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Davide Antonioli Massimiliano Mazzanti Paolo Pini

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Abstract

This work lies within the literature that investigates the co-causation relationships between innovation activities, broadly conceived, and firm performances. It specifically focuses on SME local systems. The paper aims to provide an original contribution evaluating the role of four areas of innovation activities - training, technology, organization, ICT - that are likely to co-evolve and to be adopted in bundles by firms. In addition, following the recent stream of works in organizational innovations, we investigate the role of participative characteristics of industrial relations system as factor favouring the adoption of innovations, and indirectly enhancing productivity. We exploit rich survey data on innovation strategies merged with official balance sheets regarding firm performances, a rarity, and thus a main added value, in SME based studies.

The case study is represented by 192 manufacturing firms with at least 20 employees located in a province of Northern Italy, Reggio Emilia. The sample is highly representative of the entire population. Quantitative evidence is provided by exploiting two datasets: the first is derived from a direct survey carried out in 2005 collecting data on technological and organizational innovations, training, labour flexibility and industrial relations; the second is represented by a panel of official balance sheets data for the period 1998-2004.

The analysis is divided in two consequential main parts.

We first examine the drivers of different innovation/high performance strategies, specifically training, technological innovation, organisational innovation, ICT. Among the many factors and control variables investigated as stimulating innovations, we focus in particular on industrial relations, labour flexibility strategies, and firm's past economic trends.

Secondly, we exploit the aforementioned innovation indicators as potential drivers of firm productivity. Though the core of the analysis is based on a cross section framework the two related steps and the rich set of information allow coping with endogeneity issues.

Training activities and organizational changes show strong links with many industrial relations indicators, thus emerging as *industrial relations driven* innovations. The ICT innovation index results more influenced by firms past performances, than by industrial relations indicators, as technological innovation does.

The analysis about labour productivity drivers shows that training activities are the most relevant factors. Then, ranked consequently, technological innovation, organisational innovations and, finally, ICT also appear to impact on productivity levels. It is worth noting that the role of ICT emerges more robustly when endogeneity is specifically addressed using two stage procedures. Finally, the role of firm size seems here to be overshadowed by other drivers.

Keywords: productivity, SME, manufacturing system, technological innovation, organisational innovation, ICT, industrial relations, training

JEL: L60, M54, O33, J51, L25

♦ Department of Economics, Institutions, Territory (DEIT), and CREIC (*Research Center for Innovation and Knowledge Economy*), University of Ferrara, via Voltapaletto 11, 44100 Ferrara (Italy). Corresponding author E-mail: d.antonioli@economia.unife.it

1. Introduction

This work bridges two streams of literature, both with a particular focus on SME: the first one concerning the role of industrial relations system and labour flexibility in hindering or spurring the propensity to innovate of the firm's management; the second investigating the influence of innovation activities on labour productivity.

As far as the first stream of literature is concerned the theoretical underpinnings do not provide unambiguous insights on the role of union for the propensity to innovate (Booth, 1995; Menzes-Filho, Van Reenen, 2003; Metcalf, 2003). In a same vein the empirical evidence seems to confirm that the negative or positive union contribution to innovation seems to be driven by context specific characteristics (Menezes-Filho, Van Reenen, 2003). The specific characteristics of the industrial relations system drive the sign of union contribution to firm's innovative performance: more cooperative union/management relations are likely to be positively related to innovation. Within this framework, the present work aims at providing an original analysis on the linkages of the industrial relations system with the firm's innovative performance. Furthermore, the claim that labour contract flexibility may hinder the innovative intensity (Arulampalam, Booth, 1998; Michie, Sheean, 2003; Arvanitis, 2005) is also tested along with the hypothesis that variations in other flexibility strategies (functional, temporal, organizational and wage flexibilities) may also affect, positively or negatively, the firm innovative performance.

As far as the second objective of the present work is concerned we start from the now well rooted claim (OECD, 2005) that the innovation concept encompasses several firms activities, ranging from product and process innovation and R&D and networking activities (under the heading of technological innovation label in the present work) to ICT diffusion and to organizational and training aspects, which all contribute to sustain competitive advantages through the shaping of specific *organizational capabilities* (Nelson, Winter, 1982; Teece, 1986, 1996; Teece, Pisano, 1998; Coriat, Dosi, 2002). Grounding our understanding of innovation concept on such contributions we do not focus our attention on a single innovation category; rather the paper aims to supply an original analysis evaluating the role of four components of innovation activities that are likely to co-evolve - training, technology, organization, ICT - for the firm economic performance. The analysis specifically aims at providing insights on the nexus between innovation and labour productivity.

The basis for the empirical analysis is a unique data set of around 200 representative manufacturing firms located in a Northern Italy province, Reggio Emilia in Emilia-Romagna, that specifically focuses on industrial relations characteristics and firm's innovative behaviour. For these firms we exploit also a panel of official balance sheets data for the period 1998-2004. It is worth

noting the rarity, at our knowledge, of empirical works on SME, that can rely on the availability of official balance sheets data.

The structure of the paper is the following. Section 2 will address the theoretical and conceptual issues linking the union/management relations, firm innovative performance and economic performance. Section 3 provide a description of the data, contextually sketching a brief portrait of the Reggio Emilia local production system, along with a first hint on the applied methodology. Section 4 will provides the results of the two steps of the analysis. Section 5 concludes.

2 Literature review

Insofar as the objective of the analysis is twofold, the discussion of the theoretical background follows a similar distinction: at first, we examine a literature focused on the role of unions/industrial relations system and labour flexibility on the firm's innovation activity; secondly, we carry out a literature overview in order to make clear the utilization of our "extensive" concept of innovation activities and their role as drivers for superior economic performance.

2.1 Industrial relations, flexibility and innovation

Trade union may be an element that enhances or hinders the productivity (Hirsch, 1991; Addison, Siebert, Wagner, Wei, 2000) of a workplace as well as profitability (Addison, Schnabel, Wagner, 2001), investment in capital and in innovation activities (Booth, 1995; Menezes-Filho, Van Reenen, 2003; Metcalf, 2003; Menzes-Filho, Ulph, VanReenen, 1998; Machin, Wadhwani, 1991; Rassier, 2005).

