities and capabilities, cooperation with other firms does not prove to be significant. In the South cooperation with other firms only turns out to be significant in enhancing the technological status of inactive firms. By looking at the estimates of the gologit panels we see that this type of partnership is relevant to improving a firm's technological status from inactive to active.

In the North-East linkages with universities is never significant as far as the effect on a firm's capabilities is concerned. In the other regions cooperation with universities has a positive and strong impact in generating technological competencies but it is ineffective in enhancing them to the level of technical capabilities (it never shows itself significant in the second panel of the gologit estimation).
Cooperation with research institutes is significant in improving the technological status of inactive firms only in the North East and in the South. These last results would suggest that not only is this kind of cooperation ineffective in enhancing the technological status of a firm, but it also indicates that the assets involved could be spent in more useful ways.

5 - Concluding Remarks

In this paper we have explored the impact of R&D cooperative behaviour on the technological status of Italian innovative firms on the basis of firm level data from the Community Innovation Survey (CIS 2008). We have employed a generalized ordered logit model to analyse cooperation along three dimensions, namely vertical (with customers and suppliers), horizontal (with competitors, consultants, research institutes and private labs) and institutional (with Universities and public research centres). This modelling strategy has also been employed to investigate the impact of the local /regional component on the determinants of the competences and capabilities of Italian firms.
Our analysis indicates that both horizontal and vertical collaboration have a significant positive impact on the technological capabilities and competence of Italian firms. A particular role is played by the partnership with universities and public research centres. They are key elements in increasing firms' competencies so enhancing their status from inactive to active firms. Regarding a firm's characteristics, size as well as the level of human capital and the degree of internationalization seem to be important factors in improving technological status.
Being part of a group, on the contrary, seems to impede such improvement. Finally, both the local components and the sectorial dummies are important determinants in influencing the technological status of Italian firms. Specifically location in Northern Italy and belonging to the engineering based sector constitute act as a stimulus in improving technological competences and capabilities.
These results have clear implications for innovation policies. Increasing firm size, levels of human capital and the extent of internationalization act as strong innovation drivers. In that respect, inter-firm aggregation, collaboration with public research centres and the creation of technological networks appear relevant in setting goals for industrial policy makers.
Finally, it is important to stress that a panel-data study would significantly complement the findings of this paper. However, this would currently be difficult with Community Innovation Survey data and therefore we leave this issue to future research.

Table 1: List of variables

Name	Nature	Mean	Standard deviation
Dependent variable			
Technological status of the firm:	Categorical ordered (N=19,479)	0.583	0.831
Technologically inactive firms = 0	N=12,470		
Firms with technological competences = 1	N=2,657		
Firms with technological capabilities = 2	N=4,352		
Independent/control variable			
Cooperation partners	Dummies		
A: other enterprises		0.022	0.148
B: suppliers		0.040	0.197
C: clients		0.024	0.155
D: competitors		0.022	0.146
E: consultants		0.033	0.178
F: universities		0.027	0.163
G: public research institutes		0.011	0.106
Size: (employment) **(Number of employees)**	Continuous	3.380 (67.446)	1.076 (135.557)
Group	Dummy	0.270	0.444
Internationalization	Dummy	0.329	0.470
Human capital	Continuous	11.902	0.903
Sectors	Dummies		
Primary sector		0.045	
Engineering-based manufacturing		0.110	
Other manufacturing		0.216	
Construction		0.224	
Retail and distribution		0.172	
Knowledge-intensive services		0.077	
Other services		0.149	
Regions	Dummies		
North-East		0.300	
North-West		0.340	
Centre		0.192	
South		0.168	

Table 2: Regional distribution of the categorical dependent variable – number of firms and relative percentage (in brackets)

	North-East	**North-West**	**Centre**	**South**
Technologically inactive firms (value 0)	3,536 (60.42)	3,971 (60.04)	2,602 (69.44)	2,361 (72.29)
Firms with technological competences (value 1)	884 (15.11)	989 (14.95)	423 (11.29)	361 (11.05)
Firms with technological capabilities (value 2)	1,432 (24.47)	1,654 (25.01)	722 (19.27)	544 (16.66)
Total	5,852	6,614	3,747	3,266

