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The Underlying Internal Learning Processes of Incremental and Radical Innovations: An Empirical Analysis of the Reggio Emilia Industrial Districts

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Abstract – The model of a flatter internal structure is nowadays attracting great interest as far as the organisation of firms' productive and innovative activity is concerned. Nevertheless, the underlying learning processes still need to be explored. Within this framework, the paper investigates whether the introduction of incremental and radical innovation underlies different learning processes in terms of de-verticalised labour organisational practises, different modes of organising R&D activity and the nature of employees' competences. The empirical evidence provided on a sample of 166 firms located in Reggio Emilia province in Italy points out that incremental innovation seems to be mainly grounded on a problem-solving activity based on *learning by doing* and *learning by using* processes, while in the case of radical innovation a *learning by searching* process seems to be at work.

Keywords: internal learning types, incremental and radical innovations, horizontal information structure, R&D organisational modes, employees' competences

JEL classification D83, L2, O33, R1

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1. Introduction

The role of major competence-destroying innovations has been extensively studied by Schumpeter (1934, 1942) in its analysis of technological change as a central feature of the capitalist system. More recent literature (e.g. Abernathy, 1978, Nelson and Winter, 1982, Tushman and Anderson, 1986) has balanced this emphasis on radical innovation by drawing attention to incremental competence-enhancing innovations. Scholars have drawn on this distinction to study different issues such as market entry (e.g. Tushman and Anderson, 1986), firms' investment behaviour (e.g. Herderson, 1993) and organisational structure (e.g. Down and Mohr, 1976). As far as the later issue is concerned, the interplay between economic and organisational theory was already recognised in the work of Williamson (1975), Chandler (1977) and Porter (1980), who highlighted the crucial linkages between innovation and firms' organisation.

However, in the economics of innovation several domains remain to be explored as far as the relationship between innovation and organisation is concerned (Tushman and Nelson, 1990). This notwithstanding, this relationship has played a strategic role in the history of the capitalist system. Firm's internal organisation has traditionally impact on its innovative and economic performance. This has been reflected in the shift from old models of production organisation to new models centred on the conception of the firm as a learning organisation (Penrose, 1958) in the sense that firms' organisational capabilities are a reflection of routinised practices developed over time. Along these theoretical lines of thought, post-fordist models of production organisation (such as the Swedish (Berggren, 1992) and Japanese (Aoki, 1988) model *vs*. the American (Coriat, 1995) one)[i] are based upon functional flexibility made operational through the active involvement of workers in production activity. Thus, the model of a flatter internal structure is nowadays attracting great interest as far as the organisation of firms'

productive and innovative activity is concerned. Nevertheless, the underlying learning processes at the firm level still need to be investigated. Building upon Malerba (1992), different types of learning *internal* and *external* to the firms are at work.

In this study, we are interested in *internal* types of learning in the attempt of understanding the role of firms' internal organisation in shaping and orienting innovation. The question we attempt to answer is whether the introduction of incremental and radical innovation underlies different learning processes in terms of de-verticalised labour organisational practises, different modes of organising R&D activity and the nature of employees' competences. This research question is investigated in the context of the Reggio-Emilia province (Eurostat NUTS 3) hosting an industrial district in mechanicals, ceramics and made-in–Italy sectors, by using a dataset stemming from a questionnaire administered to 166 industrial companies with at least 50 employees out of 257 (65%) firms with local establishments in the province in question.

The paper is developed in 5 sections. Next section sets the theoretical framework and the research question investigated by also discussing the hypotheses tested in the econometric exercise. Section 3 illustrates the variables and the model specification. In section 4, the econometric results are discussed for incremental and radical innovation, in turn. Concluded remarks are put forward in section 5.

2. Theoretical framework and the research question

Traditional economic theory has conceptualised technological change as rooted on a costless, easily transferable and readily imitable learning process which reduces average production costs through its innovative output. Although this conceptualisation is common to most economists, not all the economic literature shares this view. The evolutionary tradition, initiated by Nelson and Winter (1982) and grounded on

Schumpeter's work, has proposed an alternative conceptualisation of learning. Without disregarding the public nature of the process, this stream of literature has emphasised the private (or *tacit*) aspect of learning that enables firms to develop throughout their history (path-dependency) unique dynamic capabilities (Teece *et al*., 1997) mirrored in their managerial and organisational routines. Given the heterogeneity of firms (Jovanovic, 1982) in accumulating capabilities and translating them into organisational routines, firms differ across and within industries (Nelson, 1991) in the way they perceive technological opportunities.

Firms heterogeneity implies that firms learn in a variety of different ways and, as a consequence, that there are a variety of learning processes each of which is related to a different source and type of knowledge (Malerba, 1992). More specifically, firms' learning may be linked to knowledge developed *internally* to the firm in activities such as production and R&D or sourced *externally* by the firm through its interactions with other firms operating in the same industry, with suppliers and/or customers as well as from science and technology advancements. As anticipated above, our attention is here devoted to the firm's internal learning understood as a collective process in the sense that individual contributions to advances in learning are developed through interactions among firms' workers. Such a collective aspect gains great significance as far as human resource management practices are concerned. As shown by the Japanese experience, a firm's internal horizontal information structure may prove to be highly competitive (Aoki, 1986).[ii] The rotation of workers among various jobs and the encouragement to workers in the shop floor to solve emergent problems by themselves and improvise improvements on designed work process allows firms to train multiskilled workers who understand the entire production process and are able to respond to unexpected events without calling the supervisors (Carmichael and MacLeod, 1993; Black and Lynch,

2001; Lundvall and Nielsen, 2002). Conversely, strategic decisions (such as R&D investments) are placed under hierarchical control. Thus, collective learning and informal knowledge sharing have been identified as strategic tools in the internal development of potentially useful knowledge by allowing firms to respond timely to a wide variety of changes in the competitive environment (Volberda, 1996).

Although the recognised significance of more de-verticalised organisational forms in shaping and directing firms' learning (see e.g. Moch and Morse, 1977), no attempt has been made, as far as our knowledge is concerned, to investigate whether the association between these practices and the introduction of incremental and radical innovations underlies different learning processes. Conversely, several studies drawing on the managerial literature have investigated the organisational determinants of incremental and radical innovation calling into question the search of a universal theory of innovation (Dows and Mohr, 1976). In this literature, the basic reference is the work of Ettlie *et al*. (1984) which in the context of the food processing industry provides empirical evidence suggesting that the strategy-structure causal sequence is differentiated for incremental and radical innovation. Along the same lines, Dewar and Dutton (1986) test empirically the role of different models in predicting the adoption of the two types of innovation in the footwear industry. Similarly, Koberg *et al*. (2003) investigate the influence of environment, organisation, structure process and managerial characteristics in the introduction of the two different innovation types, while McDermott and Colarelli O'Connor (2002) explore the process of radical new products from a management strategic perspective. In all these studies, however, the focus is on the managers willingness to decentralise the decision process rather than in the actual workers' involvement in the management of the firm. Despite the interest shown in the distinction between incremental and radical innovation by the managerial literature,

Henderson and Clark (1990) have questioned this traditional categorisation when analysing market entry and competitive issues, while Henderson (1993) recognised the utility of a careful distinction between the two types of innovations for the understanding of investment behaviour of incumbents firms. Along the same lines, Tushman and Anderson (1986) have investigated the association between new and incumbent firms, and incremental and radical innovations.