Focusing on the latter aspect, innovation activities, the theoretical literature does not provide unambiguous insights. If some authors point out the hindering effect of union presence on management investment decision (Grout, 1984), others show some mechanisms that can reduce the underinvestment problem (Baldwin, 1983). In the particular case of investments in innovation (usually intended as investments in R&D) we have non univocal conceptual hints (Menezes-Filho, Van Reenen, 2003). Unions may exercise a direct negative effect on innovation through the attempt of blocking the introduction of new technology and/or an indirect negative effect through their rent seeking behaviour. Thus, according to Metcalf (2003) we can say that "the issue cannot be decided theoretically: any impact of unions on capital accumulation [*and innovation*] is an empirical matter" (Metcalf, 2003, p.150, *italic added*)

Despite the importance of collecting empirical evidence on this subject the works are still quite scanty at international level and, at our knowledge, they are restricted at local level for the Italian

context[1]. Following the comprehensive surveys in Menezes-Filho and Van Reenen (2003) and Metcalf (2003), to which we remind the reader for in depth information, it is possible to identify a common feature among the empirical studies on union/innovation linkages. They usually aim at disentangling the role of union presence on innovation through comparisons between unionized and non unionized sectors or firms, with less attention paid to the role of the industrial relations system[2], even though the conceptual hints highlight the importance of industrial relations regime on productivity, profitability and, more important to this work, innovation (Black, Lynch, 2001; Deery, Erwin, Iverson, 1999). If industrial relations are cooperative then we would expect more workforce commitment to the firm, a higher moral and a more stable environment: innovations not contrasted by unions may be smoothly implemented and the management may find incentives to invest in innovation. On the contrary, if the industrial relations are adversarial, unions act in a conflicting way, management ignores the union voice and there is no kind of alignment between unions and management goals; then we would expect to find a less intense innovation activity within the firm.

On the basis of the above discussion it emerges that an intriguing, but almost unexplored, question is how the industrial relations regime influences the innovative performance of a firm. The following working hypothesis can be formulated:

Hypothesis.1a (H.1a) *The more intense the non-adversarial industrial relations climate, the greater the innovation intensity of the firm, when innovation concept encompasses technological, organizational, ICT and training components.*

As far as the issue of flexibility is concerned, we stress the attention on the possibility to identify several dimensions of the flexibility concept. The usual distinction in the literature is between numerical and functional flexibilities (Kalleberg, 2001; Arvanitis, 2005). However, it is possible to recognise a more refined definition of flexibilities at firm level (Fabbri, Nosvelli, Pini, 2001). We distinguish (1) contractual flexibility (also external numerical flexibility), as an expression of the institutional arrangements on the labour markets, (2) temporal flexibility, as the possibility of using overtime and other flexible forms of the working time, (3) functional flexibility, that is "the ability of the firms to vary the amount of labour they use without resorting to the external labour market and is accomplished primarily by having a labour force that is able to carry out a wide range of tasks" (Michie, Sheehan, 2003, p.126), (4) wage flexibility, which indicates if the payment system encourage improved performance through performance related pay, (5) organizational flexibility, as

[1] For empirical evidence on the linkages between industrial relations and specific aspects of the innovation activities in local production contexts see: Mazzanti, Montresor, Pini (2007a,b); Antonioli, Mazzanti, Pini, Tortia (2004); Mazzanti, Pini, Tortia (2004; 2006); Pini, Santangelo (2005), Cristini, Leoni (2005).

[2] The shortcoming of reliable data on the quality of the industrial relations regime coupled with those about innovation activities may be a cause of such a lack of empirical works.

the capacity of the firm of modifying its production processes towards more flexible arrangements, both internal (eg. hierarchical de-layering) and external (eg. outsourcing, networking). In framing the considerations about flexibility diffusion and its impact on the workforce we rely on the so called core-periphery model (Atkinson, 1984; Cappelli, Neumark, 2004). In brief the model suggests that the types of flexibility can be combined segmenting the firm's workforce. On the one hand, the firm establishes long term relations with its 'core' workforce, the part of employees involved in firm's key activities, that are highly trained, committed to the organization and high skill endowed. Flexibility strategies addressed to this segment of the workforce may create an organizational *milieu* within which workers are more prone to implement and exploit innovations. On the other hand, firms also employ 'peripheral' workers, which have short term contracts and usually low skill levels. This type of workers are used to buffer the core workforce when firms face demand variations that cannot be managed using the functional flexibility (Kalleberg, 2001)[3]. The rate of conversion of flexible contracts into long-lasting ones may help in understanding whether the use of contractual flexibility answers to the need of selecting skills and competences of the employees, with the aim of hiring as permanent workforce those that fulfil the firm requirements, or if contractual flexibility is used as a mere device for lowering down the personnel costs and buffering the 'core' workforce.

This work aims at providing new empirical evidence on the impact of flexibilities on innovation (Arulampalam, Booth, 1998; Arvanitis, 2005; Michie, Sheehan, 2003), through the use of a more refined classification of flexibility typologies with respect to the standard decomposition in numerical and functional flexibilities. Relying on the above conceptual framework we note that the sign of the relation between contractual flexibility and innovative performance cannot be addressed theoretically, instead it needs to be disentangled empirically. Thus we set the following hypothesis:

Hypothesis.1b (H.1b) *The variations in temporal, functional, organizational and wage flexibilities are positively linked with innovation intensity, while the sign of contractual flexibility on the innovation intensity may be positive or negative according to the strategic orientation of the firm.*

[3] Some assumptions of the core-periphery model have been criticized and different theories capable of justifying the capacity of organizations in combining numerical and functional flexibilities have been put forward. For an overview see Kelleberg (2001).

2.2 Innovation Activities and Economic Performance

The present work adopts a multifaceted concept of innovation, encompassing technological innovation[4], organizational innovation, ICT adoption and training policy. The importance of taking a broad perspective on innovation has also been spurred by the now well rooted concept of knowledge based economy (Foss, 2005), which is an "expression coined to describe trends in advanced economies towards greater dependence on knowledge, information and high skill levels and the increasing need for ready access to all of these by business and public institutions" (OECD, 2005). The diffusion of knowledge intensive technologies of production as well as knowledge intensive organizational practices shifted the attention of a wide part of economists on the importance of the ways knowledge is managed within the firms (Kremp, Mairesse, 2004; Hall, Mairesse, 2006). The firms themselves can be considered as *knowledge/learning organizations* (Nielsen, Lundvall, 2003; Lundvall, 2006) capable of generating and spreading knowledge (Nonaka, Toyama, Nagata, 2000) inside and outside their boundaries.