Table 3 Sectorial distribution of the categorical dependent variable – number of firms and relative percentage (in brackets)

	Primary sector	**Engineering-based manufacturing**	**Other manufacturing**	**Construction**	**Retail & Distribution**	**Knowledge intensive services**	**Other services**
Technologically inactive firms (value 0)	549 (63.10)	961 (45.03)	2,222 (52.92)	3,306 (75.81)	2,435 (72.51)	737 (49.07)	2,166 (74.54)
Firms with technological competences (value 1)	113 (12.99)	516 (24.18)	780 (18.58)	361 (8.28)	311 (9.26)	312 (20.77)	242 (8.33)
Firms with technological capabilities (value 2)	208 (23.91)	657 (30.79)	1,197 (28.51)	694 (15.91)	612 (18.23)	453 (30.16)	498 (17.14)
Total	870	2,134	4,199	4,361	3,358	1,502	2,906

Table 4: Determinants of firms' capabilities. Generalized ordered logit estimates. Categorical ordered dependent variable: 0 = technologically inactive firm; 1 = firm with technological competences; 2 = firm with technological capabilities

	0 vs. 1-2	**0-1 vs. 2**
Ln(employment)	0.384***	0.235***
	(0.017)	(0.019)
Group	-0.822***	-0.689***
	(0.044)	(0.044)
Internationalization	0.541***	0.360***
	(0.039)	(0.044)
Human capital	***0.158****	***0.158****
	(0.020)	***(0.020)***
Cooperation partners for innovation		
A: other enterprises	2.340***	0.332**
	(0.407)	(0.138)
B: suppliers	2.554***	0.698***
	(0.274)	(0.118)
C: clients	1.963**	-0.138
	(0.440)	(0.147)
D: competitors	2.615***	0.646***
	(0.404)	(0.136)
E: consultants	1.194***	0.112
	(0.283)	(0.138)
F: universities	1.329***	-0.143
	(0.282)	(0.146)
G: public research institutes	***-0.074***	***0.074***
	(0.191)	***(0.191)***
Regional dummies	yes***	
North-East	***0.036***	***0.036***

	(0.038)	***(0.038)***
North-West	--	--
Centre	***-0.149****	***-0.149****
	(0.046)	***(0.046)***
South	***-0.263****	***-0.263****
	(0.050)	***(0.050)***
Sectorial dummies	yes***	
Primary sector	***-0.156****	***-0.156****
	(0.086)	***(0.086)***
Engineering-based manufacturing	--	--
Other manufacturing	***-0.155****	***-0.155****
	(0.052)	***(0.052)***
Construction	-0.620***	-0.518***
	(0.060)	(0.065)
Retail and distribution	-0.745***	-0.566***
	(0.063)	(0.067)
Knowledge-intensive services	***0.043***	***0.043***
	(0.070)	***(0.070)***
Other services	-0.763***	-0.563***
	(0.062)	(0.066)
const.	-3.426***	-3.578***
	(0.238)	(0.240)
Pseudo R^2	0.125	
LR χ^2(d.f.)	χ^2(32) 2146.15***	
Number of firms	19479	

Notes:

- In the column (0 vs. 1-2) the first panel of the gologit model results is reported (firms with technological status=0 versus firms with technological status =1 and =2); in the column (0-1 vs. 2) the second panel is reported (firms with technological status=0 and =1 versus firms with technological status=2).
- In brackets: standard errors; *=10% significant, **=5% significant, ***=1% significant
- The control and the cooperation regressors are reported; the 7 sectorial dummies (Engineering-based manufacturing is the reference case) as well as the 3 regional dummies (NUTS2 regional aggregations – North-West is the reference case) are reported.
- The numbers in ***Italic Bold*** highlight the variables that satisfy the parallel lines assumption at the 1% significant level.
- yes*** for sectorial and regional dummies reporting that they are, respectively, jointly significant at 1% level.