Given our focus on internal learning, it also seems relevant to investigate whether the introduction of specific innovation types shows specific patterns in terms of R&D organisation and employees' competences as a result of different underlying learning processes. As far as the organisation of R&D activity is concerned, firms can conduct it either internally or externally. In the first case, firms develop specific capabilities on selected problems through a *learning by searching* process and rely on knowledge produced outside them to the extent that it is complementary to their internal knowledge path. Conversely, firms relying on market transactions to source knowledge face severe constrains in fully exploiting the potential of the acquired knowledge since they miss the preceding learning process. Turning to the nature of employees' competences and their relationships with the two innovation types under analysis, we consider employees' competences new to the firm or existing but reshaped workforce's competences. The former would imply that the innovation process requires a great effort to the firm in terms of diversification of its portfolio of competences. The latter would, instead, require an adjustment of the firm's competences profile.

In this study, we are interested in investigating empirically whether the association between different innovation types (namely incremental and radical innovations),[iii] and de-verticalised labour organisational practices, different modes of organising R&D activity and different employees' competences takes different shapes

due to the nature of the underlying learning processes. More specifically, we define radical innovations in terms of introduction of new products and processes, while incremental innovation as related to ameliorations of existing products and processes. Drawing on previous results (Pini and Santangelo, 2005), we then link incremental and radical innovations to de-verticalised labour organisational practices as well as to different modes of organising R&D activity and different employees' competences. We hold that the association between incremental and radical innovations, and de-verticalised labour organisational practices takes different shapes due to the nature of the underlying innovation processes. Drawing on Malerba (1992), we distinguish three types of internal learning processes according to different sources and types of knowledge: 1) *learning by doing* related to production activity, 2) *learning by using* related to the use of products, machinery and inputs, and 3) *learning by searching* mainly related to formalised activities (i.e. R&D) aimed at generating new knowledge. If the first type of learning dates back to Arrow's (1962) seminal work,[iv] other scholars (i.e. David, 1975, Rosenberg, 1976) have emphasised its cumulative character. Similarly, cumulative effects of learning by using and learning by searching have been extensively acknowledged (i.e. Rosenberg (1982), and Nelson and Winter (1982) and Dosi (1988) respectively).

2.1 Hypotheses

Within this theoretical framework, we argue that incremental innovation is mainly grounded on a problem-solving activity based on a *learning by doing* and l*earning by using* process. Conversely, radical innovation mainly relies on a problem-solving activity based on *learning by searching* process. Therefore, the association between incremental innovation and de-verticalised labour organisational practices goes through

productivity (understood as the firm's problem-solving capabilities in production issues accumulated over time). That is, the greater the adoption of de-verticalised labour organisational practices the greater the productivity of the firm as a result of its experience translated in learning. The active participation of workers to everyday problem-solving activity related to production issues enhances the ability of the firm to survive in the market by both developing internal problem-solving trajectories and then responding timely to market feedbacks and signals. In turn, the greater the firm's productivity, the greater the likelihood the firm will introduce incremental innovation as a result of the *learning by doing* and *learning by using* process underlying this innovative activity. Conversely, the association between radical innovation and de-verticalised labour organisational practices is not mediated by firm's productivity. Due to the underlying *learning by searching* process specific to the nature of this type of innovation, radical innovation mainly requires some systematic R&D activity, although, somehow, stimulated by market feedbacks. Thus, we test the following hypotheses

Hypothesis 1a: The association between the likelihood of introducing incremental innovation and labour organisational practises is mediated by firms' productivity.

Hypothesis 1b: The association between the likelihood of introducing radical innovations and labour organisational practises is not mediated by firms' productivity.

Moreover, the different processes underlying the introduction of the two types of innovation (i.e. *learning by doing* and *learning by using* for incremental innovation and *learning by searching* for radical innovation) are mirrored in different modes of organising R&D activity as well as in the different nature of employees' competences

(whether new to the firm or reshaped). More specifically, firms conducting *in house* R&D develop a learning path through trial and error enabling them to fully exploit the potential of their *searching* activity and relying on knowledge produced outside them to the extent that it is complementary to the internally generated knowledge. Therefore, this allows to increase the likelihood that they will introduce radical innovation. Conversely, firms trading R&D in the market miss the underlying learning path, being able to use this R&D mainly for amelioration of existing products. As far as the nature of employees' competences is concerned, on the one hand radical innovations are likelier to rely on employees' competences new to the firm due to the major breaking generated by the innovative activity. On the other hand, the likelihood of introducing incremental innovations is enhanced by reshaped employees' competences as a result of the need to adjust employees' expertise to the amelioration of existing product and processes. Thus, the following hypotheses are tested:

Hypothesis 2a: The likelihood of introducing incremental innovation is greater for firms trading R&D in the market as well as for firms reshaping the existing employees' competences.

Hypothesis 2b: The likelihood of introducing radical innovation is greater for firms conducting in *house* R&D and acquiring new employees' competences.

All these hypotheses are tested in the context of the Reggio Emilia industrial districts, characterised 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, pp. 182–183).

3. The empirical methodology

In what follows, we describe the variables and the specification of the econometric model adopted.

3.1 The variables[v]

The adoption of incremental and radical innovation was captured by two binary variables:

- $INNO\_INCR_i$ is equal to 1 if firm (i) has introduced ameliorations on the quality of an existing product and/or process, 0 otherwise.
- $INNO\_RAD_i$ is equal to 1 if firm (i) has introduced a new product and/or process innovation, 0 otherwise;

Productivity was proxied by the average revenue per employee at 2000 constant price ($FATDIP_i$).

The other variables considered were classified as variables related to: (a) *labour organisational practices*; (b) *different modes of conducting R&D activity*; (c) *the impact of new techno-organisational innovations on employees' competences*. We also consider variables related to the firm's *quality of labour force*, *industrial relations* and *intangible assets*.

A first set of variables (*group (a)*) related to *labour organisational practices*, are the following:

- wof_i equals 1 if firm (i) has adopted a flexible labour organisation; 0 otherwise.
- $empsug_i$ equals 1 if firm (i) has established channels for employees' suggestions;
- $empqcm_i$ equals 1 if in firm (i) workers are individually encharged of quality control; 0 otherwise.
- $empev_i$ equals 1 if in firm (i) managers formally evaluate employees, 0 otherwise.

Moreover, additional variables related to labour organisational practices were considered in both *aggregated* and *cumulated* form. As far as *aggregated* labour organisational practices are concerned,

- jt_wp_i equals 1 if firm (i) has provided training to specialised and qualified workers on at least one of the following practises: team work, interpersonal relations and communications, training for using new equipment, problem-solving methods, time management, quality, changes management ; 0 otherwise.
- $intro\_wp_i$ equals 1 if at least one of the following practises has been introduced by firm (i) since 1998: team work, total quality projects, job rotation, autonomy in problem-solving, structured channels for workers' suggestions on organisational topics, structured channels for workers' suggestions on quality topics, permanent training; 0 otherwise.
- wop_i equals 1 if at least one of the following labour organisational practises has been adopted by firm (i): team work, quality circles, just-in-tine, job rotation, total quality management; 0 otherwise.
- ep_i equals 1 if at least one of the following involvement practices has been adopted by firm (i): meeting stimulation, meeting organisation, participation in panels, evaluation of workers' suggestions; 0 otherwise.