The conceptual background that justifies the adoption of our integrated view on the innovation activities stems from contributions that can be put under the heading of *knowledge based perspective of the firm* (Foss, 2005).

Focusing the attention on a specialized literature (Teece, 1986, 1996; Teece, Pisano, 1998; Coriat, Dosi, 2002; Chandler, 1992) that identifies in the (*dynamic*) *organizational capabilities* co-evolving assets and activities to the technological innovations we can understand the importance of "new organizational practices". Following Teece and Pisano (1998) we assume that "the term 'capabilities' emphasizes the key role of strategic management in appropriately adapting, integrating and re-configuring internal and external organizational skills, resources and functional competences towards changing environment" (Teece, Pisano, 1998, p.194). In a knowledge based economy, the management, in order to cope with knowledge intensive productions, ought to develop and accumulate capabilities that shape the organizational forms in a way that relies on "cross-functional processes, extensive delayering and empowerment" (Foss, 2005, p.12). This mechanism contributes to determine the absorptive capacity of the firm towards specific technologies and, in so doing, it also shape the technological trajectories along which the firm moves. Thus, "*new*" *organizational practices* (EC, 2002), which require/imply a more skilled workforce, the flattening of the hierarchical structure, delegation of responsibility, some degree of decisional decentralization and autonomy in managing the job tasks, coupled with t*echnological innovations* contribute to sustain firm's competitive advantages (Black, Lynch, 2001; Janod, Saint

[4] For technological innovation we mean product and process innovation, both radical and incremental, as well as R&D activities and collaborative relations with other firms in undertaking research activities.

Martin, 2004; Huselid, 1995; Huselid, Becker, 1996; Hall, Mairesse, 1995; Griffith, Huergo, Mairesse, Peters, 2006).

The human capital of the employees becomes a fundamental resource since "innovating organization benefits from a strong skill-base" (Leiponen, 2005, p.304) capable of sustaining and directing the organization's absorptive capacity. It becomes clear the importance of *training activities* (Zwick, 2005; Conti, 2005) that help in generating and accumulating skills and competences complementary to technological innovations: "only" in this way the latter are fully exploited, generate quasi-rents and positively influence the workforce productivity. Put it another way the mere introduction of technological innovations may be not conducive to better performances (productivity paradox) if it is not supported by adequate organizational practices (Laursen, Foss, 2003; Michie, Sheehan, 2003; Pini, Santangelo, 2005), when the latter have to be understood also as adequate human resource management practices (Brynjolfsson, Yang, 1996; Arnal, Ok, Torres, 2001).

Beside organizational transformations and the importance of human capital, obviously related with training activities, "virtually all discussions of the knowledge economy invoke recent *information and communication technologies* (ICT) as a main driver and primary characteristic of the knowledge economy" (Foss, 2005, p.6). The relevance of ICT diffusion relies on the following arguments: they increase productivity (Hempell, 2005; Brynjolfsson, Yang, 1996; Bresnahan, Brynjolfsson, Hitt, 2002), they facilitate the exchange of information between and inside firms, they contribute to flattening the hierarchical structure, they help the networking activities between firms and they contribute to the downsizing of the firms, facilitating outsourcing activities (Foss 2005). The wide based potential impact of the ICT adoption on several aspects of the firm structure "necessarily" implies a good integration with other innovation activities in order to positively influence the firm economic performance.

Relying on the outlined conceptual framework it is possible to recognize a process of co-evolution as the underlying mechanism of interaction between innovation aspects. We may argue that the latter in a reciprocal "feeding" process create the conditions for generating and sustaining competitive advantages (Chandler, 1992; Teece, 1996) and superior economic performances (Pini 2005).

Drawing from the above conceptual framework we set out the following general hypothesis to be tested:

Hypothesis.2 (H.2) *The innovation activities are linked with labour productivity and the interactions between the areas of innovation show the existence of complementarities on the labour productivity.*

3 Empirical Framework and Methodology

The local production system of Reggio Emilia, a Northern Italy province located in Emilia Romagna, is the geographical location of the manufacturing firms analyzed in the present work. The connective texture of the Reggio Emilia "local industrial system" (Seravalli, 2001) is characterized by a predominant presence of small and medium enterprises (SME). A relevant characteristic of the Reggio Emilia manufacturing system, which linked to the prevalence of SME, is the existence of two districts: the first regarding non-electrical machinery and equipments - machinery for mechanical energy and agriculture in particular; the second concerning non metallic mineral products - ceramic tales in particular (Brusco, 1982; Brusco, Cainelli, Forni, Franchi, Malusardi, Righetti, 1997). Given the firm distribution by sectors and size (Tab.A.1), we can easily infer that about a half of the surveyed firms operate in a district-like environment, usually constituted by networks of SME. Because of the features just described the Reggio Emilia industrial system may be considered as a paradigmatic version of the so called "*emilian model*" (Amin, 1999; Brusco, 1982), in which coexist a well marked entrepreneurship spirit and an equally strong, deep-rooted unionism next to a productive apparatus characterized by the presence of a district-like industrial system[5].

The Reggio Emilia industrial system is analysed on the basis of two different datasets.

The first source of data is a firm level survey conducted on the manufacturing firms located in Reggio Emilia[6]. The criteria we decided to use for the identification of the population of 634 firms are the following: a) firms with at least 20 employees[7]; b) firms belonging to manufacturing sectors according to the ISTAT ATECO 2002[8] classification. The information on the year 2004 were provided by union representatives, through face-to-face interviews. On the basis of a representative sample (250 firms) of the 376 firms with union delegates the interviews lead to 192 respondents, which constitutes the 51% of the 376 firms having union representatives (RSU). The survey provide a unique source of information about firm's structural characteristics, workforce composition, innovation activities, working conditions and industrial relations features.

[5] We especially refer to the role of CGIL, the left wing union. For an overview of the union history and the linkages with political party we remind the interested reader to Baglioni (1998).