Table 5: Determinants of firms' capabilities, Macro-regions of Italy
Generalized ordered logit estimates
Categorical ordered dependent variable: 0 = technologically inactive firm; 1 = firm with technological competences; 2 = firm with technological capabilities

	North-East		North-West		Centre		South	
	0 vs. 1-2	0-1 vs. 2	0 vs. 1-2	0-1 vs. 2	0 vs. 1-2	0-1 vs. 2	0 vs. 1-2	0-1 vs. 2
Ln(employment)	0.409***	0.235***	0.406***	0.250***	0.342***	0.210***	0.311***	0.207***
	(0.031)	(0.034)	(0.028)	(0.030)	(0.044)	(0.049*	(0.049)	(0.054)
Group	-0.762***	-0.762***	-0.841***	-0.684***	-0.736***	-0.736***	-0.945***	-0.945***
	(0.075)	(0.075)	(0.073)	(0.078)	(0.104)	(0.104)	(0.124)	(0.124)
Internationalization	0.474***	0.191**	0.563***	0.336***	0.630***	0.630***	0.450***	0.450***
	(0.067)	(0.074)	(0.065)	(0.070)	(0.095)	(0.095)	(0.112)	(0.112)
Human capital	0.187***	0.187***	0.174***	0.174***	0.138***	0.138***	0.103**	0.103**
	(0.039)	(0.039)	(0.033)	(0.033)	(0.048)	(0.048)	(0.049)	(0.049)
Cooperation partners for innovation								
A: other enterprises	1.986***	-0.127	3.017***	0.819***	0.291	0.291	17.990***	0.727
	(0.671)	(0.266)	(0.728)	(0.175)	(0.340)	(0.340)	(0.592)	(0.573)
B: suppliers	2.433***	0.637***	2.320***	0.450**	3.129***	0.801***	18.569***	1.528***

	(0.463)	(0.203)	(0.428)	(0.187)	(0.631)	(0.308)	(0.299)	(0.360)
C: clients	1.868***	-0.024	1.720***	-0.015	2.766**	-0.611	16.722***	-0.477
	(0.717)	(0.247)	(0.632)	(0.224)	(1.132)	(0.400)	(0.562)	(0.575)
D: competitors	3.293***	0.756***	3.436***	0.492**	1.109***	1.109***	0.509	0.509
	(0.749)	(0.211)	(1.108)	(0.248)	(0.315)	(0.315)	(0.403)	(0.403)
E: consultants	1.636***	0.054	0.022	0.022	0.705**	0.705***	0.113	0.113
	(0.506)	(0.236)	(0.204)	(0.204)	(0.313)	(0.313)	(0.465)	(0.465)
F: universities	-0.186	-0.186	1.720***	-0.368	2.186***	-0.008	1.035***	1.035***
	(0.242)	(0.242)	(0.501)	(0.226)	(0.684)	(0.373)	(0.308)	(0.380)
G: public research	14.779***	0.357	0.102	0.102	-0.969*	-0.969*	15.940***	-2.567***
institutes	(0.472)	(0.336)	(0.328)	(0.328)	(0.496)	(0.496)	(0.545)	(0.878)
Sectorial dummies	yes***		yes***		yes***		yes***	
Primary sector	-0.346**	-0.346**	-0.091	-0.091	0.176	0.176	-0.335	-0.335
	(0.164)	(0.164)	(0.139)	(0.139)	(0.232)	(0.232)	(0.209)	(0.209)
Engineering-based manufacturing	--	--	--	--	--	--	--	--
Other manufacturing	-0.324***	-0.324***	-0.084	-0.084	-0.071	-0.071	-0.159	-0.159
	(0.088)	(0.088)	(0.079)	(0.079)	(0.156)	(0.156)	(0.158)	(0.158)
Construction	-0.900***	-0.900***	-0.564***	-0.563***	-0.415***	-0.415***	-0.500***	-0.500***
	(0.111)	(0.111)	(0.096)	(0.096)	(0.156)	(0.156)	(0.160)	(0.160)
Retail and	-0.738***	-0.738***	-0.630***	-0.375***	-0.740***	-0.740***	-0.880***	-0.880***
distribution	(0.105)	(0.105)	(0.107)	(0.111)	(0.170)	(0.170)	(0.171)	(0.171)
Knowledge-	-0.068	-0.068	-0.014	-0.014	0.272	0.272	0.036	0.036
	(0.128)	(0.128)	(0.105)	(0.105)	(0.179)	(0.179)	(0.231)	(0.231)

