innovations. Prior research has also argued that exploitation and exploration are associated to different types of learning (Baum *et al.* 2000; Benner and Tushman 2003) and knowledge search (Vermeulen and Barkema 2001; Rosenkopf and Nerkar 2001; Vassolo *et al.* 2004). We propose and test a conceptual model suggesting that the underlying learning processes of exploitation and exploration are mirrored in different organizational structures as well as shop floor workers' competences. Along these lines, we show that exploitative technological innovation can be associated to *learning by doing* and *learning by using*, and explorative technological innovation to *learning by searching*.

Based on a dataset stemming from face-to-face interviews with 166 manufacturing firms, we find that the adoption of decentralized HRMP influences the introduction of exploitative technological innovations via firm's productive capabilities, while *in-house* R&D influences the introduction of explorative technological innovations. We also find evidence consistent with extant literature that the introduction of a) exploitative technological innovation is positively related with tweaked existing competences, and b) explorative technological innovation is positively related with new competences.

2. Theoretical framework

2.1 Exploitative and explorative innovation, and learning

The distinction between exploitation and exploration has been widely acknowledged in several domains of management literature which have identified a number of substantial differences in firm strategy, behavior and performance (March 1991).

Drawing upon the construct exploitation *versus* exploration, He and Wong (2004) distinguish between exploitative and explorative technological innovation strategies with reference to the firm's market dimension. Linkages have been drawn between the concepts of incremental and radical innovation, and exploitation and exploration respectively. Scholars have argued that incremental innovations draw upon exploitation activities such as local search for knowledge, refining existing knowledge and deepening the firm's knowledge base, while radical innovations draw upon exploration activities such as distant search for knowledge, developing new knowledge, increasing variety of the firm knowledge base (Katila and Ahuja 2002; Rosenkopf and Nekar 2001; Subramaniam and Youndt 2005).

Several studies embrace the idea that exploitation and exploration are associated with different types of learning (Baum *et al.* 2000; Brenner and Tushman 2002; He and Wong 2004) and search

(Vermeulen and Barkema 2001; Rosenkopf and Nerkar 2001; Vassolo *et al.* 2004). More specifically, exploitation has been referred to "learning gained via local search, experiential refinement, and selection of existing routines", while exploration to "learning gained through processes of concerted variation and planned experimentation" (Baum *et al.* 2000: 768). As far as search is concerned, exploitation has been defined as the "ongoing use of a firm's knowledge base" and exploration as the "search for new knowledge" (Vermeulen and Barkema 2001: 459). Research in organizational learning has connected learning to organization design by distinguishing between single-loop learning, which heavily relies on routines by restricting itself to detecting and correcting errors, and double-loop learning, which involves modification of the organization's underlying norms, policies, and objectives (Argyris and Schön 1978). The literature of the economics of innovation (e.g. Malerba 1992) has singled out *learning by doing* and *learning by using*, which rely on productive capabilities and the use of product machinery and inputs, from *learning by searching*, which relies on formalized (i.e. R&D) activity aimed at generating new knowledge.

In what follows, we propose and test a conceptual model suggesting that the introduction of exploitative technological innovation can be associated to *learning by doing* and *learning by using* processes via decentralized HRMP and existing but restructured shop floor workers' competences, while the introduction of explorative technological innovation is associated to *learning by searching* via *in-house* R&D and new shop floor workers' competences. We build on the exploitation *versus* exploration construct and define technological innovation along two dimensions: 1) an exploitative innovation dimension to denote technological innovation relying on the firm's existing knowledge, and 2) an explorative innovation dimension to denote technological innovation relying on knowledge new to the firm.

2.2 Firm's organizational structure and innovation

Firms use different coordination mechanisms to combine key resources and independent functions to develop innovation and, as a result, different organizational antecedents have been recognized to differently influence exploitative and explorative innovation (Benner and Tushman 2003). Research in organization theory has focused on how organizational design elements may encourage or inhibit a firm to simultaneous pursue exploitation and exploration (Adler *et al.* 1999; Rivkin and Siggelkow 2003; Van Den Bosch *et al.* 1999; Volberda 1996). In this study, we focus on HRMP and R&D organization.

As far as HRMP are concerned, mechanisms of innovation coordination may range from hierarchical to horizontal structures. Prior research has tended to focus more on the former (Subramaniam and Youndt 2005) and the evidence on the latter is mixed. However, the documented shift away from rigid Tayloristic models of production organization towards post-fordist models has promoted interest in flatter organizational structures, characterized by decentralization and delayering, collective work and multi-task. In such organizational structures, functional flexibility is accomplished by the active involvement of workers in production activity and their greater responsibility and autonomy (Caroli 2001), and operationalized through "clusters" of decentralized HRMP (Milgrom and Roberts 1995; Ichniowski *et al.* 1997). On this vein, scholars in organization theory have recently investigated the role of decentralized organizational design elements in firms' innovative activity (e.g. Moch and Morse 1977).

Management scholars have argued that companies can successfully innovate by "liberating" low level managers (Peters 1992) and adopting "federal" structures in which "power belong to the most lowest possible point" (Handy 1992; 62). Similarly, Jansen *et al.* (2006) empirically show that centralization negatively affects exploratory innovation, whereas formalization positively influences exploitative innovation. Focusing on organizational units, these findings demonstrate that centralization reduces non-routine problem solving and the likelihood that unit members seek innovation and new exploratory solutions. In this perspective, any positive association between decentralization and innovation is interpreted as a signal that low-level exploration feeds firm-level exploration. This argument is rooted in the belief that centralized bureaucracies resist innovation (Thompson 1965), while decentralized firms can adapt quickly to change (Child 1984; Michie and Sheehan 1999). However, concerns have been expressed that semiautonomous business units may focus to much on incremental improvements and short-term returns (Kochen and Deutsch 1980; Kanter 1985; Arnold 1992), and that "liberated" empowered managers may persist on their historical, non innovative routines (Hales 1999). Along these lines, Siggelkow and Rivkin (2006) provide evidence that low-level managers' decentralization may reduce firm-level exploration. Although firms delegate search efforts in order to broaden search and reduce the burden on top managers, parochial interests of low level managers can reduce exploration for the firm as a whole when interdependencies span departments.

Summarizing, although the recognized significance of more decentralized organizational forms in shaping and directing firms' innovative activity, empirical evidence has so far been largely inconclusive with very little quantitative survey-based research focusing on internal organizational environments that promote the introduction of different types of innovations.[i] In this paper, HRMP are investigated as labor organizational practices related to a horizontal organizational structure as well as to practices involving delegation to shop floor workers especially.