[6] Several official sources were used to construct the firms population: Reggio Emilia Chamber of Commerce, Istat Census, Aida data bank, Impero data bank, balance sheets data bank of the Reggio Emilia Camera del Lavoro Territoriale. Due to homogeneity reasons and information availability the population is referred to the year 2001.

[7] Five size classes in terms of employees have been constructed: 20-49 (A), 50-99 (B), 100-249 (C), 250-499 (D), more than 499 (E).

[8] The sectors are: food (DA), textile (DB-DC), wood (DD-DE), chemical (DF-DG-DH), non-metallic minerals (DI), machineries (DJ-DM), other industries (DN).

The second source of information is represented by official balance sheets data for the period 1998-2004[9]. For the year on which information are collected by the survey (2004) 171 balance sheets are available out of the 192 interviewed firms, while for the years before the survey (1998-2003) 156 balance sheets are available out of the 192 interviewed firms.

Table A.1 shows the distribution, with respect to the 376 firms with union representatives, of the sample with 192 interviewed firms in terms of size and sector. Some minor distortions emerge: the only evident bias in terms of different percentage distribution of the sample interviewed with respect to the population with union representatives concerns the size 20-49 employees and the machineries sector, which are under represented. The same weak distortions are shown by the two other samples of firms with interviews and balance sheets: 171 and 156 firms. A version of the Cochran Test (Tab.A.1) for sample distortions shows acceptable results[10].

As anticipated above the analysis is conducted along two main lines. The first one aims at providing insights on the role of industrial relations system and flexibility on the innovation intensity of the firm. The second one provides evidence on the relationship between innovation activities and labour productivity in a multivariate cross-sectional framework.

Starting from the first line of analysis, we stress the appropriateness of the firm level choice of investigation (Menezes-Filho, Van Reenen, 2003). Instead of focusing the attention at industry level as many international study does, in the attempt of disentangling the role of unions on innovation, we rely on firm level data given the two layers bargaining structure among the social partners in the Italian context: a national wide level and a firm level. At this latter level the union recognition and, when exist, cooperative relationships between management and union usually spur an "intense" bargain over wages, work organization, training and other items concerning the content of the job (Antonioli, Pini, 2004; Brusco, 1982; Cella, Treu, 1998).

The econometric exercise has the following innovation indexes as dependent variables (Tab.1): **INNO_TECH** for technological innovation, **INNO_TRAIN** for training activities, **INNO_ORG** for organizational innovation and **INNO_ICT** for information and communication technologies. The four indexes are able to capture a great part of the multifaceted phenomenon of innovation at firm level.

[9] Information on balance sheets data are mainly based on the firm balance sheets registered in Reggio Emilia Chamber of Commerce and reclassified by the balance sheet unit of the Reggio Emilia Camera del Lavoro Territoriale.
[10] For details about the data see Antonioli, Delsoldato, Mazzanti, Pini (2007).

TAB.1 – Dependent variables in the first line of analysis (192 observations)

Variables	Definitions	Min	Max	Mean
	Dependents in equation (1)			
Synthetic index of technological innovation (INNO_TECH)	Synthesises the information on technological innovation in terms of both input and output components	0	1	0.39
Synthetic index of organizational innovation (INNO_ORG)	Synthesises the information on organizational innovation: organizational practices in production activities; organizational practices in working activities; individual and collective rewards; in-sourcing and out-sourcing; relations with clients and/or suppliers	0.05	0.62	0.24
Synthetic index of training innovation activities (INNO_TRAIN)	Synthesises the information on training activities: % of employees involved in training activities; modalities of training; target competences of the training activities; advantages for trained employees	0	0.97	0.31
Synthetic index of ICT innovation (INNO_ICT)	Synthesises the information on the adoption of information and communication technologies: ICT adoption for communication, production and the management of systems	0.08	1	0.64

Note: For a detailed description of the contents of each variable constituting the innovation indexes see Tab.A2 in Appendix.

The second line of analysis has always captured a great interest among researchers. However, empirical works adopting an integrated analysis as the one here proposed are scanty at our knowledge (Mazzanti, Pini, Tortia, 2006; Leoni, 2007; Pini, 2004). In the econometric analysis the value added per capita (**VA/EMP**) is our dependent variable (Tab.2)[11].

TAB.2- Dependent variables in the second line of analysis (192 observations)

Variables	Definitions	Min	Max	Mean
	Dependent in equation (2)			
Labour Productivity 2004 (VA/EMP2004)	Continue variable. Ratio between Value Added and Employment in 2004 (€.000)	2.81	126.95	48.49

The two analysis aim at identifying the following "chain" of relationship: industrial relations system/flexibility → innovation drivers → labour productivity. The hypothesis on the influencing factors of innovation and productivity can be synthesized as reported in Tab.3

TAB.3- Hypothesized signs of influencing variables on the innovation and productivity indexes

Influencing factors	Innovation indexes	Labour productivity
Firm structural variables	(+,-)	(+,-)
Union density	(+,-)	/
(Good quality) Industrial relations	(+)	/
Flexibilities	(+,-)	/
Past economic performances	(+,-)	/
Technological innovation	/	(+)
Organizational innovation	/	(+)
Training	/	(+)
ICT	/	(+)

[11] The simple correlation between VA/EMP and REV/EMP is 0.41.

A general specification of the econometric models we are going to estimate has the following form, which will be taken into consideration in more details in the next sections:

(1) Dependent Variable $= \beta_{0i} + \beta_{1i}$[firm structural variables] + β_{2i}[vectors of questionnaire covariates] + $\beta_{3,i}$[vectors of balance sheets covariates] + ε_i

where β is a vector of coefficients, the dependent variable and the questionnaire covariates have to be intended for the year 2004, *i* identifies each firm. For balance sheets covariates we have information both for the year of the survey collection, 2004, and for antecedent years, 1998-2003.

The information can be aggregated in several variables sets (Tab.A.3): structural variables; industrial relations variables; flexibility variables; innovation variables and variables drawn form balance sheets.