The same variables were considered in a *cumulated* form. In particular,

- $jt\_wp\_cumul_i$ ranges from 0 to 6 according to the number of practises (i.e. team work, interpersonal relations and communications, training for using new equipment, problem-solving methods, time management, quality, changes management) firm (*i*) has provided training for to specialised and qualified workers.
- $intro\_wp\_cumul_i$ ranges from 0 to 7 according to the number of practises (i.e. team work, total quality projects, job rotation, autonomy in problem-solving, structured channels for workers' suggestions on organisational topics, structured channels for workers' suggestions on quality topics, permanent education) firm (*i*) has introduced since 1998.
- wop_cumul_i ranges from 0 to 5 according to the number of labour organisational practises (i.e. team work, quality circles, just-in-tine, job rotation, total quality management) adopted by firm (*i*).
- ep_cumul_i ranges from 0 to 4 according to the number of involvement practices (i.e. meeting stimulation, meeting organisation, participation in panels, evaluation of workers' suggestions) adopted by firm (*i*).

The second set of variables (*group (b)*) refers to variables related to *different modes of conducting R&D activity*. That is,

- $R\&D_i$ equals 1 if firm (*i*) has an R&D function, 0 otherwise;
- $marketR\&D_i$ equals 1 if firm (*i*) has not an R&D function and externalises it, 0 otherwise;
- $R\&Doutsourcing_i$ equals 1 if firm (*i*) has an R&D function and externalises it, 0 otherwise.

In order to consider whether techno-organisational innovations adopted by the firms in the sample have promoted the reshaping of employees competences through

training or the acquisition of new employees' competences through recruitment, a third set of variables (*group (c)*) relates to the *impact of new techno-organisational innovations on employees' competences* was considered. More specifically,

- $compres_i$ equals 1 if firm (*i*) has introduced techno-organisational innovations that have impacted on training for the existing work-force, 0 otherwise.
- $newcomp_i$ equals 1 if firm (*i*) has introduced new techno-organisational innovations that have impacted on recruitment of workers with new competences, 0 otherwise.

Moreover, to account for the *firm's quality of the labour force* we built

- $skill_i$, which is the share of skilled labour (i.e. top managers, executive and specialized workers) employed in firm (*i*) relative to the firm's total employees.

The peculiarity of *industrial relations* in the Emilian districts, characterised by a strong unionism tradition (Brusco, 1982, Brusco and Solinas, 1997)[vi], are accounted for by

- $inno\_rs_i$, which ranges from 0 to 1 according to the degree of unions involvement in different techno-organisational innovations and personnel training.

Finally, we also considered a variable related to *the firm's intangible assets*:

- $iimn_i$, which, for each firm (*i*), is equal to the annual average of the net intangible capital at constant price using the year 2000 as baseline.

Table A.1 lists and describes the variables adopted, while the summary statistics and correlation matrix are reported in Table 1 and 2 respectively.

3.2 The model specification

For each of the two types of innovation identified, we estimated a two equation model specified as follows:

$$INNO_i = f(FATDIP_i, x_i) \quad (1)$$

$$FATDIP_i = f(lop_i) \quad (2)$$

where $INNO_i$ stands, in turn, for $INNO\_RAD_i$ and $INNO\_INCR_i$, x_i is the vector of the independent variables not related to labour organisational practices, $FATDIP_i$ stands for labour productivity as illustrated above, lop_i is the vector of the variables related to labour organisational practises as described above, and. Due to the structure of the model, we use an instrumental variables estimation procedure. In the first step, we regress the average revenue per employee on a set of instrumental variables related to labour organisational practises. In the second step, we used predicted values of $FATDIP_i$ as independent variables in the estimation of equation (1) together with other *assumed* exogenous variables not related to labour organisational practises and a number of controls such as firms' sectoral specificities (in terms of Pavitt classification), age, different behaviour of foreign firms and firm operating directly in the output market (rather than as sub-contractors).[vii] Due to the binary nature of the dependent variables, in the second step a probit estimation was adopted.[viii] This procedure is run instrumenting $FATDIP_i$ in turn with the aggregated and cumulated version of labour organisational practises.

However, before running this instrumental procedure, a Smith-Blundell test was performed to test the exogeneity of the firm's productivity in the model described in equation (1) and (2) in turn for incremental and radical innovation, using as instruments labour organisational practices in both aggregated and cumulated form for the sake of econometric robustness.

4. The econometric results

The results of the Smith-Blundell test, reported in Table 3, illustrate that firms' productivity seems to be exogenous as far as radical innovation is concerned, but not in the case of incremental innovation when using as instruments labour organisational practices in both aggregated and cumulated form (Table 3). That is, firms' productivity mediates the association between incremental innovation and labour organisational practises, but not between radical innovation and labour organisational practices. Thus, these results confirm *Hypotheses 1a* and *1b*.

In order to test the specificity of the process underlying each of the two types of innovation and on the grounds of these results we run the model specified in section 2 for incremental innovation only, while adopting a simple probit model for radical innovation including as independent variables productivity, labour organisational variables in aggregated and cumulated form in turn, different modes of organising R&D activity and different employees' competences together with some controls. In what follows, the results obtained for each of the two innovation types are discussed.

4.1 Incremental Innovation

For incremental innovation, the structural model was run by considering the variables related to labour organisational practices in turn in aggregated and cumulated form, as reported in Table 4 and 5, respectively. The results obtained seem to be quite robust. In both cases, the likelihood of introducing incremental innovation is positively associated to the firm's average revenue per employee ($FATDIP_i$ is statistically significant at $p \leq 0.10$ when considering the aggregated version of labour organisational practices and at $p \leq 0.05$ when considering the cumulated version of labour organisational practices). This confirms the significance of knowledge acquired by workers over time in the

association between incremental innovation and labour organisational practices. Workers' involvement in production issues amplifies the firm's ability to develop specific problem-solving capabilities. Following Arrow's (1962), problem-solving activity in the production realm enables experience accumulation which in turn generates *learning* (*by doing*). This is line with the analytical results of Fudenberg and Tirole (1983) on the implications of *learning by doing* on market performance as well as Gerowski *et al*. (1993) analytical findings according to which higher profitability of innovating firms reflects the building-up of firms' core competences that makes them more capable in dealing with market pressure. Similarly, the repeated use of products, machinery and inputs enables worker to accumulate experience generating *learning* (*by using*). In turn, firms showing a greater productivity (i.e. accumulation of problem-solving capabilities through experience in productive activity) as a result of the adoption of more de-verticalised labour organisational practises are likelier to introduce incremental innovation (*Hypothesis 1a*). This finding is somehow linked to the result gathered as far as the firm's R&D activity is concerned. Firms externalising R&D activity are likelier to introduce incremental innovation ($marketR\&D_i$ is statistically significant at $p \leq 0.10$ when considering both the aggregated and cumulated version of labour organisational practises). That is, the likelihood of introducing incremental innovation can rely on knowledge traded in the market rather than on knowledge internally developed (*Hypothesis 2a*). This can be explained when considering that incremental innovations rely on a *learning by doing* and *learning by using* process grounded on a problem-solving activity of production issues where the everyday workers' experience is a crucial aspect. This result emphasises the significance of workers and their problem-solving activity rather than of a structured R&D function in the generation of incremental innovation. Along the same lines, the successful