As far as R&D organization is concerned, firms can conduct R&D internally or externally (by fully or partially externalizing it) depending on the trade-off between "make" or "buy". Capon *et al.* (1992) found that devoting resources to R&D to generate new ideas would lead to innovation. *In-house* R&D is a first-best choice when technological opportunities are high, while, when firms face low technological opportunities, the likelihood of introducing an explorative innovation can hardly be an incentive for *in-house* R&D. However, in this later scenario potential hold-up costs (Hennart 1993) and the path-dependent nature of learning (Patel and Pavitt 1997) may act as incentives to conduct *in-house* R&D, which may eventually lead to the introduction of explorative innovation. If R&D activity is entirely conducted *in-house*, firms avoid hold-up costs and develop specific capabilities on selected problems through a firm-specific learning process (Richardson 1972; Nelson and Winter 1982) monitored by a formalized laboratory aiming at generating new knowledge. Off-line R&D and experimental research has been recognized to play a powerful role in facilitating the evolution of technological change. Nelson (2003) argues that the uneven advance of human know-how across fields can be traced back to the unevenness of advance of sciences behind various technologies through off-line R&D activity. Conversely, firms merely relying on market transactions to source knowledge face opportunistic behavior and severe constrains in fully exploiting the potential of the acquired knowledge since they miss the preceding learning process, while firms partially externalizing R&D activity can rely on knowledge produced outside its knowledge boundaries, to the extent that it is complementary to their internal knowledge path and according to the degree of their absorptive capacity (Cohen and Levinthal 1990).

2.3 Firm's competences and innovation

The resource-based view of the firm argues that firm's competitive advantage lies in the development of firm-specific competences (Peteraf 1993). More recently, it has been argued that sustainable competitive advantage relies on the firm's "dynamic capability" (Teece *et al.* 1997) to move beyond local search and to reconfigure their knowledge. Along these lines, competence-based strategic management studies have addressed the distinction between exploitation and exploration in terms of competence leveraging (Sanchez *et al.* 1996) and competence deployment (Floyd and Lane, 2000), and competence building (Sanchez *et al* 1996) and competence definition (Floyd and Lane 2000). In managerial economics, a clear distinction is made between static and dynamic efficiency, with the former implying refinement of existing products and processes or capabilities, and the latter development of new ones (Ghemawat and Ricart I Costa 1993). Prior research has also recognized that firms focusing inward on their core competences risk to innovate incrementally (Rosenkopf and Nerkar 2001) as a result of local search and learning myopia (Levinthal and March 1993). Conversely, firms relying on competences spanning organizational boundaries are able to explore knowledge from non-local domains (Rosenkopf and Nerkar 2001). Extant literature, however, has devoted little attention to the role of shop floor workers competences in technological development.

3. Conceptual model and hypotheses development

Our model, illustrated in Figure 1, contends that the introduction of exploitative and explorative technological innovation underlies different learning processes in terms of organizational structure and competences of shop floor workers. The former is accounted for by decentralized HRMP and *in-house* R&D (left hand side of Figure 1), while the latter are distinguished between existing but restructured competences and new competences (right hand side of Figure 1). The introduction of exploitative innovation underlies *learning by doing* and *learning by using* processes, illustrated in Figure 1 by the connecting continuous lines and associated to decentralized HRMP and restructured competences. The introduction of explorative technological innovation underlies a *learning by searching* process, illustrated in Figure 1 by the connecting dashed lines and associated to *in-house* R&D and new workers' competences.

FIGURE 1

As far as organizational structure is concerned, Figure 1 describes a mechanism running from adoption of decentralized HRMP to exploitative innovation *via* productive capabilities mirrored in great firm's labor productivity. Delegation to shop floor workers of production decisions promotes workers' active participation to everyday problem-solving activity related to production issues and allows firms to

build up "productive capabilities". Such capabilities (in Winter's (2003) words defined "zero level capabilities") are about firms general and specific knowledge of how to do things (Richardson 1972; Teece *et al.* 1997) and are mirrored in the firm's labor productivity to the extent that they prompt firm's efficiency or effectiveness in engaging in its current business activities (Hatch and Mowery 1998). Great firm's labor productivity facilitates the introduction of exploitative technological innovation by providing financial resources with high growth rates, large profits and healthy cash flows (Hao and Jaffe 1993; Cohen 1995) as well as through the accumulation of selected (through the market) zero level capabilities enabling the firm to develop internal problem-solving trajectories and then responding timely to market feedbacks and signals through the amelioration of existing products and/or processes. Such a mechanism may seem to be at odds with empirical evidence showing that a causal relationship captures the impact of innovation on productivity (Crepon *et al.* 1998). However, more recently, it has been argued that firm productivity and innovation act as reinforcing mechanisms (Cainelli *et al.* 2006). We claim that divergences on this issue may be due to the failure of unpacking the concept of innovation into organizational and technological innovation. In particular, the introduction of organizational innovation has been proved to impact positively on firm productivity (Damanpour and Evan 1984; Michie and Sheehan 1999). Greater productivity has been recognized to provide firms with financial resources and capabilities to introduce (exploitative) innovations (Cyert and March 1963; Hao and Jaffe 1990; Cohen 1995; Winter 2003), which, then, increase firm productivity (Crepon *et al.* 1998). The failure to distinguish between organizational and technological innovation (Poole and Van de Ven, 1989) allows to capture only this latest part of the story, while distinguishing between the two accounts for the fact that organizational innovation positively impacts on firms' productivity and innovative activity (Michie and Sheehan 1999). However, this mechanism can hardly work as far as explorative innovation is concerned since decentralized HRMP may have an inertial effect on the innovation process leading to develop "core rigidities" (Leonard-Barton 1995) or fall into competency traps (Levitt and March 1998). This is indicated on the left of Figure 1 by the crossed dotted lines connecting HRMP to explorative innovation. The introduction of exploitative and explorative innovation is likely to rely on in-house R&D, as indicated in Figure 1 by the dashed lines connecting in-house R&D to explorative innovation. Basic off-line research in specialized facilities separated from where the technology is being employed (e.g. industrial R&D laboratories) informs and strengthens science and engineering disciplines, allowing for exploratory technological change (Nelson 2003).