intensive services								
Other services	-0.914***	-0.740***	-0.762***	-0.587***	***-0.553****	***-0.553****	**-0.581*****	**-0.581*****
	(0.106)	(0.111)	(0.100)	(0.108)	***(0.160)***	***(0.160)***	**(0.184)**	**(0.184)**
const.	-3.669***	-3.635***	-3.744***	-3.834***	-3.419***	-3.553***	-2.795***	-3.079***
	(0.449)	(0.451)	(0.390)	(0.392)	(0.557)	(0.560)	(0.586)	(0.594)
Pseudo R^2	0.130		0.126		0.119		0.102	
LR χ^2(d.f.)	χ^2(26) 1789.68***		χ^2(27) 863.35***		χ^2(21) 342.19***		χ^2(22) 9533.73***	
Number of firms	5852		6614		3747		3266	

Notes:

- For each macro-region, in column (0 vs. 1-2)) the first panel of the gologit model results is reported (firms with technological status=0 versus firms with technological status =1 and =2); in column (0-1 vs. 2) the second panel is reported (firms with technological status=0 and =1 versus firms with technological status=2).
- In brackets: standard errors; *=10% significant, **=5% significant, ***=1% significant
- The control and the cooperation regressors are reported; the 7 sectorial dummies (Engineering-based manufacturing is the reference case) are reported.
- The numbers in ***Italic Bold*** highlight the variables that satisfy the parallel lines assumption at the 1% significant level.
- yes*** for sectorial and regional dummies reporting that they are, respectively, jointly significant at 1% level.

Appendix

This appendix sets up the empirical model used in the analysis. The aim of the model is that of showing which characteristics and forms of cooperation influence the technological status of a firm. For this purpose, since the dependent variable is a categorical one, with categories that can be ordered in a meaningful way, we have first specified an ordered multilogit model

$$y_i = \mathbf{x}_i^{'}\boldsymbol{\beta} + \varepsilon_i \qquad (1)$$

where y_i is the technological status of the i-*th* firm, $\mathbf{x}_i$ is the vector of the explanatory variables introduced above, namely

$$\mathbf{x}_i^{'} = \{ln(E_p, Gr, In, Hc, Coopk, Rgj, Sdi,\}, \qquad k=1,\ldots 7, j=1\ldots 3, i=1,\ldots 5. \qquad (2)$$

where the symbols have the meaning previously introduced and a ε_i is a non-systematic error term with a logistic distribution At a first stage this model has been estimated by using all the firms in the sample and, at a second stage, taking firms based on their specific macro regions (regional models).

The parallel regression assumption, also known as the proportional odds assumption, verified by the Brant test, is violated. This means that some coefficients of the independent variables in the model (1) vary across the modalities of this categorical variable. The same is found for the regional models[7]. This entails that using an ordered logit model would lead to incorrect and misleading results. An alternative, less restrictive than the parallel-lines model, is the generalized ordered logit model (also termed gologit). This latter is more parsimonious and interpretable than those fitted by a non-ordinal method, such as the multinomial model, freeing all variables from the parallel-lines constraint, even though this assumption may be violated by some of them. The gologit model can be specified as follows

$$Prob(y_i > j\,|\mathbf{x}) = \frac{exp(\mathbf{x}_i{'}\boldsymbol{\beta}_j)}{1 + exp(\mathbf{x}_i{'}\boldsymbol{\beta}_j)}, j=1,\ldots, M\text{-}1 \qquad (3)$$

where M is the number of categories of the ordinal dependent variable[8],[9].

The estimates of the Stata program gologit[10] are shown in Table 4 for all firms in the sample and in Table 5 for firms of different regional areas. Here, the first panel of both these tables contrasts

[7] Results regarding the regional models can be provided by the authors upon request

[8] The ordered logit model, fitted by using ologit Stata program, is a special case of (3) which occurs when

$$Prob(y_i > j \mid \mathbf{x}_i) = \frac{exp(\mathbf{x}_i^{'}\boldsymbol{\beta} - \alpha_j)}{1 + exp(\mathbf{x}_i^{'}\boldsymbol{\beta} - \alpha_j)}, j=1,2\ldots M\text{-}1$$

where $\mathbf{x}_i^{'}$ is the vector of explanatory variables and α_j are the thresholds or cut points. The partial proportional odds model restricts some coefficients of the independent variables to being the same for every modality of the dependent variable while others are free to vary.