introduction of incremental innovation is associated with the reshaping of competences already present in the firms as shown by the positive statistically significance of the variable capturing the impact of techno-organisational innovations on employees training ($compres_i$ is statistically significant at $p \leq 0.05$ in the case of aggregated labour organisational practises and at $p \leq 0.01$ in the case of cumulated labour organisational practises) (*Hypothesis 2a*). Given the competence-enhancing nature of incremental innovations, employees' competences already present in the firms but, somehow, reshaped gain great significance in the likelihood of introducing this type of innovation. Surprisingly, the introduction of this type of innovation is also associated to the acquisition of competences new to the firms, although to a lesser extent as a shown by statistical significance of the coefficient ($newcomp_i$ is statistically significant at $p \leq 0.10$). Similarly, when considering both the aggregated and cumulated version of labour organisational practices, the greater involvement of unions in different techno-organisational innovations and personnel training impacts on the likelihood of introducing incremental innovation. This last result also confirms the peculiarity of the Emilian districts as far as the role of unions is concerned (Pini and Santangelo, 2005). Conversely, firms operating in resource intensive and scale intensive sectors seem to introduce incremental innovations to a lesser extent than labour intensive ones, confirming the hypothesised learning process underlying this type of innovation. The same seems to apply to firm producing directly for the output market which introduce incremental innovations to a lesser extent than firms operating as sub-contractors, reflecting the role of firms interactions in the Reggio Emilia industrial district in orienting technological trajectories. Finally, foreign firms do not seems to introduce incremental innovations.

4.2 Radical Innovation

Turning to radical innovation and drawing upon the results gathered from the Smith-Blundell test, as anticipated above, we run a simple probit model where firms' productivity and variables related to labour organisational practises (considered in both aggregated and cumulated form) were all considered exogenous independent variables. The results obtained are reported in Tables 6 and 7. In the probit model, the existence of an R&D function within the firm enhances the firm's likelihood of introducing radical innovation ($R\&D_i$ is statistically significant at $p \leq 0.05$) when considering both the aggregated and cumulated version of the variables related to labour organisational practises (*Hypothesis 2b*). Such a function enables firms to learn and generate technological advance in specific directions coherently with firms' past history of searching. Similarly, the introduction of techno-organisational innovations promoting the recruitment of employees with new competences is positively associated to the likelihood of introducing radical innovation ($newcomp_i$ is statistically significant at $p \leq 0.05$) (*Hypothesis 2b*). This is not surprising given the competence-destroying nature of the innovation type under analysis. Both these results (i.e. Smith-Blundell test and probit estimations) can be read together in the sense that the nature of this type of innovation seem to underlie a *learning by searching* process relying on a more structured R&D function and fed by employees with competences new to the firm.

The discriminating factor between the two types of innovation (i.e. incremental *versus* radical) seems to lie in the nature of the problem-solving activity at work (*Hypothesis 2a* and *2b*). As discussed above, in the case of incremental innovation, the innovative process is fed by the problem-solving activity of workers whose active participation in the firm's production issues enhances the firm's ability to survive the market. The innovative process concerning radical innovation is, instead, related to an

R&D laboratory structured within the firm, carrying out a problem-solving activity but of a different type. In this case the innovative process appears to mainly rely on a *learning by searching* process grounded on a problem-solving activity linked to an *in house* research activity and employees' competences new to the firm as a result of the new rules of the game necessary in the innovative process. Nonetheless, when considering the aggregated version of variables related to labour organisational practices (Table 6), the likelihood of introducing radical innovation is greater for firms introducing at least a workers' involvement practice (ep_i is statistically significant at $p \leq 0.05$) and encharging workers of quality control ($empqcm_i$ is statistically significant at $p \leq 0.10$). Therefore, specific organisational practises seem, somehow, to play a role. The peculiarity of the Emilian district is confirmed also in the case of radical innovation, as illustrated by the positive impact of the grater involvements of unions in different techno-organisational innovations and personnel training on the likelihood of introducing incremental innovation ($inno\_rs_i$ is statistically significant at $p \leq 0.10$). Conversely, firms' sectoral specificity seems to matter only when considering the cumulated version (Table 7). In this case, firms operating in scale intensive sectors are likelier to introduce radical innovation most likely as the results of their risk-bearing capacity to conduct in-house R&D activity and face its implications.[ix]

5. Conclusions

This paper has attempted to investigate the *internal* learning processes underlying incremental and radical innovation in terms of labour organisational practices, R&D organisational modes and the nature of employees' competences. If the distinction between these two types of innovation can be traced back to Schumpeter's work, the relationship between them and firms' internal organisation has been explored more

recently mainly in the management literature. However, current studies have missed, as far as our knowledge is concerned, to dig deeper into this relationships by investigating the learning processes underlying the introduction of the two different innovation types. In attempting to fill this gap, the paper can be framed within the evolutionary approach to technological change, which understands firms' organisation as encompassing the development of firms' successful routines making their knowledge operational. Moreover, being the spatial unit of analysis the Reggio Emilia province, the study also contributes to explore further the idea of localised knowledge in local productive systems.

The econometric exercise carried out provides empirical evidence of the heterogeneity of innovative activity as far as incremental and radical innovations are concerned. The former seems to be mainly grounded on a problem-solving activity based on *learning by doing* and *learning by using* process as illustrated by the endogeneity of employees productivity (understood as the firm's problem-solving capabilities in production issues accumulated over time) in the association between incremental innovation and de-verticalised labour organisational practises. Similarly, this kind of innovation seems to rely mainly on R&D traded in the market as well as in employees competences both reshaped and new to the firms. Being mainly an amelioration of existing products and processes, incremental innovations are hardly the results of an R&D activity internal to the firm. Rather, they draw on existing competences - given their competence-enhancing nature - and, to a lesser extent, to new competences. Conversely, in the case of radical innovation no endogeneity of employees' productivity is detected when investigating the relationship between this type of innovation and de-verticalised labour practices. The main driver of major innovations seems to be the existence of an *in-house* R&D activity, which reflects an

internal *learning by searching* process. Firms internally conducting research activity accumulate competences by trial and error grounded on their specific learning by searching path. Similarly, the competence-destroying nature of this innovation type calls for new employees competences.

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ANNEX: SAMPLE OF ANALYSIS AND METHODOLOGY

The sample of analysis refers to 166 firms drawn from a universe of 257 companies located in the Italian province of Reggio Emilia in the year 2001, listed in national[x] and local[xi] databases.