As far as competences of shop floor workers of the innovating firms are concerned, the introduction of exploitative innovations is likelier to be associated to restructured existing employees' competences due to *learning by doing* and *learning by using*, as illustrated on the right of Figure 1 by the continuous lines connecting restructured shop floor workers' competences to exploitative innovation. Such kinds of innovation builds on firm's existing technological capabilities (March 1991) to the extent that the search of new ways of doing things is localized in the neighborhood of firms' existing skills and knowledge. Reliance on firm's existing skills and technological competences may spur innovations utilizing existing or familiar knowledge and also prompt learning myopia which restricts firms' innovative activity to exploitation by overlooking distant times, distant places and failures (Levinthal and March 1993). Following Henderson and Clark (1990), we contend, instead, that explorative innovations require new competencies in the firms, which also means acquisition of new routines enabling the exploration of new knowledge through a *learning by searching* for new knowledge re-combinations. This is shown again on the right of Figure 1 by the dashed lines connecting new shop floor workers' competences to explorative innovation.

3.1 Hypotheses

Firm's organization has been recognized to shape its short- and long-term prospects by affecting productive capabilities (how well it works) as well as dynamic capabilities (how effectively it changes) (Dosi and Gazzi 2006; Jacobides 2006). In this perspective, established literature has argued for the impact of decentralized HRMP on firm innovative activity. Great involvement of shop floor workers enhances productive capabilities (Michie and Sheehan 1999) facilitating the introduction of exploitative innovation through experiential learning. Along these lines, we pose that

H1a: The likelihood of introducing exploitative technological innovation is indirectly associated to decentralized HRMP via firms' productive capabilities.

Explorative innovative activity implies a modification of the organization's underlying norms, policies and objective (March 1991) and firms' organizational routines of greater involvements, responsibility and autonomy at the shop floor level may act as rigidities to explorative changes. Shop floor workers may fail

to strategically integrate knowledge flexibility across disciplinary class boundaries within the organization (Henderson and Cockburn 1994). Thus, we test the following hypothesis

H1b: The likelihood of introducing explorative technological innovation is not associated to decentralized HRMP.

The introduction of explorative innovation is likelier for firms with a formalized R&D activity, which favors the generation of new ideas through a path-dependent learning (Patel and Pavitt 1997). Therefore, we pose that

H2: The likelihood of introducing explorative technological innovation is associated to firms' in- house R&D.

Turning to the nature of employees' competences and their relationships with the two innovation activities under analysis. As result of the development of distinctive competences, firms tends to be myopic preferring short-run to long run survival, ignoring distant in space effects, and over sampling successes against failures (Levinthal and March 1993). In sum, the re-shaping of existing employees' competences through training on the job is likelier to nourish firms' experience and, furthermore, the introduction of exploitative innovations, which requires minor adjustments of the firm's competences profile. Thus, the following hypothesis is tested

H3a: The likelihood of introducing exploitative technological innovation by innovating firms is associated to the restructuring of firm's existing employees' competences.

Hiring new workforce eases the diversification of the firm's competences portfolio and avoids local search which builds upon similar technology residing within the firms. Spanning the organizational boundaries of the firm by hiring new people also spans firm's technological boundaries to the extent that explorative innovation builds upon distant technology residing outside the firm (Rosenkopf and Nerkar 2001). Along these lines, the following hypothesis is tested:

H3b: The likelihood of introducing explorative technological innovation by an innovating firm is associated to the acquisition of new employees' competences.

H1a suggests the following two equation model

$$INNO\_EXPL_i = f(Productive\ capabilities_i,\ in\text{-}houseR\&D_i,\ \omega_i,\ \gamma_i) \quad (1)$$

$$Productive\ capabilities_i = f(HRMP_i,\ x_i,\ \omega_i,\ \gamma_i) \quad (2)$$

where *INNO_EXPL* stands for exploitative innovation, *Productive capabilities* is proxied by firm's labor productivity, *in-houseR&D* is a variable capturing whether the firm has conducting internal R&D activity,

ω_i is the vector of independent variables related to shop floor workers' competences, γ_i is a vector of controls, *HRMP* is the vector of variables related to decentralized HRMP. *H1b* suggests a single equation model given by

$$INNO\_EXPR_i = f(Productive\ capabilities_i, HRMP_i, in\text{-}house R\&D_i, \omega_i, \gamma_i) \quad (3)$$

where *INNO_EXPR* stands for explorative innovation. *H2* requires the statistically positive significance of *in-house*R&D in equation (3). The significance of specific elements of vector ω_i (i.e. the restructuring of existing employees' competence and the acquisition of new employees' competences) is suggested by *H3a* and *H3b* in equation (1) and (3), respectively.

4. Data collection and sample

Data on firms' technological innovative activity, organizational innovations and HRMP for the overall period 1998-2002 has been collected through personal structure interviews. The population to be interviewed concerns all firms located in the Italian province of Reggio Emilia[ii] (NUTS 3 level[iii]) in the year 2001 with at least 50 employees as listed in the Intermediate Census of the National Institute of Statistics (ISTAT 1999) and in the Chamber of Commerce of Reggio Emilia (Infocamere 2001) for a total of 257 firms operating in four sectors (i.e. specialized suppliers, scale intensive, resources intensive, labor intensive and science based).[iv]

Data collection was started by contacting firms' top managers by phone and faxing them the introductory part of the questionnaires in February 2002, asking to answer questions concerning the structural features of the firm and formally requesting a personal interview. Interviewers were sent to accepting firms between May and July 2002. Interviewees are generally top managers and human resources directors. Firms were contacted again, if necessary, to address doubtful and contradictory answers or to fill in missing responses. A total of 199 valid responses were achieved, yielding a response rate of 77.4%. In terms of sectoral distribution, specialized suppliers (39%) and resource intensive (28%) firms are predominant, followed by labor intensive (19%) and scale intensive (14%) ones, this distribution mirroring the characteristics of the local economy, which shows a strong advantage in mechanicals and ceramics. The research method adopted for data collection can pose issues related to non-response bias. In order to address such issues, we compared the two subsets of respondents and non-respondents along two dimensions, such as sector and size (i.e. class of employees' number) (see Table A1). Using a χ^2 test of

independence, no statistically significant differences were found between respondents and non-respondents in terms of sector and size, the only exception being the overrepresentation of firms with more than 999 employees.