The estimations are conducted through OLS in a cross section environment. Although the OLS estimates may be biased due to endogeneity, mainly caused by the presence of unobserved heterogeneity and simultaneity between covariates and the dependent variable, it is possible to argue that our OLS models do not loose interpretative capacity of the phenomena analyzed. In fact, the high number of firm structural variables that can be used as controls in the regressions helps in capturing a great part of firm specific heterogeneity (Huselid, Becker, 1996). Furthermore, in order to cope with simultaneity problem, in the second line of analysis, we conduce endogeneity tests, and, in accordance to the results of such tests, we implement a two stages estimation procedure.

4 Econometric Analysis

4.1 Industrial Relations System and Firm's Innovative Performance

In this section we show briefly the procedure adopted for the estimation along the first line of analysis and the results obtained.

The estimated functions aim to capture the associations among innovation intensity indexes, for the four type of innovation activities, on the one hand, and industrial relations and labour flexibility variables, on the other hand.

The regression function is the following:

(2) INNO $= \beta_{0i} + \beta_{1i}$[structural variables] $+ \beta_{2i}$[union density and industrial relations] $+ \beta_{3i}$[flexibilities] $+ \beta_{4i}$[past economic performances$_{1998\text{-}2003}$] $+ \varepsilon_i$

where INNO stands for, in turn, each specific innovation index: INNO_TECH, INNO_ORG, INNO_TRAIN, INNO_ICT.

Among the covariates we have the firm specific **structural variables**. They are used in order to isolate the "real" effect of the explicative variables in a multivariate context, partially addressing the problems of heterogeneity and omitted variables.

The second set of variables includes the **industrial relations** characteristics, which, in their multiplicity, capture both formal (eg. *Bilaterl Techical Commisions*[12]) and informal (eg. intensity of the interaction between union representatives and management on several issues) cooperative aspects of the union/management relations.

The third set of explicative variables encloses several types of labour organizational **flexibility**. It ranges from labour contract flexibility, which is a form of numerical flexibility external to the firm, to temporal, wage, functional and organizational flexibilities, which are used to capture several sub-dimensions of the internal firm flexibility. Indeed the several sub-dimensions of the internal flexibilities may be associated to the willingness of creating an organizational *milieu* within which workers are more prone to accept, implement and exploit innovations. Thus we would expect a positive sign associated to the internal flexibility variables. Within this cluster of variables we also have the rate of conversion of flexible labour contracts in long-lasting ones. Such an index can be used to verify the appropriateness of the core-periphery model hypothesis[13].

Finally, the last group of variables is given by **past performance indicators** of productivity, profitability and labour costs. These variables inform us whether the firms with higher performances in the past (1998-2003) are the more innovative in the present (2004) or whether, on the contrary, the firms with bad performances in the past are the more innovative in the present. The utilization of performance variables prior to the period of innovation helps us in reducing problems of simultaneity (Michie, Sheehan, 2003).

[12] The role of the *Bilateral Technical Commissions* (BTC) is that of creating a *milieu* of consultation between the social parties, typically management and union representatives. Furthermore, nothing impedes the two parties in subscribing formal agreement on non controversial issues emerged in the BTC activity. In so doing, the BTC may (sometimes) turn from consultation instrument to negotiation device (Cella, Treu, 1998).

[13] The two segments of the workforce may not be sharply distinct and the periphery may not be used to buffer the core, instead the periphery can be thought to be linked to the core when firms use numerical flexibility in the hiring process "to recruit, screen and try out workers for permanent positions" (Kalleberg, 2001, p.488).

Two specifications are used for each dependent variable[14]. Specification (1) "isolates" the contribution of the *union density* in order to "align" the results to those of the empirical international literature on the role of union on innovation. The second specification (2) adds the *industrial relations* variables we have at our disposal in order to account for the role of the industrial relations climate on the innovative intensity instead of relying only on the union density[15].

As a first evidence we note that almost all of the structural variables do not contribute to the innovation intensity. However, it is worth stressing the attention on the results concerning the role of firm size (Cohen, Levin, 1989; Bhattacharya, Bloch, 2004; Rogers, 2004), captured by a dummy variable that identifies the firm having from 20 to 99 employees. We could have expected both a significant negative and a significant positive sign associated to such dummy according to two Schumpeterian interpretations of the size/innovation relationship: *creative destruction* (Schumpeter Mark I) and *creative accumulation* (Schumpeter Mark II) processes respectively (Breschi, Malerba, Orsenigo, 2000). Indeed, we do find that size is not significant when we control for a wide set of explanatory variables. Our result is in line with the evidence provided by Cohen and Levin (1989), whose comprehensive survey, carried on almost twenty years ago, on empirical works pointed out the fragility of the results, ascribing it to a wrong perspective: it is not the firm size *per se* that influence the innovation propensity, rather is the market structure in which the firms operate. In our case when the industrial relations variables are added to the specification the size dummy loses its negative significance. For SME based industrial context analyzed it might be the case that are collaborative relationship between the firms (eg, client/supplier relationship) to influence the innovation intensity, quite irrespectively of the firm size (Malerba, 2007).

Analyzing now the industrial relations variables we can see a first clear result comparing specifications (1) and (2) for each dependent variable. In the specification (1) UNION_DENS shows a negative relation with both INNO_TECH and INNO_ICT suggesting a harmful impact of the union on these two kinds of innovation. Such a results is in line with part of the empirical literature (Hirsch, 1991; Menezes Filho, Ulph, Van Reenen, 1998; Blundell, Griffith, Van Reenen, 1999). When industrial relations variables, that identify cooperative, formal and informal aspects of the union/management relations, are added in the estimated models the UNION_DENS becomes not significant as shown in INNO_TECH (2) and INNO_ICT (2) specifications. The weight of union density is overshadowed by the specific characteristics of the industrial relations system: INTERAC_FLEX and BTC presence.

[14] For brevity we discuss only the most relevant results.

[15] We are not able to compare unionized and not-unionized firms because our starting population is composed by firms having union representatives. For this reason our results on the union density variable only tell us how the intensity of unionization relates to the innovation intensity of the firm.