The 257 firms in the population operate in 19 manufacturing sectors as classified by the ISTAT-ATECO 91 code and are all firms with at least 50 employees. Firms were also classified according to an OECD (1994) revision of Pavitt's sectors (specialised suppliers, scale intensive, resources intensive, labour intensive and science based).[xii] However, no science-based firms are present in the dataset.

The 166 firms in the sample are those for which economic performance indicators as well as variables concerning firm characteristics are available. Economic performances indicators cover the period 1998-2001 and are based on the dataset of firm balance sheets registered in Reggio Emilia Chamber of Commerce and reclassified by the balance sheet unit of the Reggio Emilia Camera del Lavoro (trade union). The information about firms' characteristics has been gathered through a survey made up of a questionnaire addressed to the management, on four main topics: (a) firm's characteristics and employment structure; (b) organisational innovations and human resources management practices; (c) industrial relations; (d) employee evaluation and payment systems. The time span covered concerns 1998-2001. After a first phone contact, the introductory part of the questionnaires was sent by fax directly to each firm in February 2002, asking to answer the questions concerning the structural features of the firm and ascertaining the willingness to answer the whole questionnaire during a direct 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 solve problems pertaining their answers or to complete the questionnaire.

As shown in Table A.2, the firms in the sample are 64,59% of the entire population, all responding firms (the questionnaire had a reply ratio of 77,4%[xiii]) with balance sheet available. Firms' distribution by sector and size is characterised by limited bias when comparing the 166 firms with all surveyed firms. Both the textile sector and small-size firms (50 to 99 employees) are slightly under-represented.[xiv] However, no significant distortion emerges in all other sectors and dimensional employees' classes, with the number of interviewed firms approaching or reaching 100% of the total in many of them (see Tables A.3*)*[xv]. The questionnaire methodology is justified by the lack of usual statistical data at the NUTS3 level in the Italian context as far as the issues under analysis are concerned.

Going into the details of the information gathered from the questionnaire concerning radical and incremental innovation, the approach adopted in constructing the database used is a *firm level approach* in the sense that innovations are classified by the interviewed managers of the innovating firm according to the distinction made in section 2.[xvi]

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[i] See also Dore (2004).

[ii] It should be, however, borne in mind that the Japanese model experiments a deep crisis in the 1990s, as documented by, e.g., Dore (2000).

[iii] Our focus is on the technological rather than on the administrative nature of innovation. Although we are aware of documented differences in the adoption of these two types of innovation (Kimberly and Evanisko, 1981).

[iv] For a test of Arrow's *learning by doing* assumption see Sheshinski (1967).

[v] All variables considering refer to the period 1998-2001, unless differently specified.

[vi] Reggio Emilia province has shown a very high trade union density ever since the war (with the percentage of unionized workers reaching almost 45%).

[vii] Sectoral specificities were accounted for scale-intensive, specialised suppliers, resource-intensive and labour intensive sectors. The firm age was calculated as the difference between 2002 (i.e. the year where the interviews where carried out) and the establishment year. The discrimination between foreign and domestic firms was operationalised in terms of foreign participation in each of the firms in the sample. Along the lines drawn by the International Monetary Fund (1977), foreign participation was defined in terms of control or lasting interests rather than in terms of share. The total number of firms with foreign

participation in the sample is, therefore, 22, which is representative of the attractiveness of foreign investors in Reggio Emilia provinces (see Piscitello, 1999). The difference between firms operating directly in the output market and those operating as sub-contractors was captured by a binary variables (*output_market*$_i$) built on the information gather through the questionnaire.

[viii] The ivprob-STATA programme estimates the endogenous variable as a linear function of the instrumental variables and corrects the second step standard errors (Wooldridge, 2002).

[ix] Although existing empirical evidence (e.g. Mohr and Morse, 1977 and Germain, 1996) has documented the association between radical innovation and size, no statistically significant results were obtaining when controlling for firms' dimension.

[x] Intermediate Census 1996 of the National Institute of Statistics (ISTAT, 1999).

[xi] *Camera di Commercio* in Reggio Emilia (Infocamere, 2001).

[xii] The OECD revision of Pavitt's sectoral classification intends to aggregate industrial sectors according to market orientations, input characteristics, technological contents for manufacturing firms in order to link sectoral performance with labour markets. In the text, this sectoral classification has been referred to as Pavitt's classification for the sake of simplicity.

[xiii] For details on the structures of the database see Antonioli, Crudeli, *et al*. (2004).

[xiv] Although there are a few other industrial sectors showing representation biases in the database, their weight in Reggio Emilia economy is rather negligible.

[xv] In order to verify if the firms' sample, distributed by sectors and firm size, is representative, *Marbach Test* (Marbach, 1992) was performed:

$$\theta = \sqrt{\frac{N}{(N-1)n} - \frac{1}{N-1}}$$

where N is the number of universe's firms, n is the sample's firms and θ is the parameter which identifies the tolerated margin of error used to determine whether the sample is representative. Such an indicator is sensible to the universe's firms number: the smaller is N, the lesser the distance between N and n has to be in order to generate a small θ.

The analysis shows that: (a) as far as all the firms are concerned, the margin of error tolerated is $p = 0.045$, which is below the "critical value" for small sample ($p = 0.10$) usually accepted in the literature; (b) when single sectors and size groups are considered, a margin of error significantly above $p = 0.10$ is found for small firms (50-99 employees) and for the sector textiles, clothing and leather products. Other sectors or size groups are out of this range, but they cover a small number of firms in the population (see table A3).

[xvi] Like for other approaches adopted in the literature, some drawbacks have been identified for this method too. Indeed, it is claimed that a *firm level approach* contains a high degree of subjectivity and is meaningless from a macroeconomic point of view (i.e. an innovation which is radical for a firm could be an incremental for another). Nonetheless, due to the micro-economic nature of our analysis, the later drawback is by-passed. As far as the former is concerned, if the perspective of classifying the innovation surely confers subjectivity to the classification, it is also revealing of an in-depth knowledge of the innovation introduced by the interviewee.