TABLE A.1

In order to avoid sampling on the dependent variables, we include all relevant firms whether or not they introduce technological innovations. However, availability of economic performance data for the period 1998-2002 (drawn form the firms' balance sheet submitted at the Chamber of Commerce of Reggio Emilia) reduces the final sample to 166 firms (accounting for 65% of the entire population). Given the nature of our data, we perform the Harman's single-factor test (Harman 1967; Podsakoff and Organ 1986; Podsakoff *et al.* 2003) on items included in our econometric model to examine whether common method bias augmented relationships.[v] The results obtained reported good properties, thus supporting the validity of the data.[vi]

5. Model specification and variables description

The hypothesized association between the likelihood of introducing exploitative/explorative technological innovations and their organizational and competence drivers may require different estimation models. As argued above, a major point is the potential endogeneity of firm productive capabilities. Firms may self select to the extent that those showing greater accumulation of productive capabilities are likelier to introduce exploitative innovation because of unoberservable managerial choices on organizational design elements (Hamilton and Nickerson 2003). To address the endogeneity concern, we use a weak exogeneity test of firm productivity for models with limited dependent variables as suggested by Smith and Blundell (1986). The test is constructed in two steps involving equation (1) and (2). In the first step, we regress the firm's productive capabilities indicator on the instruments and the exogenous variables. In the second step we use the residuals from the first stage regression as additional explanatory variables in equation (1). The test is also performed by substituting *INNO_EXPR* to *INNO_EXPL* in equation (1) in order to verify that equation (3) correctly specifies the likelihood of introducing explorative innovation. Under the null hypothesis of exogeneity, the coefficient of the residuals of the first stage regression is not statistically different from zero at the second stage. According to the results of the test, an instrumental variable (IV) probit model proposed by Newey (1987) or a simple probit estimation is adopted as explained below. In the former case, we use as instruments a set of HRMP indicators. Tests of validity of the instruments are reported in the results section.

5.1 Variables description

The variables adopted refer to the overall period 1998-2002 unless differently specified, thus preventing us from the use of a dynamic panel structure.

Exploitative and explorative technological innovation measures. Previous studies have proposed various ways of operationalized the concept of exploitation and exploration such as radicalness of innovation (Bierly and Chakrabati 1996), the degree to which search behavior spans both technological and organizational boundary (Rosenkopf and Nekar 2001) and the scope and depth of patent search (Katila and Ahuja 2002).

Following the established literature (Bierly and Daly 2001; Katila and Ahuja 2002; He and Wong 2004), we conceptualize exploitation and exploration as two distinct dimensions and operationalized them as orthogonal variables. In particular, we use two binary measures to capture whether firms have introduced technological innovations relying on knowledge *within* or *outside* the boundaries of their existing knowledge. More specifically, in equation (1), (2) and (3), the introduction of exploitative technological innovation was proxied by a variable ($INNO\_EXPL_i$) equal to 1 if firm (i) has introduced ameliorations on the quality of a firm's existing product and/or process, 0 otherwise, while the introduction of explorative technological innovation was proxied by a variable ($INNO\_EXPR_i$) equal to 1 if firm (i) has introduced a new to the firm product and/or process innovation, 0 otherwise.

We did not adopt the dichotomy radical-incremental innovation because we are interested in the firm itself, and its existing capabilities, resources and processes, not in technological trajectories, industry and competitors (Garcia and Calantone 2002). The firm-centered use of the concepts of exploitation and exploration allows us to capture the fact that activity perceived as exploratory by a firm may be perceived as exploitative by another and *vice versa*. Moreover, very few firms in our sample engage in breakthrough innovations. Similarly, we did not operationalized exploitation and exploration with patent data (e.g. Katila and Ahuja 2002; Rosenkopf and Nekar 2001) since none of the firms in our sample reported significant patenting activity.

Productive capabilities were proxied by the average added-value per employee at 2000 constant prices following Jacobides and Winter (2005: 397), who claim that "'productive capabilities' embraces the underlying determinants of the efficiency with which firms manage to carry out their productive activities". ***HRMP*** encompasses various kinds of team-based organizations, continuous team-based and/or firm internal learning, decentralization of decisions, proposals for improvements, quality circles, emphasis on internal knowledge dissemination (Lado and Wilson 1994; Zenger and Hesterly,1997). Along these lines, we considered HRMP related to a horizontal organizational structure and to delegation to shop floor workers in production decisions in particular. The former is captured by: a) *Flexible labor organization*, which equals 1 for firms adopting a flexible labor organization; 0 otherwise; b) *Channels for employees suggestions*, which equals 1 for firms establishing channels for employees' suggestions; 0 otherwise; c) *Quality control responsibility*, which equals 1 for firms where workers are individually encharged of quality control; 0 otherwise. d) *Employees evaluation*, which equals 1 for firms where managers formally evaluate employees, 0 otherwise; e) *HRMP favoring lean production*, which ranges from 0 to 5 according to the number of labor organizational practices (i.e. team work, quality circles, just-in-time, job rotation, total quality management) adopted by the firm. The greater the number of practices adopted, the greater the diffusion of lean production system. HRMP involving specific delegation to shop floor workers in production decisions are proxied by *Delegation of responsibility*, which ranges from 0 to 7 according to the number of labor and production organizational practices (i.e. team work, total quality projects, job rotation, autonomy in problem-solving, structured channels for workers' suggestions on organizational topics, structured channels for workers' suggestions on quality topics, permanent training) the firm has introduced. The greater the number of practices introduced, the greater the delegation of production decisions to shop floor workers. ***In house-R&D*** measures whether the firm conducts *in-house* R&D through an internal R&D function, 0 otherwise. Such a function enables firms to learn and generate technological advance in specific directions coherently with firms' past history of searching (Nelson 2003). ***Shop floor workers' competences*** refer to the *Restructuring of existing employees' competences* (which equals 1 for innovating firms providing training to its existing work-force, 0 otherwise) and *Acquisition of new employees' competences* (which equals 1 for innovating firms recruiting workers with new competences, 0 otherwise). The *innovating* firm is here understood as a firm introducing technological and organizational changes along the lines of a recent theoretical and empirical literature focusing on the joint occurrence of both kinds of changes (Pavitt *et al.* 1989; Milgrom and Roberts 1990; 1995; Piva *et al.* 2005).

Control variables. The estimated models also include a set of control variables. Chesbrough's (2003) 'open innovation' model has pointed out that firms use a wide range of external actors and sources in their innovation process. Interactions with lead users, suppliers, and with a range of institutions inside the innovation system have been recognized as key sources of innovation to firms, which rarely innovate alone (von Hippel 1988; Brown and Eisenhardt 1995; Szulanski 1996). Rather, firms are nested in communities of practice and embedded in a dense network of interactions (Scott and Brown 1999). In order to capture the effect of different types of firms' external relationships in the introduction of exploitative and explorative innovation, we include in the models a control variable measuring whether firms operate directly in the output market (as a proxy for the significance of user-producer relationships) rather than as sub-contractors (as a proxy for the significance of buyer-supplier relationships) (*output_market*). R&D leading to different types of innovation are characterized by varying degrees of uncertainty and complexity (Freeman and Soete 1997). When levels of uncertainty and complexity are low, full R&D externalization trough market-mediated contracts can function, whereas more complex and uncertain research requirements would make contractual arrangements difficult to specify and monitor, and will eventually preclude market-based contracts and favor full R&D internalization (Williamson 1975). However, when the degree of uncertainty and complexity is high, firms may opt for a partial R&D externalization by contracting out R&D while engaging in *in-house* technological activity. Internal technological activity makes firms capable to utilize acquired external specialist expertise and to access external specialist techniques or equipments to the extent that the external R&D activity is complementary to firms' core competences (Cassiman and Veuglers 2006). In this study, we control for such effects by including two binary variables for full (*fullR&Dext*) and partial R&D externalization (*partialR&Dext*), respectively. The former equals 1 for firms without an R&D function that externalize R&D, 0 otherwise; the latter is equal 1 for firms with an R&D function that externalize R&D activity, 0 otherwise. Scholars have long debate on the effects of firm age in their innovation performance. On the one hand, studies have demonstrated that, as firms age, they become more institutionalized with their established set of routines, consequently explore less (Hannan and Freeman 1984) and build their innovation on refinement