[9] According to (3), the formulas for the probabilities turn out to be

$$Prob(y_i = 1|\mathbf{x_i}) = F(\mathbf{x}_i^{'}\boldsymbol{\beta}_1)$$

$$\vdots$$

$$Prob(y_i = j|\mathbf{x_i}) = F(\mathbf{x}_i^{'}\boldsymbol{\beta}_j) - F(\mathbf{x}_i^{'}\boldsymbol{\beta}_{j-1}), j=2,\ldots, M\text{-}1$$

$$\vdots$$

$$Prob(y_i = M\,|\boldsymbol{x_i}) = 1 - F(\boldsymbol{x}_i^{'}\boldsymbol{\beta}_{M-1})$$

where F is the cumulative distribution of the logistic function[9].

[10] Gologit2 is a Stata programme inspired by Vicent Fu's gologit routine. The major strength of Gologit2 is that it can fit three models as special cases of the generalized model: the proportional odds/parallel lines, the partial proportional odds model, and the logistic regression model.

inactive firms, that is to say firms with technological status equal to 0, with firms having both capacities and capabilities (i.e. firms with technological status equal to 1 and 2, respectively). The second panel of both these tables, contrasts inactive firms as well as firms with capacities (i.e. firms with technological status 0 and 1) with firms with capabilities (i.e. firms with technological status equal to 2)[11]. Positive coefficients in a panel mean that higher values of the corresponding explanatory variables turn out to be associated with higher categories of the dependent variable than the current one and, vice versa. So negative coefficients denoting higher values of the corresponding explanatory variables turn out to be related to the current or lower categories of the dependent variable. The gologit model includes more parameters than an ordered logit model, indeed sometimes many more than necessary. In fact the assumption of parallel lines may only be violated by certain variables. In order to check this eventuality, we have run an iterative process which aims at identifying the partial proportional odds model that best fits data[12]. This iterative process first fits an unconstrained model coinciding with that fitted by the original gologit2. Then a series of Wald tests have been performed on each variable in order to check whether its coefficient varies across the categories of the dependent variable in order to meet the parallel lines assumption. If the null assumption of the test is accepted for a certain variable, the parallel line assumption is imposed on this variable and its coefficient is assumed to be equal across the equations explaining the different modalities of the dependent variable. Finally, a global Wald test is applied in order to assess the validity of the final constrained model. This latter, with some possible constraints, is the model imposed on the coefficients of the variables according to the parallel-lines assumption, along with the original unconstrained model.

References

Acemoglu, D. 1998, "Why do new technologies complement skills? Directed technical change and wage inequality", *Quarterly Journal of Economic,* 113, 1055-1090

Archibugi, D., and S. Iammarino, 1999, "The Policy Implications of the Globalisation of Innovation," *Research Policy*, 28(2-3), 317-336.

Aschhoff B., and T. Schmidt, 2008, "Empirical Evidence on the Success of R&D Cooperation—Happy Together?", *Review of Industrial Organization*, Springer, 33(1), 41-62.

Audretsch, D. B., and M. Vivarelli, 1996, "Firms Size and R&D Spillovers: Evidence from Italy," *Small Business Economics*, 8(3), 249–258.

Belderbos, R., M. Carree, B. Diederen, B. Lokshin, and R. Veugelers, 2004, "Heterogeneity in R&D Cooperation Strategies", *International Journal of Industrial Organization*, 22(8–9), 1237–1263.

Belderbos, R., M. Carree, and B. Lokshin, 2004, "Cooperative R&D and firm performance," *Research Policy*, 33(10), 1477-1492.

Braczyk H. J., P. Cooke, M. Heidenreich and G. Krauss (Eds), 1998, "*Regional Innovation Systems. The Role of Governance in a Globalized World*". UCL Press, London.