Table 1 - Summary statistics

Dependent variable	***Obs***	***Mean***	***Std. Dev.***	***Min***	***Max***
$INNO\_RAD_i$	166	0.868	0.340	0	1
$INNO\_INCR_i$	166	0.542	0.500	0	1
Independent variable	***Obs***	***Mean***	***Std. Dev.***	***Min***	***Max***
$FATDIP_i$	166	434.209	4401.130	109.903	3240.616
jt_wp_i	166	0.880	0.327	0	1
$intro\_wp_i$	166	0.867	0.340	0	1
wop_i	166	0.681	0.468	0	1
ep_i	166	0.807	0.396	0	1
wof_i	166	0.723	0.449	0	1
$jt\_wp\_cumul_i$	166	1.861	1.293	0	6
$intro\_wp\_cumul_i$	166	2.699	1.837	0	7
wop_cumul_i	166	1.331	1.272	0	5
ep_cumul_i	166	1.494	1.094	0	4
$empsug_i$	166	0.783	0.413	0	1
$empqcm_i$	166	0.542	0.500	0	1
$empev_i$	166	0.428	0.496	0	1
$R\&D_i$	166	0.578	0.495	0	1
$marketR\&D_i$	166	0.048	0.215	0	1
$R\&Doutsourcing_i$	166	0.108	0.312	0	1
$newcomp_i$	166	0.596	0.492	0	1
$compres_i$	166	0.855	0.353	0	1
$skill_i$	166	38.975	21.881	0	92.76
$inno\_rs_i$	166	0.329	0.324	0	1
$iimn_i$	166	4223.269	19166.640	-223.022	205519.500
$foreign_i$	166	0.133	0.340	0	1
age_i	166	25.235	14.868	1	98
$output\_market_i$	166	80.771	33.136	0	100

Table 2 - Correlation matrix

	$INNO\_RAD_i$	$INNO\_INCR_i$	$FATDIP_i$	jt_wp_i	$intro\_wp_i$	wop_i	ep_i	wof_i	$jt\_wp\_cumul_i$	$intro\_wp\_cumul_i$	wop_cumul_i	ep_cumul_i	$empsug_i$	$empqcm_i$	$empev_i$	$R\&D_i$	$marketR\&D_i$	$R\&Doutsourcing_i$	$newcomp_i$	$compres_i$	$skill_i$	$inno\_rs_i$	$iimn_i$	$foreign_i$	age_i	$output\_market_i$
$INNO\_RAD_i$	1.000																								
$INNO\_INCR_i$	-0.110	1.000																							
$FATDIP_i$	-0.066	0.048	1.000																						
jt_wp_i	0.074	0.180	0.080	1.000																					
$intro\_wp_i$	-0.048	0.141	0.147	0.128	1.000																				
wop_i	0.075	0.149	0.057	0.183	0.304	1.000																			
ep_i	0.169	0.133	0.087	0.194	0.079	0.255	1.000																		
wof_i	0.115	0.079	-0.094	-0.064	-0.083	0.067	0.039	1.000																	
$jt\_wp\_cumul_i$	0.027	0.258	0.166	0.535	0.192	0.147	0.161	0.027	1.000																
$intro\_wp\_cumul_i$	0.101	0.206	0.202	0.262	0.576	0.297	0.170	-0.021	0.332	1.000															
wop_cumul_i	0.074	0.231	0.207	0.199	0.242	0.719	0.188	0.024	0.297	0.497	1.000														
ep_cumul_i	0.096	0.261	0.104	0.185	0.071	0.263	0.669	0.095	0.233	0.298	0.383	1.000													
$empsug_i$	0.010	0.015	-0.042	0.120	0.053	0.235	0.113	0.099	0.023	0.105	0.207	0.158	1.000												
$empqcm_i$	0.069	0.050	0.055	-0.055	0.211	0.019	0.072	-0.083	0.136	0.100	0.069	0.139	0.133	1.000											
$empev_i$	0.015	0.183	0.123	0.123	0.051	0.096	0.423	0.100	0.046	0.136	0.216	0.636	0.130	0.086	1.000										
$R\&D_i$	0.206	0.048	-0.063	0.134	0.006	0.200	0.108	0.098	0.098	0.139	0.204	0.130	0.054	-0.026	-0.002	1.000									
$marketR\&D_i$	0.005	0.150	-0.068	-0.090	0.005	-0.148	0.110	0.139	-0.041	-0.101	-0.103	0.027	0.050	0.037	0.147	-0.207	1.000								
$R\&Doutsourcing_i$	0.079	-0.068	-0.113	0.070	-0.035	0.073	0.072	-0.001	0.007	0.026	0.046	0.091	0.137	-0.107	0.051	0.298	0.012	1.000							
$newcomp_i$	0.222	0.205	-0.050	0.186	0.041	0.227	0.189	0.094	0.112	0.106	0.196	0.080	0.014	-0.066	0.140	0.118	0.185	0.011	1.000						
$compres_i$	0.193	0.276	-0.055	0.374	0.041	0.123	0.147	0.090	0.248	0.213	0.216	0.186	0.199	0.069	0.113	0.100	0.013	0.033	0.290	1.000					
$skill_i$	0.008	0.058	0.212	0.143	0.115	0.000	-0.029	-0.009	0.184	0.126	0.105	0.061	-0.001	0.071	0.035	-0.001	-0.057	-0.091	-0.035	-0.054	1.000				
$inno\_rs_i$	0.142	0.113	-0.053	0.091	0.142	0.072	0.057	0.048	0.061	0.273	0.126	0.017	0.084	-0.011	0.011	0.166	0.032	0.124	0.104	0.136	0.105	1.000			
$iimn_i$	-0.022	0.024	0.223	0.067	0.070	0.030	0.097	-0.025	0.219	0.223	0.239	0.149	0.059	0.116	0.055	-0.107	0.090	-0.045	0.113	0.070	0.156	0.035	1.000		
$foreign_i$	0.048	-0.033	0.196	0.090	0.100	0.192	0.101	-0.036	0.152	0.220	0.318	0.181	-0.009	0.003	0.093	0.010	-0.005	-0.079	0.177	0.060	0.034	0.097	0.317	1.000	
age_i	0.040	0.053	-0.007	0.011	0.042	0.044	0.053	-0.027	0.008	0.037	0.037	0.068	0.127	0.040	0.032	0.028	-0.076	-0.015	-0.066	-0.048	0.051	0.042	-0.033	-0.090	1.000
$output\_market_i$	0.026	-0.143	-0.021	0.029	0.011	0.074	0.091	0.075	-0.103	0.087	0.057	0.001	0.046	-0.079	-0.021	0.193	-0.021	0.102	0.146	0.039	-0.047	0.176	0.072	0.095	0.009

Table 3 - Results of the Smith-Blundell test of the exogeneity of $FATDIP_i$

Instruments		*Cumulated labour organisational practises*		*Aggregated labour organisational practises*	
Dependent varibales					
$INNO\_RAD_i$	chi2 (1)	0.427		0.003	
$INNO\_INCR_i$	chi2 (1)	10.716	***	6.039	**

*** Significant at $p < 0.01$

** Significant at $p < 0.05$

Table 4 – Results of the second stage instrumental variable procedure (dependent variable *INNO_INCR* $_i$) using as instruments

Variables	***Model 1***					***Model 2***				
	dF/dx	***Std. Err.***	***Z***		***x-bar***	***dF/dx***	***Std. Err.***	***Z***		***x-bar***
FATDIP $_{i\ (ag}$	0.001	0.006	1.820	*	434.209	0.001	0.001	1.870	*	434.209
R&D $_i$	0.120	0.120	0.990		0.578					
marketR&D	0.371	0.140	1.680	*	0.048					
R&Doutsou	0.000	0.198	0.000		0.108					
newcomp $_i$	0.188	0.118	1.570		0.596	0.262	0.119	2.130	**	0.596
compres $_i$	0.404	0.013	2.530	**	0.855	0.385	0.135	2.370	**	0.855
skill $_i$	-0.026	0.003	-0.770		38.975					
inno_rs $_i$	0.328	0.188	1.750	*	0.329	0.363	0.191	1.900	*	
iimn $_i$	-2.54e-06	3.31e-06	-0.770		4223.270					
specialised s	0.117	0.174	0.670		0.410					
scale intensi	-0.224	0.216	-1.000		0.157					
resource int	-0.270	0.187	-1.380		0.277					
foreign $_i$	-0.372	0.171	-1.830	*	0.133	-0.461	0.164	-2.040	**	0.133
age $_i$	0.003	0.004	0.780		25.235					
output_mark	-0.004	0.002	-1.910	*	80.771					
obs. P	0.542					obs. P	0.542			
pred. P	0.544	(at *x* -bar)				pred. P	0.541	(at *x* -bar)		
No of obs.	166					No of obs.	166			
Log likeliho	-94.542					Log likelihood		-97.536		
	chi2(15)	39.860	***				chi2(7)	33.870	***	
	Pseudo R2	0.174					Pseudo R2	0.148		