of older technologies, emphasizing exploitation (Sørensen and Stuart 2000). On the other hand, it has been argued that, as firms grow older, they accumulate financial and technical capabilities to bear the costs required for developing routines to manage strategic contradictions (Smith and Tushman 2005). We thus include firm's age (*AGE*) as a measure of number of years since firm foundation. In order to account for different propensities to innovate across industries, 4 sectors (i.e. *scale-intensive*, *specialized suppliers*, *resource-intensive* and *labor-intensive*) were considered with labor-intensive as the omitted category. These sectors are drawn from an OECD (1994) revision of Pavitt's (1984) taxonomy, which intends to aggregate industrial sectors according to market orientations, input characteristics, and technological contents for manufacturing firms in order to link sectoral performance with labor markets.[vii] Descriptive statistics and correlation matrix for all variables are reported in Table 1.

TABLE 1

6. Results

6.1 Endogeneity

The results of the Smith-Blundell (see Table 2 and 3) provide support to the hypothesis of an undirected association between exploitative innovations and decentralized HRMP *via* productive capabilities (*H1a*).

TABLE 2 AND 3

More specifically, the Smith-Blundell test does not reject the hypothesis that firm's productivity is weakly exogenous for explorative innovation (Table 3), thus the model is appropriately specified with all explanatory variables as exogenous, as outlined in equation (3), and a single probit model can be appropriately used. Conversely, the weak exogeneity test rejects the null hypothesis that firm's productivity in equation (1) is exogenous, making the use of a single probit model inappropriate for the likelihood of introducing exploitative innovation (Table 2). To control for endogeneity we use a fully specified instrumental variables (IV) probit estimation routine by adopting Newey's (1987) method as implemented in STATA by Harkness (2003). Such a method allows to generate consistent estimates for non-linear models via Amemiya Generalized Least Squares when addressing estimation bias due to endogeneity and omitted characteristics instrumenting the independent variables in the model that are thought to be endogenous.[viii]

6.2 Hypothesis Tests

Table 2 and 3 report the results of the IV probit and probit analysis, respectively. All our hypotheses were supported by the analysis. As stated in *H1a*, the estimates confirm that the likelihood of introducing exploitative innovation is positively associated to the firm's average added-value per employee instrumented with decentralized HRMP indicators. Firms showing greater productive capabilities (i.e. accumulation of financial resources and problem-solving capabilities through experience in productive activity) as a result of the adoption of more decentralized HRMP are likelier to introduce amelioration of existing products and/or processes. Delegation of responsibility in production decisions is the main driver of firm's productive capabilities enhancing the likelihood of the introduction of exploitative innovation, as revealed by the positive statistically significant relationship between the two variables in the first stage of the IV probit analysis (second column in Table 2).

Based upon the results of the Smith-Blundell test, to test *H1b* we run a simple probit model where firms' labor productivity and indicators related to decentralized HRMP were all exogenous independent variables. Table 3 reports the results obtained, which support *H1b* confirming that the likelihood of introducing explorative innovation is not associated to decentralized HRMP. The analysis presented in Table 3 finds also support to *H2* as illustrated by the statistically positive significant coefficient of *in-house R&D* on the likelihood of introducing explorative technological innovation.

In *H3a*, we proposed that the restructuring of firms' existing employees' competences will have a positive relationship with the likelihood of introducing exploitative innovation. Accordingly, statistically positive significant results for *Restructuring of existing employees competences* are gathered from the instrumental probit regression analysis (last column of Table 2). *H3b* predicts a positive relationship between *Acquisition of new employees' competences* and the likelihood of introducing explorative innovation. The positive estimates of acquisition of new competences reported in Table 3 provide support for this hypothesis.

Overall, the only control variable yielding statistically significant result is the variable controlling for the fact that firms produce directly for the output market in the IV probit model. The estimates reported in Table 2 show that firms producing directly for the output market introduce exploitative innovations to a lesser extent than firms operating as sub-contractors. The result that buyer-supplier relationships matter more than user-producer ones in the introduction of exploitative technological

innovation support previous findings in the literature focusing on the Japanese keiretsu (e.g. Dore 1988) as well as on industrial districts (Bianchi and Giordani 1993).

In order to assess the size-effect of the independent variables in each of the two models we compute marginal effects and changes in probabilities, which are reported in Table 4 and 5, respectively.

TABLE 4 AND 5

This analysis confirm *H1a* also in terms of significance of the size-effect of firm's productive capabilities on the likelihood of introducing exploitative innovation. The predicted probability of introducing exploitative innovation increase from 19% to 100% when firm's labor productivity ranges from its minimum to its maximum value, yielding a change in the probability of successfully introducing exploitative innovation of 81% (Table 4). The change in the predicted probability of introducing exploitative innovation is also notable when firm's labor productivity range from ½ standard deviation below the mean to ½ standard deviation above the mean, being equal to 40%. As far as the marginal effects are concerned, for a €100 increase in firm's labor productivity the probability of introducing exploitative innovation is expected to increase by 1%. The size-effect of *in-houseR&D* on the likelihood of introducing explorative innovation (*H2*) is more limited. If a firm conducts in-house R&D, its probability of introducing explorative technological innovation is 9% greater than a firm without an R&D function. This implies that the predicted probability of introducing explorative innovation is 85% for firms with no internal R&D function and 94% for firms with an internal R&D function (Table 5). As far as employees' competences are concerned, a firm restructuring existing employees' competences through training has a probability of introducing exploitative innovation 36% higher than a firm which does not apply such a restructuring strategy (*H3a*). Table 4 shows that probability of introducing exploitative innovation is 24% for the former and 60% for the latter. The size-effect of the acquisition of new employees' competences on the probability of introducing explorative innovation (*H3b*) is more contained. A firm acquiring new employees' competences has a probability of introducing explorative technological innovation 15% greater than a firm not adopting such a recruitment strategy with the former showing a 96% probability of successfully introducing explorative innovation and the latter 81%.