Moreover, it turns out that INNO_ORG and INNO_TRAIN are the most affected dependent variables by the quality of the industrial relations regime, while they do not show any linkage with the unionization variable. The variables INTERAC_ISSUES, INTERAC_FLEX and INDREL_EVAL are all positively linked with INNO_ORG. The negative sign associated to INDREL_TREND[16] may be due to contingent situations. INNO_TRAIN also shows robust and positive associations with industrial relations variables that synthesize the good quality and the co-operative aspects of union/management relation. Moreover, INNO_TRAIN is positively associated to FL_BARG: it is not a surprising result given that training is an issue frequently bargained at firm level. Overall organizational changes and training activities seem to be "*industrial relations driven*" innovative activities, while technological and ICT innovations are probably driven by managerial strategies without (or with few) interactions with union representatives.

Also the third group of explanatory variables, flexibilities, influences more INNO_ORG and INNO_TRAIN than INNO_TECH and INNO_ICT. In particular, the organizational changes are positively linked with WAGE_FLEX, FUNC_FLEX and TEMP_FLEX. Arguably INNO_ORG is linked with several types of flexibility through a feed back process: changes in the organization of labour and production contribute to generate functional flexibility and the latter in turn spurs further changes in organization. As explained in section one we could have expected a negative or a positive sign associated to labour contract flexibility (external numerical flexibility) but it is not significant for any of the dependent variable. However, CONV_LCF is positively associated with training activities, challenging the usual core-periphery model approach in explaining the combined existence of core and peripheral workers (Kalleberg, 2001). We can hypothesize that management adopts a personnel selection strategy using flexible contracts, instead of using them as device to create a *peripheral workforce*. If the employees fulfill the "basic" skills requirements the flexible contracts are converted in long-lasting ones and training programs are implemented to widen the skills and competences of the workforce permanently hired. Furthermore, the positive sign of WAGE_FLEX on INNO_TRAIN may be explained by the fact that flexible wages, related to performance indicators, can provide incentives to the employees in acquiring more human capital, increasing their productivity and gaining higher wages.

Finally, three results are worth commenting about past performances as explanatory variables. INNO_TECH is positively influenced by past productivity (per capita) and negatively by the labour cost (per capita). The combination of the two results seems to suggest that better performing firms, in terms of economic outcomes, are likely to be more intensively innovative. Because INNO_TRAIN is also positively associated with past labour cost per capita we may infer that firms

[16] The trend of the industrial relations is measured on the period 2003-2004 (three points scale: worse, unchanged, better).

with high labour cost try to increment the human capital of their employees in order to increase their productivity, augmenting the positive gap between productivity and labour cost. About INNO_ICT we can say in line with the explanation for INNO_TECH that the past high productivity may free resources to invest in the adoption of new information and communication technologies.

In conclusion, the results partially support **H.1a** given that cooperative and participative-like industrial relations are linked to organizational and training innovations, but they are less significant for technological and ICT innovations. At the same time **H.1b** is supported as well because flexibility strategies conducive to a functionally flexible workplace environment are positively related to innovation activities, while labour contract flexibility does not show any significant linkage. Furthermore, the positive relation between the rate of conversion of flexible contracts in long-lasting ones and training activities seems to support the claim of the human capital theory stating that stable and long-lasting employment relations provide incentives to both management and employees to invest in training.

TAB.4 – Innovation function OLS results ^

Dependent Variable	*INNO TECH*		*INNO ORG*		*INNO TRAIN*		*INNO ICT*	
Specification	*(1)*	*(2)*	*(1) Ω*	*(2) Ω*	*(1) Ω*	*(2)*	*(1)*	*(2) Ω*
Cons.					*(-)	***(-)	**	*
Sructural Variables								
Sector Dummies #	Textile; Wood **(-)			Wood *(-)	Wood *(-)	Non metallic mineral **(-)	Wood * (-)	
Firm Typology Dummies ϕ					Cooperative firm **	Cooperative firm *		
WC/BC			*	*				
SRB	**	**			*			
DELOC					*			
TURN_ABR					*	**		
CP_STR						**(-)		
TQ_STR	**	*						*
VA_STR	*	*	*					
BR_STR							*	
Size Dummy (20-99 emp.)	**(-)		**(-)		*(-)		**(-)	
Industrial Relations								
UNION_DENS	**(-)						*(-)	
INTERAC_FLEX	/	***	/	***	/	***	/	**
FL_BARG	/		/		/	*	/	
INTERAC_ISSUES	/		/	**	/		/	
BTC	/	**	/		/		/	
INDREL_EVAL	/		/	**	/	*	/	
INDREL_TREND	/		/	***(-)	/		/	

TAB.4 – Continue

Flexibility								
LCF								
TEMP_FLEX			**	*			**	
WAGE_FLEX				*	**	*		
FUNC_FLEX			**	**				
ORG_FLEX								
CONV_LCF	**				***	***		
Past Performance Variables								
Average Profitability in 1998-2003 §			**					
Average per capita Productivity in 1998-2003 §	***	***					*	**
Average per capita Labour Cost in 1998-2003	**(-)	*(-)			**	**		
Breusch-Pagan Test (Chi2; dof.1)	prob. 0.55	prob. 0.89	prob. 0.02	prob. 0.01	prob. 0.04	prob. 0.89	prob. 0.27	prob. 0.04
AdjR^2 (o R^2 for robust to heteroshedasticity estimates)	0.385	0.851	0.401	0.52	0.43	0.478	0.196	0.387
Prob. F-test	0	0	0	0	0	0	0	0
N	156	156	156	156	156	156	156	156

Notes: ^ only the level of significance of the coefficients and their signs, when negative, are reported (10% *, 5%**, 1%***); the coefficients are not reported for brevity but full results are available upon request; empty cells mean that the variable is not significant at least at 10%; / stands for variables not included in the estimation; # only significant sectors are reported; ϕ Private firm and Industrial group dummies are dropped due to a high Variance Inflation Factor, which is an index of multicollinearity; Ω indicates robust to heteroskedasticity estimates in accordance with the rejection of the null in the Breusch-Pagan test; § the profitability variable used in all the specifications is ROE, because the use of ROS or ROI does not change the fit of the regression and variables significance; the productivity variables used are M_VA/EMP98-03 for INNO_TECH and M_TURN/EMP98-03 for all the other innovation indexes in accordance with the contribution they give to the regression fit (they are not used simultaneously because of their high correlation).