Capron, H., and M. Cincera, 2003, "Industry-University S&T Transfers: What can we Learn From Belgian CIS-2 Data?", *Brussels Economic Review*, 46(3), 59-86.

[11] The first panel gives results which are equivalent to those of a logistic regression in which inactive firms has been recoded to zero and the set of the other firms has been recoded to one, while the second panel gives results equivalent to a logistic regression where the set of both the inactive firms and firms with capacities has been recoded to zero and the set of the firms with capability has been recoded to one. The estimate of overall equations is simultaneous.

[12] Basically, autofit uses a backward stepwise selection procedure. It starts with the least parsimonious model and gradually imposes constraints. Being a stepwise procedures it may lead to wrong conclusions, this is why this option should be applied by assuming a stringent significance level such as 0.01.

Carlsson, B. and Eliasson G., 1991, "The nature and importance of economic competence", Industrial Institute for Economic and Social Research (IUI), Stockholm, Sweden.

Cassiman, B., and R. Veugelers, 2002, "R&D Cooperation and Spillovers: Some Empirical Evidence from Belgium," *American Economic Review*, 92(4), 1169–1184.

Chandler, A. D. (1977), *The Visible Hand: The Managerial Revolution in American Business*, Belknap/Harvard University Press: Cambridge, MA.

Chandler, A. D. (1990), *Scale and Scope: The Dynamics of Industrial Capitalism*, Belknap/Harvard University Press: Cambridge, MA.

Chandler, A. D. (1992), "Organizational Capabilities and the Economic History of the Industrial Enterprise", *The Journal of Economic Perspectives*, 6(3), 79-100.

Chesbrough, H, 2003, "*Open innovation*", Harvard Business School Press, Boston.

Chun, H., and S. B. Mun, 2011, "Determinants of R&D Cooperation in Small and Medium-Sized Enterprises," *Small Business Economics*.

Cohen, W.M. and D.A. Levinthall, 1989, "Innovation and learning: the two faces of R&D", *The economic Journal*, 99, 569-S596.

Cohen W.M. and D.A. Levinthal, 1990, "Absorptive capacity: new prospective on learning and innovation", *Administrative Science Quarterly*, 35, 128-152

Cooke P., 2001, "Regional innovation systems, clusters and the knowledge economy", *Industrial and Corporate Change*, 10, 945-974

Dachs, B., B. Ebersberger, and H. Lööf, 2008, "The Innovative Performance of Foreign-owned Enterprises in Small Open Economies," *The Journal of Technology Transfer*, 33(4), 393-406.

Das T.H., and B. Tend, 2000, "A Resource-based theory of Strategic alliances", *Journal of Management*, 26(1), 31-61.

Day G.S., (1994), "The Capabilities of Market-Driven Organiza-tions", *Journal of Marketing*, 58(4), 37-52.

D'Este P., S. Iammarino, M. Savona and N. von Tunzelmann, 2011, "What hampers innovation? Revealed versus deterring barriers", *Research Policy* 41, 482-488

Evangelista R., S. Iammarino, V. Mastrostefano and A. Silvani, 2002, "Looking for regional systems of innovation: evidence from Italian innovation survey", *Regional Studies* 36, 173-186.

Drejer, I., and B.H Jørgensen, 2005, "The dynamic creation of knowledge: analysing public private collaborations". *Technovation* 25, 83 94.

Eliasson, G., 1990, "The firm as a competent team", *The Journal of Economic Behavior and Organization*, 13(3), pp. 275-298.

Freel, M.S., 2005, "Patterns of innovation and skills in small firms", *Technovation,* 25, 123-134.

Fritsch, M., and R. Lukas, 2001, "Who Cooperates on R&D?" *Research Policy*, 30(2), 297-312.

Fischer, M., and A. Varga, 2002, "Technological Innovation and Inter-firm Cooperation: an exploration analysis using data from manufacturing firms in the metropolitan region of Vienna", *Technological Managment*, 24(7), 724-742.

Greene, W. H., 2012, *Econometric analysis,* 7th ed., Harlow Pearson, 2012.