6.3 Validity of instruments

As anticipated above, the variables adopted as instruments refer to decentralized HRMP indicators. Good instruments are correlated with the endogenous variables but not with the dependent variables. Therefore, we expected these variables to be strong predictors of firm productivity, but not of the likelihood of introducing exploitative innovation. Valid instruments must be orthogonal to the error process in the structural equation. Therefore, we expected these variables to be uncorrelated with the unobservable factors affecting *INNO_EXPL* in the structural equation.

The relevance of the selected instruments is tested by computing the F-statistics on the excluded variables (i.e. instruments) in the firm productivity equation (whose results are reported in the second column of Table 2) in order to test their joint insignificance (Bound test). The first stage seems to explain fairly well firm productivity and the Bound test rejects the null hypothesis that the instruments are all joint insignificant. We also compute a standard probit model for exploitative innovation including the decentralized HRMP indicators (first column of Table 3) in order to test for their separate and joint insignificance, which is confirmed by the econometric results.

The validity of the selected instruments is tested through a test of overidentification. Since the direct application of Sargan (1958) and Basmann's (1960) instrumental variable method to nonlinear errors-in-variables models fails to yield consistent estimators, Lee (1992) shows that the Newey's (1987) minimized distance (or minimum-χ^2) for the IV probit estimator provides a test of overidentifying restrictions. The Amemiya-Lee-Newey minimum χ^2 statistic is performed through the overid STATA module (Baum *et al.* 2006). Like Sargan and Basmann statistics, the test statistic is distributed as χ^2 with (L-K) degrees of freedom (where L is the number of instruments, K the number of regressors and L-K the number of overidentifying restrictions) under the null that the instruments are valid. The results of the test confirm the validity of our selected instruments, as shown in the third column of Table 2.

7. Discussion

By applying the construct exploitation *versus* exploration, this paper develops a typology of technological innovations based on the firm existing knowledge, and examine the influences of organizational structure and shop floor workers' competences on the introduction of each of this kind of technological innovation. We test and find support for five hypotheses showing that the introduction of exploitative and explorative innovation rely on different firm's organizational determinants mirroring different underlying

learning mechanisms: 1) the introduction of exploitative technological innovation is influenced by decentralized HRMP *via* an increase in firm productive capabilities and restructured existing shop floor workers' competences – describing underlying *learning by using* and *learning by doing* mechanisms; 2) the introduction of exploitative technological innovation is not influenced by decentralized HRMP, rather by *in-house* R&D and the acquisition of new shop floor workers' competences – describing an underlying *learning by searching* mechanism.

This study contributes to the understanding of innovation development within organization by means of a quantitative survey. Very few quantitative survey-based studies have addressed the relationships between internal organizational environment and the introduction of exploitative and explorative innovation due to constrains on data availability. The value-added of such a kind of studies lies in the fact that they allow to considered innovation indicators relevant to understand the role of organizational structure in the development of different types of knowledge, otherwise neglected in studies adopting secondary data such as material (e.g. R&D expenditures) and human capital inputs (e.g. available pool of skills based on the number of years of education), which miss to capture how these resources are used and organized within the firm. Moreover, our results cast doubts on the success of the Japanese model for innovation creation, suggesting that the success of such a model should be evaluated according to the level of novelty yielded by the innovation process. If factors blocking or slowing down innovation may be located downstream reflecting rigid organizational frameworks that limits employees' participation and contribution to the innovation process, decentralized HRMP may be a solution to the extent that the final strategic target is exploitative innovation. *In-house* R&D activity appears to be the route to follow when targeting a greater level of firm's innovation novelty.

This study has theoretical implications for organizational learning research. We suggest that the learning processes underlying exploitative and explorative innovation, being based upon different knowledge searches, are mirrored in different organizational structures. Relatedly, we advance the idea that heterogeneity of innovative activity brings about heterogeneity of organizational structure which feeds different kinds of learning, that of providing *completely new solutions* and that of *combining existing solution to generating new combinations* (Schumpeter 1934). The study also contributes to the dynamic capability approach to the firm by identifying specific kinds of problem solving capabilities leading to exploitative and explorative innovation. The idea central to the dynamic capability approach that problem solving capabilities are a source of resources heterogeneity in technology development is supported by the study. Innovation performance is characterized by different learning mechanisms according to the capability firms mobilize.

A better understanding of the organizational and competence determinants of exploitative and explorative technological activity bears important implications for managers to intentionally select different types of innovation projects. Being aware of the non neutral effect of formal organization and employees' competences on the firms' technological activity provides a more stable basis for strategy formulation. An aspect of this study makes it useful to this end. Prior research suggests that organizational design elements are important antecedents of technological innovation (Jansen *et al.* 1999, Michie and Sheehan 1999) and has unfolded technological outcomes with regards to incremental and radical innovation types (Downs and Mohr 1976; Ettlie *et al.*, 1984; Deware and Dutton 1986; Tushman and Anderson 1986; Cardinal 2001). This study draws managers attention to the fact that the relevance of organizational design elements should be also considered with reference to what the firm knows. Prescriptions often presented to practitioners are based upon technology (Benner and Tushman 2002) and market/customer (Abernathy and Clark 1985) dimensions. In contrast, we suggest that the effects of organizational structure on innovation activity could be more suitably evaluate for the design of successful innovation strategies by considering whether firm's technological development occurs *within* or *outside* its existing knowledge base. Related to this point, we also provide evidence that organizational structure can be a source of competitive advantage to the extent that managers are explicitly aware of the kind of technological advantage it can lead to: decentralized management techniques are the key organizational strategy if short-term revenues are sought, while the adoption of more ambitious innovation projects calls for off-line and experimental research carried out in a internal R&D function, which can freely search around and beyond the firm's current knowledge.