4.2 Innovation Activities and Labour Productivity

The details of the procedure adopted in the second line of analysis are here reported along with the results stemming from the estimation of the following function (Tab.5):

(3) $VA/EMP_{2004} = \beta_{0i} + \beta_{1i}$[structural variables] + β_{2i}[technological innovation] + β_{3i}[organizational innovation] + β_{4i}[training] + β_{5i}[ICT][17] + ε_i

where both the dependent and the covariates refer to 2004. The suffix *i* stands for the unit of analysis: the firm.

The procedure can be conceptually decomposed in two steps. The first is a standard OLS estimation and the second is related with the validation strategies that can be adopted in a cross

[17] In some specific regressions we add as covariate the labour cost per capita measure on the period 1998-2003, which shows to be highly significant with a positive sign. For more extensive discussion on this point which is not core to the present paper see Antonioli et al. (2007, ch.11).

section environment in order to verify the robustness of OLS results. As a consequence, two stage procedures are eventually adopted in case the exogeneity hypothesis is rejected for some main productivity drivers.

The analysis intends at first to present the associations between productivity and specific innovation areas[18] (Tab.5). The variables belonging to the four innovation areas (see below) are (separately) used according to the correlation level observed in the full correlation matrix (not reported). The main innovation variables emerging from this stage are then used simultaneously in a final regression which includes all four innovation strategies as drivers. Furthermore, we use *ad hoc* interactions among innovation variables in order to verify the importance of integrated policies of innovation (eg. joint adoption of product and process innovations, interaction between INNO_ICT and INNO_ORG, etc…).

The sets of explicative variables are five. Firm specific **structural variables**, which encompasses the same variables used in the preceding line of analysis[19], and the four sets of innovation variables according to the four areas of innovation activities identified in this work[20]: the **technological innovation** set, which comprises both innovation input and output; the **organizational variables** that can be distinguished in innovation and changes concerning production and labour organization, in/out sourcing strategy, reward mechanisms for employees and relations with supplier and clients; the **training** components, as number of both employees involved and of training activities, the competences on which the training programs are addressed and the advantages for trained employees; the **ICT innovation** variables that capture the diffusion of information and communication technologies.

The results of the econometric exercise are reported in Tab.5[21].

A first comment applicable to all the specifications concerns the structural variables. They are almost always not significant, with only WC/BC showing an impact, thus suggesting the existence of an expected relation between the skill level of the workforce and the labour productivity. We recall that some structural variables are indeed significant in the innovation functions, emerging as indirect drivers of productivity.

Examining technological innovation effects, we find that the synthetic index INNO_TECH is positively related to productivity, as the two comprehensive indexes of input and output of

[18] The structural variables are kept in the final specification as long as they are significant at least at 20%. Basic controls, sector and dimensional dummies, are always kept.
[19] Small differences can be recognized: the dimensional dummies here used are five (20-49, 50-99, 100-249, 250-499, >499), while the firm typology dummies are two (cooperative firm/group, industrial firm/group).
[20] For each area of innovation a general index, which capture the whole innovation phenomenon, is used along with specific variables listed in Tab.A.3.
[21] For brevity we discuss only the most relevant results.

innovation are. The other specific proxies, both for input and output sides of innovation, are less relevant in our regression[22].

The role of training, instead, robustly emerges as relevant, in particular when expressed by COV_TRAIN, which always increases the fit of the regression in terms of R^2. When COV_TRAIN is jointly included in regression with technological innovation variables the significance of the latter decreases, and is lost for some. As a general comment we note that both technological innovation and training activities are robustly linked with productivity (Tab.5 columns 1-4 for training and columns 5-9 for technology). COMP_TRAIN, beside COV_TRAIN, also has positive relations with the productivity variable: the development of specific competences matter in explaining labour productivity.

As far as organizational changes are concerned only INNO_ORG and REW are significant (Tab.5 columns 10-12). REW is robust as much as the training variables, suggesting the importance of providing monetary incentives to the employees in order to obtain gains in productivity. The remaining organizational variables do not emerge as significant in our regressions, when not coupled with other innovation drivers. This may be interpreted as a signal of the complementary and coevolving nature of organizational innovation and other forms of innovation, especially technological innovation. Anticipating a result discussed below the multiplicative interaction between these two types of innovation, using the overall indexes, is robustly linked with productivity (Tab.5 column 17). The significance of the synthetic index INNO_ORG may also be consistent with the hypothesis, sustained by several empirical studies (Osterman, 2000; Ichniowksi, Prennushi, Shaw, 2001; Black, Lynch, 2001 to quote a few) that is not the adoption of one or few organizational changes to impact on productivity, instead is a joint adoption of several "new" organizational practices to influence the productivity.

Finally, despite some recent evidence (Brynjolfsson, Hitt, 2000; Hempell, 2005) the ICT innovation variables are not significant (Tab.5 column 13) nor when considered in isolation neither when interacted each other.

Overall regressions have been also conducted including innovation *drivers* belonging to all the four areas of innovation (Tab.5 columns 14-15). The results emerging from these two are in line with those of the above regressions obtained including the innovation variables of each area at a time.

[22] Only process and incremental innovations are relevant where training is not included.

TAB.5 – Productivity and innovation : results ^

Dependent Variable VA/EMP												
Specification	1	2	3	4	5	6	7	8	9	10	11	12
Cons.						***						
Structural Variables												
Size Dummies						Not significant						
Sector Dummies (6)	Chemical* (-)		Non-metallic minerals*; Chemical*(-)			Chemical*(-)					Non-metallic minerals *	
Firm Typology Dummy: Cooperative Firm/Group		*	*	***	**	*		**	**	*		*
Brand Strategy (7)	*	*	*	*	*	*	*	*	*	*		**
WC/BC	*	***	*	**	**	**	**	***	***	**	**	**
Training												
	INNO_TRAIN *** (1)	COV_TRAIN ***	COMP_TRAIN ***	INF*ORG; TEC*EC ***(2)	/	COV_TRAIN *** (3)	/	/	/	/	COV_TRAIN ***	/
Technological Innovation												
	/	/	/	/	INNO_TECH **	INNO_TECH *	INNO_INPUT **	INNO-OUT **	PROC** (4)	/	/	/
Organizational Innovation												
	/	/	/	/	/	/	/	/	/	INNO_ORG * (5)	REW ***	INS* (-)
ICT												
INNO_ICT (predicted values)	/	/	/	/	/	/	/	/	/	/	/	/
ICT_PROD(ICT_PROD*ICT_COMM)	/	/	/	/	/	/	/	/	/	/	/	/
Innovation Interactions												
INNO_TECH * INNO_ORG	/	/	/	/	/	/	/	/	/	/	/	/
INNO_TECH * INNO_ICT	/	/	/	/	/	/	/	/	/	/	/	/
F test (prob)	0.0001	0.0002	0	0	0.0011	0.0002	0.0033	0.0019	0.0027	0.0059	0.0001	0.0058
Adj-R^2	0.135	0.123	0.156	0.158	0.102	0.134	0.087	0.095	0.09	0.079	0.144	0.083
N	171	171	171	171	171	171	171	171	171	171	171	171