Iammarino, S., M. Piva, M. Vivarelli, and N. von Tunzelman, 2012, "Technological capabilities and patterns of innovative cooperation of firms in the UK regions", forthcoming in *Regional Studies*.

Istat, 2010, "Rilevazione Statistica sull'Innovazione nelle Imprese (CIS 2008). Anni 2006-2008. Aspetti Metodologici dell'Indagine," Rome.

Kamien, M.I., E. Muller, and I. Zang, 1992, "Research Joint Ventures and R&D Cartels," *American Economic Review*, 82(5), 1293–1306.

Laursen, K, and A.J. Salter A.J, 2006, "Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms", *Strategic Management Journal*, 27, 131-150.

Li, T. and R.J. Calantone (1998), "The Impact of Market-Knowledge Competence on New Product Advantage: Conceptualization and Empirical Examination," *Journal of Marketing*, 62(4), 13–29.

Lööf, H., and A. Heshmati, 2002, "Knowledge Capital and Performance Heterogeneity: An Innovation Study at Firm Level", *International Journal of Production Economics* 76(1), 61-85.

López, A., 2008, "Determinants of R&D cooperation: Evidence from Spanish Manufacturing Firms", *International Journal of Industrial Organization,* 26(1), 113–136.

Lundvall B.A., 1988, *Innovation as an interactive process: from user-producer interaction to the national system of innovation*, in Dosi G. Freeman C., Nelson R.R., Silverberg G. and Soete L. (Eds) , Technical Change and Economic Theory, 349-369, Pinter, New York.

Miotti, L., and F. Schwald, 2003, "Co-operative R&D: Why and with Whom? An Integrated Framework of Analysis," *Research Policy,* 32(8), 1489–1499.

Mohnen, P., and C. Hoareau, 2003, "What Type of Enterprise Forges Close Links with Universities and Government Labs? Evidence from CIS 2," *Managerial and Decision Economics*, 24(2-3), 133–145.

Narula, R., and A. Zanfei, 2003, "Globalisation of Innovation The Role of Multinational Enterprises," DRUID Working Papers 03-15, DRUID, Copenhagen Business School.

Ozman, M., 2009, "Inter-firm networks and innovation: a survey of the literature", Economics of Innovation and New Technology, 18(1), 39-67.

Piga, C. A., and M. Vivarelli, 2004, "Internal and External R&D: A Sample Selection Approach," *Oxford Bulletin of Economics and Statistics*, 66(4), 457–482.

Piva M., E. Santarelli and M. Vivarelli, 2005, "The skill bias effect of technological and organizational change: evidence and policy implications", *Research Policy* 34, 141-157

Piva M. and M. Vivarelli, 2004, "The determinants of the skills as a major driver of corporate R&D", *International Journal of Manpower* 30, 835-852.

Prahalad, C.K. and Hamel G., 1990, "The Core Competence of the Corporation", *Harvard Business Review*, 68(May-June), 79-91.

Rasche, C. and B. Wolfrum, 1994, Ressourcenorientierte unternehmensfuhrung, in: Die Betriebswirtschaft, 54, 501-517.

Schumpeter, J., 1943, *Capitalism, Socialism and Democracy*, New York: Harper.

Teece, D. J. and G. Pisano, 1994, "The dynamic capabilities of firms: An introduction", *Industrial and Corporate Change*, 3(3), 537-556.

Tether, B. S., 2002, "Who Co-operates for Innovation, and Why: An Empirical Analysis," *Research Policy,* 31(6), 947–967.

Von Hippel, E., 1988, *The Sources of innovation*, Oxford Univeristy Press, New York.

Von Tunzelmann N. and Q. Wang, 2003, "An evolutionary view of dynamic capabilities", *Economie Appliquée* 6, 33-64

Von Tunzelmann N. and Q. Wang, 2007, "Capabilities and production theory", *Structural Change and Economic Dynamics*, 18, 192-211

Whitley, R., 2002, "Developing innovative competences: the role of institutional frameworks" *Industrial and Corporate Change* 11, 497-528.

Winter, S.G., 1987, "Knowledge and competence as strategic assets", D.J. Teece (Ed.), *The competitive challenge: strategies for industrial innovation and renewal*, Ballinger, Cambridge, MA, 159-183.