The study suffers from some drawbacks that need to be considered. First, the binary measures used to construct technological innovation may be a limited proxy to exhaustively capture exploitative and explorative innovations. The use of a Likert-scale or finer measures needs to be explored in future research. Second, we mainly focus on formal organization when identifying organizations as antecedents

of knowledge creation, while the literature has clearly acknowledged the significance of formal (Jansen *et al.* 2005) and informal (Hansen 2002; Tsai 2001) organizations in such a process. It may be, however, reasonable to expect a complementary relationships between the two. The study also fails to consider individual behavior which can have a mediating effect between HRMP and innovation outcome. Moreover, for each firm all the questionnaire's answers were provided by the same person, this entailing potential common method bias. We control for this limitation performing the Harman's single-test and submitting the questionnaire through face-to-face interviews. Future research should attempt to overcome the limitations of self-reported data. A further limit of the study lies in the fact that the different types of underlying learning mechanisms are a possible interpretation of the results since they are captured indirectly rather than through direct measurements. To address this issue, future research should be devoted to investigate alternative direct measures capturing the complexity and multidimensional nature of the phenomenon. Future research should be, then, aimed at extending the time span covered by the data in order to allow longitudinal studies.

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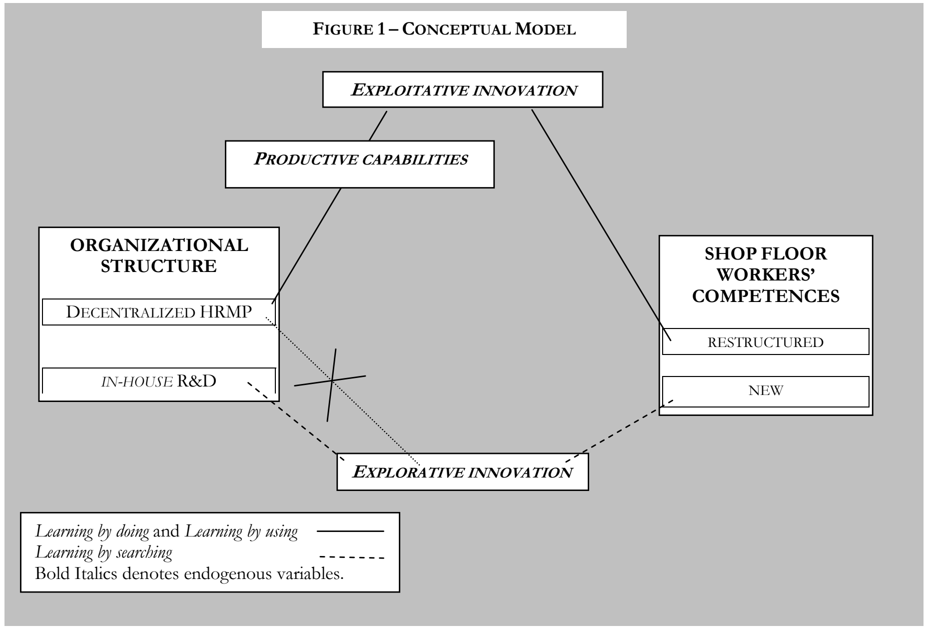

Table 1 – Descriptive Statistics and correlation matrix

		Mean	Std. Dev.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1)	*INNO_EXPR*	0.54	0.50	1													
(2)	*INNO_EXPL*	0.87	0.34	-0.11	1												
(3)	*Productive capabilities*	105.14	62.91	-0.02	-0.01	1											
(4)	*HRMP favoring lean production*	1.33	1.27	0.23	0.07	0.24	1										
(5)	*Delegation of responsibility*	2.70	1.84	0.21	0.10	0.26	0.50	1									
(6)	*Employees evaluation*	0.43	0.50	0.18	0.02	0.05	0.22	0.14	1								
(7)	*Flexible labor organization*	0.72	0.45	0.08	0.12	0.07	0.02	-0.02	0.10	1							
(8)	*Quality control responsibility*	0.54	0.50	0.01	0.07	0.01	0.07	0.10	0.09	-0.08	1						
(9)	*Channels for employees suggestions*	0.78	0.41	0.02	0.01	0.05	0.21	0.11	0.13	0.10	0.13	1					
(10)	*R&D$_i$*	0.58	0.50	0.05	0.21	0.02	0.20	0.14	0.00	0.10	-0.03	0.05	1				
(11)	*fullR&Dext$_i$*	0.05	0.22	0.15	0.01	-0.03	-0.10	-0.10	0.15	0.14	0.04	0.05	-0.21	1			
(12)	*partialR&Dext$_i$*	0.11	0.31	-0.07	0.08	-0.06	0.05	0.03	0.05	0.00	-0.11	0.14	0.30	0.01	1		
(13)	*Restructuring of existing employees competences*	0.86	0.35	0.28	0.19	0.06	0.22	0.21	0.11	0.09	0.07	0.20	0.10	0.01	0.03	1	
(14)	*Acquisition of new employees competences*	0.60	0.49	0.21	0.22	0.07	0.20	0.11	0.14	0.09	-0.07	0.01	0.12	0.19	0.01	0.29	1

Table 2 – Probit and ivprobit estimations for the likelihood of introducing exploitative innovation

	Specification											
	PROBIT				*FIRST STAGE*				*IVPROBIT*			
Variables	***Coef.***	***Robust Std. Err.***	***Z***		***Coef.***	***Std. Err.***	***t***		***Coef.***	***Std. Err.***	***Z***	
Productive capabilities	-0.002	0.002	-0.850						0.017	0.008	2.13	**
Flexible labor organization	0.123	0.240	0.510		10.646	10.787	0.99					
Channels for employees suggestions	-0.257	0.264	-0.970		-1.237	12.145	-0.1					
Quality control responsibility	-0.143	0.228	-0.630		-1.813	9.661	-0.19					
Employees evaluation	0.239	0.217	1.100		2.18	9.915	0.22					
HRM favoring lean production	0.183	0.106	1.740		5.905	4.581	1.29					
Delegation of responsibility	0.085	0.069	1.240		7.047	2.986	2.36	**				
R&D	0.183	0.239	0.770		-7.951	10.546	-0.75		0.333	0.304	1.09	
Acquisition of new employees competences	0.246	0.231	1.060		4.331	10.52	0.41		0.222	0.306	0.73	
Restructuring of existing employees competences	0.906	0.349	2.600	***	-4.669	14.569	-0.32		0.939	0.431	2.18	**
fullR&Dext	1.183	0.742	1.600		-0.388	23.506	-0.02		1.149	0.719	1.6	
partialR&Dext	-0.389	0.339	-1.150		-20.658	16.349	-1.26		0.006	0.497	0.01	
AGE	0.134	0.367	0.370		1.904	14.822	0.13		0.094	0.438	0.22	
output_market	-0.163	0.399	-0.410		39.892	17.5	2.28	**	-0.896	0.604	-1.48	
specialized suppliers	-0.098	0.367	-0.270		20.77	15.316	1.36		-0.483	0.467	-1.04	
scale intensive	0.010	0.007	1.360		0.486	0.32	1.52		0	0.01	0.03	
resource intensive	-0.009	0.003	-2.510	**	0.319	0.15	2.13	**	-0.015	0.005	-2.69	***
contant	-0.699	0.549	-1.270		20.015	22.432	1.29		-1.419	0.718	-1.98	
	No of obs.	166			No of obs.	166			No of obs.	166		
	Log pseudolikelihood	-93.882			R2	0.19						
	Wald chi2(17)	33.27	***		Adj R2	0.103			Wald chi2(11)		21.24	**
	Pseudo R2	0.18										
	Smith-Blundell test chi2(1)	8.18	**									
	Bound test	10.29			Bound test	2.32	**		Amemiya-Lee-Newey minimum chi2 statistic chi2(5)			1.407