*** Significant at $p \leq 0.01$

** Significant at $p \leq 0.05$

* Significant at $p \leq 0.10$

Table 5 – Results of the second stage instrumental variable procedure (dependent variable *INNO_INCR* $_i$) using as instruments labour organisational practises in *cumulated* form

Variables	***Model 1***					***Model 2***				
	dF/dx	***Std. Err.***	***Z***		***x-bar***	***dF/dx***	***Std. Err.***	***Z***		***x-bar***
FATDIP $_{i\ (cumulated\ form)}$	0.001	0.001	2.140	**	434.209	0.001	0.001	2.460	**	434.209
R&D $_i$	0.122	0.125	0.970		0.578					
marketR&D $_i$	0.384	0.133	1.710	*	0.048					
R&Doutsourcing $_i$	-0.001	0.203	-0.010		0.108					
newcomp $_i$	0.193	0.123	1.550		0.596	0.222	0.118	1.850	*	0.596
compres $_i$	0.400	0.137	2.410	**	0.855	0.417	0.127	2.630	***	0.855
skill $_i$	-0.003	0.003	-0.870		38.975					
inno_rs $_i$	0.341	0.192	1.780	*	0.329					
iimn $_i$	-2.79e-06	3.30e-06	-0.840		4223.270					
specialised suppliers $_i$	0.127	0.181	0.690		0.410					
scale intensive $_i$	-0.237	0.220	-1.030		0.157	-0.339	0.156	-1.920	*	0.157
resource intensive $_i$	-0.280	0.190	-1.400		0.277	-0.376	0.136	-2.490	**	0.277
foreign $_i$	-0.390	0.168	-1.930		0.133	-0.454	0.146	-2.320	**	0.133
age $_i$	0.003	0.004	0.830		25.235					
output_market $_i$	-0.004	0.002	-1.830	*	0.067					
obs. P	0.542					obs. P	0.542			
pred. P	0.551	(at *x* -bar)				pred. P	0.545	(at *x* -bar)		
No of obs.	166					No of obs.	166			
Log likelihood	-93.071					Log likelihood		-98.573		
	chi2(15)	42.800	***				chi2(7)	31.8	***	
	Pseudo R2	0.187					Pseudo R2	0.139		

*** Significant at $p \leq 0.01$

** Significant at $p \leq 0.05$

* Significant at $p \leq 0.10$

Table 6 – Probit estimation results (dependent variable *INNO_RAD* $_i$) considering labour organisational practises in *aggregated* form

Variables	*Model 1*					*Model 2*				
	dF/dx	***Std. Err.***	***Z***		***x-bar***	***dF/dx***	***Std. Err.***	***Z***		***x-bar***
FATDIP $_i$	0.000	0.000	-0.320		434.209					
jt_wp $_i$	0.002	0.058	0.040		0.880					
intro_wp $_i$	-0.066	0.030	-1.460		0.867					
wop $_i$	-0.004	0.042	-0.080		0.681					
ep $_i$	0.164	0.102	2.100	**	0.807					
wof $_i$	0.016	0.460	0.360		0.723					
empsug $_i$	-0.351	0.371	-0.830		0.783					
empqcm $_i$	0.072	0.045	1.650	*	0.542					
empev $_i$	-0.058	0.053	-1.160		0.428					
R&D $_i$	0.072	0.048	1.640		5.783	0.123	0.054	2.380	**	0.578
marketR&D $_i$	-0.053	0.139	-0.470		0.048					
R&Doutsourcing $_i$	0.054	0.039	0.850		0.396					
newcomp $_i$	0.125	0.058	2.280	**	0.596	0.136	0.055	2.580	**	0.596
compres $_i$	0.027	0.064	0.470		0.855					
skill $_i$	0.001	0.009	1.000		38.975					
inno_rs $_i$	0.127	0.069	1.750	*	0.329					
iimn $_i$	-9.61e-07	8.79e-07	-1.080		4223.270					
specialised suppliers $_i$	0.074	0.049	1.390		0.410					
scale intensive $_i$	0.072	0.033	1.520		0.157					
resource intensive $_i$	0.006	0.054	0.110		0.277					
foreign $_i$	0.018	0.059	0.290		0.133					
age $_i$	0.001	0.002	0.680		25.235					
output_market $_i$	-0.001	0.001	-1.090		80.771					
obs. P	0.867					obs. P	0.867			
pred. P	0.938	(at *x* -bar)				pred. P	0.893	(at *x* -bar)		
No of obs.	166					No of obs.	166			
Log likelihood	-49.081					Log likelihood		-58.008		
	LR chi2(23)	31.710	*				LR chi2(2)	13.850	***	
	Pseudo R2	0.244					Pseudo R2	0.107		

*** Significant at $p \leq 0.01$

** Significant at $p \leq 0.05$

* Significant at $p \leq 0.10$

Table 7 – Probit estimation results (dependent variable *INNO_RAD* $_i$) considering labour organisational practises in *cumulated* for

Variables	*Model 1*					*Model 2*				
	dF/dx	***Std. Err.***	***Z***		***x-bar***	***dF/dx***	***Std. Err.***	***Z***		***x-bar***
FATDIP $_i$	0.000	0.000	-0.310		434.209					
jt_wp_cumu	-0.018	0.017	-1.100		1.861					
intro_wp_cu	0.010	0.015	0.670		2.699					
wop_cumul $_i$	-0.019	0.021	-0.092		1.331					
ep_cumul $_i$	0.030	0.027	1.110		1.494					
wof $_i$	0.034	0.053	0.700		0.485					
empsug $_i$	-0.042	0.039	-0.940		0.783					
empqcm $_i$	0.071	0.046	1.600		0.542					
empev $_i$	-0.057	0.062	-0.097		0.428					
R&D $_i$	0.073	0.051	1.560		0.578	0.123	0.536	2.380	**	0.578
marketR&D	-0.401	0.129	-0.360		0.720					
R&Doutsou	0.067	0.376	1.020		0.108					
newcomp $_i$	0.150	0.069	2.600	***	0.596	0.136	0.055	2.580	**	0.596
compres $_i$	0.053	0.077	0.810		0.855					
skill $_i$	0.000	0.010	0.910		38.975					
inno_rs $_i$	0.102	0.075	1.310		0.329					
iimn $_i$	-9.52e-07	-9.78e-07	-0.960		4223.270					
specialised s	0.069	0.052	1.240		0.410					
scale intensi	0.086	0.034	1.700	*	0.157					
resource int	0.048	0.047	0.890		0.277					
foreign $_i$	0.033	0.058	0.480		0.634					
age $_i$	0.001	0.002	0.840		25.235					
output_mark	-0.001	0.001	-0.970		80.771					
obs. P	0.867					obs. P	0.867			
pred. P	0.930	(at *x* -bar)				pred. P	0.893	(at *x* -bar)		
No of obs.	166					No of obs.	166			
Log likelihood						Log likelihood		-58.008		
	LR chi2(23)	28.500					LR chi2(2)	13.850	***	
	Pseudo R2	0.220					Pseudo R2	0.107		