*** Significant at $p \leq 0.01$

** Significant at $p \leq 0.05$

Table 3 – Probit estimations for the likelihood of introducing explorative innovation

Variables	*Coef.*	*Robust Std. Err.*	*Z*	
Productive capabilities	-0.002	0.002	-1.23	
Flexible labor organization	0.314	0.294	1.07	
Channels for employees suggestions	-0.272	0.350	-0.78	
Quality control responsibility	0.412	0.264	1.56	
Employees evaluation	-0.065	0.278	-0.23	
HRM favoring lean production	-0.091	0.137	-0.66	
Delegation of responsibility	0.107	0.078	1.39	
R&D$_i$	0.563	0.284	1.98	**
Acquisition of new employees competences	0.829	0.302	2.74	***
Restructuring of existing employees competences	0.311	0.387	0.8	
fullR&Dext	-0.221	0.647	-0.34	
partialR&Dext	0.459	0.549	0.84	
AGE	0.012	0.010	1.22	
output_market	-0.002	0.004	-0.43	
specialized suppliers	0.350	0.418	0.84	
scale intensive	0.791	0.550	1.44	
resource intensive	0.215	0.399	0.54	
constant	-0.388	0.558	-0.7	
No of obs.	166			
Log pseudolikelihood	-53.186			
Wald chi2(17)	34.21	***		
Pseudo R2	0.1809			
Smith-Blundell test chi2(1)		0.295		

*** Significant at $p \leq 0.01$
** Significant at $p \leq 0.05$

Table 4 - Change in probabilities for the introduction of exploitative innovation

	x=0	x=1	0->1	x=min	x=max	min->max	x-1/2sd	x+1/2sd	-/+sd/2	Marginal effect
Productive capabilities				0.19	1.00	0.81	0.34	0.74	0.40	0.01
R&D	0.47	0.60	0.13							
Acquisition of new employees competences	0.49	0.58	0.09							
Restructuring of existing employees competences	0.24	0.60	0.36							
fullR&Dext	0.52	0.89	0.36							
partialR&Dext	0.55	0.55	0.00							
specialized suppliers	0.53	0.57	0.03							
scale intensive	0.60	0.26	-0.35							
resource intensive	0.60	0.40	-0.20							
AGE				0.54	0.56	0.01	0.55	0.55	0.00	0.000
output_market	0.90	0.90	0.00							

Table 5- Change in probabilities for the introduction of explorative innovation

	x=0	x=1	0->1	x=min	x=max	min->max	x-1/2sd	x+1/2sd	-/+sd/2	Marginal effect
Productive capabilities				0.93	0.52	-0.42	0.93	0.90	-0.02	0.00
Flexible labor organization	0.87	0.93	0.05							
Channels for employees suggestions	0.94	0.91	-0.04							
Quality control responsibility	0.87	0.94	0.07							
Employees evaluation	0.92	0.91	-0.01							
HRMP favoring lean production	0.93	0.92	-0.01	0.93	0.85	-0.08	0.92	0.91	-0.02	
Delegation of responsibility	0.86	0.88	0.02	0.86	0.97	0.11	0.90	0.93	0.03	
R&D	0.85	0.94	0.09							
Acquisition of new employees competences	0.81	0.96	0.15							
Restructuring of existing employees competences	0.87	0.92	0.06							
fullR&Dext	0.92	0.88	-0.04							
partialR&Dext	0.91	0.96	0.06							
AGE				0.86	0.99	0.12	0.90	0.93	0.03	0.002
output_market	0.94	0.94	0.00							
specialized suppliers	0.89	0.94	0.05							
scale intensive	0.89	0.98	0.09							
resource intensive	0.91	0.94	0.03							

Table A.1 - Sample representativeness

Dimension	*Total firms in the population*	*Respondent*	*Non-Respondent*	χ^2 *test*	
Sector					
Labor intensive	48	33	15	2.546	
Resource intensive	73	58	15	0.238	
Scale intensive	35	30	5	1.591	
Specialized Suppliers	101	78	23	1.217	
Size					
50-99	117	86	31	1.896	
100-249	76	57	19	0.365	
250-499	33	26	7	0.04	
500-999	16	15	1	2.6	
>999	15	15	0	4.643	**

** Significant at $p \leq 0.05$

[i] A notable exception is the work by Laursen and Foss (2003) and Jensen *et al.* (2005).

[ii] Reggio Emilia is an especially suitable context for analyzing the issue at hand being characterized by 'a "primary" industrial sector with advance technological innovative ability, high wages, and considerable union presence ... and a "secondary" industrial sector, consisting of small firms *sharing* with the "primary" sector its advanced technology, its innovative capacity and its ability to compete on the world market, and at least when business is good paying a similar wages to most of its workforce' (Brusco 1982, 182–183).

[iii] For a description of NUTS classification see EUROSTAT (1995).

[iv] No science-based firms were recorded in our sample.

[v] When common-method bias occurs, either a single factor is extracted from a factor analysis of all measurement items included in the study or a general factor accounts for most of the variance.

[vi] We perform a principal component analysis for the cross sectional sample that included all explanatory and control variables, and the dependent variables. Binary variable were firstly standardised in order to avoid complications of running a principal component analysis on a tetrachoric correlation matrix without an automatic computerised routine (missing in statistical packages such as SPSS). This allowed us to perform a principal component analysis on a standard Pearson correlation matrix. The analysis retained 7 factors with egenvalue greater than 1.00 with no factor explained more than 14% of the total variance.

[vii] Previous research findings on the effects of size on innovation performance have been mixed. Although most studies have reported a positive effect of size (e.g. Moch and Morse 1977), some studies have shown a negative effect (Masfield 1968), or none effect at all (Clark *at al.* 1987). When running our estimations, we first control for firm size (proxied as the number of employees) but no statistically significant results were obtained. Thus, this control was rules out.

[viii] STATA ivprobit command estimates the endogenous variable as a linear function of the instrumental variables and corrects the second step standard errors (Wooldridge 2002).