*** Significant at $p \leq 0.01$

** Significant at $p \leq 0.05$

* Significant at $p \leq 0.10$

Table A.1 - Description of the variables

Variable	*definition*	*Source*
Dependent variables		
$INNO\_RAD_i$	equals to 1 if firm (i) has introduced a new product and/or process innovation, 0 otherwise.	Questionnaire
$INNO\_INCR_i$	equals to 1 if firm (i) has introduced ameliorations on the quality of an existing product and/or process, 0 otherwise.	Questionnaire
Endogenous variable		
$FATDIP_i$	average revenue per employee.	Authors' calculations on firms' balance sheet
Independent variables		
Variables related to labour organisational practises		
wof_i	equals 1 if firm (i) has adopted a flexible labour organisation, 0 otherwise.	Questionnaire
$empsug_i$	equals 1 if firm (i) has established channels for employees' suggestions, 0 otherwise.	Questionnaire
$empqcm_i$	equals 1 if in firm (i) workers are individually encharged of quality control, 0 otherwise.	Questionnaire
$empeval_i$	equals 1 if in firm (i) managers formally evaluate employees, 0 otherwise.	Questionnaire
Aggregated variables		
$jtwp_i$	equals 1 if firm (i) has provided training to specialised and qualified workers on at least one of the following practises: team work, interpersonal relations and communications, training for using new equipment, problem-solving methods, time management, quality, changes management ; 0 otherwise.	Questionnaire
$intro\_wp_i$	equals 1 if at least one of the following practises has been introduced by firm (i) since 1998: team work, total quality projects, job rotation, autonomy in problem-solving, structured channels for workers' suggestions on organisational topics, structured channels for workers' suggestions on quality topics, permanent education; 0 otherwise.	Questionnaire
wop_i	equals 1 if at least one of the following labour organisational practises has been adopted by firm (i): team work, quality circles, just-in-tine, job rotation, total quality management; 0 otherwise.	Questionnaire
ep_i	1 if at least one of the following involvement practices has been adopted by firm (i): meeting stimulation, meeting organisation, participation in panels, evaluation of workers' suggestions; 0 otherwise.	Questionnaire
Cumulated variables		
$jt\_wp\_cumul_i$	ranges from 0 to 6 according to the number of practises (i.e. team work, interpersonal relations and communications, training for using new equipment, problem-solving methods, time management, quality, changes management) firm (i) has provided training for to specialised and qualified workers.	Questionnaire
$intro\_wp\_cumul_i$	ranges from 0 to 7 according to the number of practises (i.e. team work, total quality projects, job rotation, autonomy in problem-solving, structured channels for workers' suggestions on organisational topics, structured channels for workers' suggestions on quality topics, permanent education) firm (i) has introduced since 1998.	Questionnaire
wop_cumul_i	ranges from 0 to 5 according to the number of labour organisational practises (i.e. team work, quality circles, just-in-tine, job rotation, total quality management) adopted by firm (i).	Questionnaire
ep_cumul_i	ranges from 0 to 4 according to the number of involvement practices (i.e. meeting stimulation, meeting organisation, participation in panels, evaluation of workers' suggestions) adopted by firm (i).	Questionnaire
Variables related to different modes of conducting R&D activity		
$R\&D_i$	equals 1 if firm (i) has an R&D function, 0 otherwise.	Questionnaire
$marketR\&D_i$	equals 1 if firm (i) has not an R&D function and externalises it, 0 otherwise.	Questionnaire
$R\&Doutsourcing_i$	equals 1 if firm (i) has an R&D function and externalises it, 0 otherwise.	Questionnaire
Variables related to the impact of new techno-organisational innovations on employees' competences		
$compres_i$	equals 1 if firm (i) has introduced techno-organisational innovations that have impacted on training, 0 otherwise.	Questionnaire
$newcomp_i$	equals 1 if firm (i) has introduced new techno-organisational innovations that have impacted on recruitment, 0 otherwise.	Questionnaire
Variable related to the firm's quality of the labour force		
$skill_i$	share of skilled labour (i.e. top managers, executive and clerks) employed in firm (i) relative to the firm's total employees.	Questionnaire
Variable related to industrial relations		
$inno\_rs_i$	ranging from 0 to 1 according to the degree of unions involvement in different techno-organisational innovations and personnel training.	Questionnaire
Variable related to the firm's intangible assets		
$iimn_i$	annual average of the net intangible capital at constant price using the year 2000 as baseline	Authors' calculations on firms' balance sheet

Table A.2 - Firms in the sample as a percentage of firms in the population

Istat Ateco91 Sectors	*Firms size: no. of employees*						*Total no. of firms in the sample*
	50-99	*100-249*	*250-499*	*500-999*	*>999*	*Total*	
Food and drink	0.00	60.00	100	100	100	71.43	*10*
Textiles. clothing and leather products	75.00	25.00	14.29	-	100	37.50	*6*
Paper and printing	75.00	-	100	-	-	85.71	*6*
Wood products	-	50.00	-	-	-	50.00	*1*
Chemical products. synthetic fibres. rubbers and plastic materials	87.50	57.14	100	-	0	72.22	*13*
Non metal minerals	44.00	64.71	80	85.71	100	60.71	*34*
Metal products. metal working equipments. mechanical machinery. office equipments. electrical devices. transport equipments	59.72	68.29	76.92	71.43	88.89	66.2	*94*
Other industries	100	-	-	-	-	100	*2*
Total	**58.97**	**63.16**	**69.7**	**81.25**	**86.67**	**64.59**	
Total no. of firms in the sample	***69***	***48***	***23***	***13***	***13***		***166***

Table A.3 – Results of the Marbach test

Istat Ateco91 Sectors	margin of error θ	Firms size: no. of employees	margin of error θ
Food and drink	0.173	50-99	0.244
Textiles, clothing and leather products	0.333	100-249	0.088
Paper and printing	0.166	250-499	0.116
Wood products	1.000	500-999	0.123
Chemical products, synthetic fibres, rubbers and plastic materials	0.15	> 999	0.104
Non metal minerals	0.108		
Metal products, metal working equipments, mechanical machinery, office equipments, electrical devices, transport equipments	0.06		
Other industries	0.00		
Total	**0.045**	**Total**	**0.045**

Note: Critical margin of error for small sample $\theta = 0.10$.