CONTINUE – TAB.5 - Productivity and innovation : results ^

Dependent Variable VA/EMP							
Specification	13	14	15	16	17	18	19
Cons.				***			
Structural Variables							
Size Dummies				Not significant			
Sector Dummies (6)		Chemical ** (-)	Non-metallic minerals*	Chemical* (-)		Non-metallic minerals*	Non-metallic minerals*; Chemical * (-)
Firm Typology Dummy: Cooperative Firm/Group	*	*		*	*		
BR_STR (7)	*						
WC/BC	***	**	**	**	**	**	**
Training							
	/	COV_TRAIN ***	COV_TRAIN ***	COV_TRAIN ***	COV_TRAIN ***	/	COV_TRAIN ***
Technological Innovation							
	/	INNO_TECH **	INNO_TECH	/	/	/	/
Organizational Innovation							
	/	INNO_ORG *	REW**	/	/	/	/
ICT							
INNO_ICT (predicted values)	/	/	/	/	/	**	*
ICT_PROD (ICT_PROD*ICT_COMM)				/	/	/	/
Innovation Interactions							
INNO_TECH * INNO_ORG	/	/	/	/	**	/	/
INNO_TECH * INNO_ICT	/	/	/	*	/	/	/
F test (prob)	0.0073	0.0009	0.0002	0.0002	0.0001	0.058	0.12
Adj-R^2	0.075	0.126	0.143	0.132	0.138	0.075	0.003
N	171	171	171	171	171	171	171

Notes: ^ only the level of significance of the coefficients and their signs, when negative, are reported (10% *, 5%**, 1%***); the coefficients are not reported for brevity, but full results are available upon request; an empty cell means that the variable is not significant at least at 10%; innovation drivers are reported in the cells with their acronyms to keep a manageable size of the table; / stands for variables not included in the estimation.

(1) the same level of significance is obtained using MOD_TRAIN and ADV_TRAIN; (2) interactions between informatics competences and organizational-relational ones (INF*ORG) and between techno-specialist competences and juridical-economics ones (TEC*EC); (3) COV_TRAIN is used because among training variables is the less correlated with technological variables; (4) if we utilize interactions among product-process, process-radical, process-incremental (that is process innovations are correlated to productivity) we note similar regression fit and technological variable significance; (5) when training variables are used in this specification the significance of INNO_ORG falls to 20%; (6) only the significant sector dummies are reported; (7) the other dummies of firm strategic behaviours are not significant.

When interaction variables are used, the results partially compensate the weak significance of the ICT and organization variables on productivity. In fact, we find that both INNO_TECH*INNO_ORG and INNO_TECH*INNO_ICT emerge as robust even if training variables, which usually subtract part of the significance level to the other innovation drivers, are included. As a general comment we can maintain that technological innovation is a complement of the organizational and ICT innovations with respect to the labour productivity.

The results discussed above may be biased because of the endogeneity problem, mainly caused by simultaneity. Focusing the analysis on the synthetic indexes for each innovation area (INNO_TECH, INNO_ORG, INNO_TRAIN, INNO_ICT) we carry out a two step analysis using a Wu-Hausman test (Wooldridge, 2002, p.118-120). The results of this two stage procedure that exploits a sound set of controls[23] do not reject exogeneity for all the indexes but INNO_ICT.

Somewhat different results respect to the simple OLS estimates emerge using the predicted values or residuals for INNO_ICT. In particular, we can see (Tab.5 column 18-19) that the innovation in ICT is more significant, both with and without COV_TRAIN: the two stages analysis conduces to more significant results for the ICT variable than the simple OLS procedure.

We can state that all the innovation activities, though to different extents, positively influence labour productivity (**H.2**). It is possible to draw a ranking in terms of the strength of their links: training is the primary driver leading to high labour productivity, then comes technological innovation, which in addition seems to be complementary to INNO_ORG and INNO_ICT, and finally organizational changes and ICT innovations, associated to weaker signs.

5. Conclusions

The paper aims to provide an original contribution evaluating the role on labour productivity of four areas of innovation activities - training, technology, organization, ICT - that are likely to co-evolve and to be adopted in bundles by firms. In addition, we investigate whether participative characteristics of the industrial relations system are positively linked with the adoption of innovations, indirectly enhancing productivity. We exploit a rich survey data on innovation strategies merged with official balance sheets regarding firm performances.

[23] The vectors of variables belonging to the industrial relations area and to the flexibility emerge as correct instruments because of their correlation with innovation activities and their lack, on average, of correlation with labour productivity. This is true especially for flexibility variables, while industrial relations ones are correlated with labour productivity, but not as strongly as the innovation variables. Operationally we used LCF and CONV_LCF (Tab.A.3) as instrumental variables for all the four first stage regressions, while for the industrial relations variables we used those that emerged as primary drivers of innovations.

A first result we want to stress concerns the role of firm size on innovation. When industrial relations aspects are taken into account in the econometric exercise, the significant negative sign of the size dummy disappears. Context specific institutions, restricted to cooperative aspects of the management/union delegates relations, cover the effect of firm size in our analysis.

About the linkages between cooperative industrial relations and innovation we find that organization and training are the innovation areas most influenced by the industrial relations system. A model of good quality and cooperative industrial relations leads to more intense innovation activities on two areas of innovation more akin to workers "interest". The results induce us to label both organizational and training innovations as *industrial relations driven.* We are not arguing that technological and ICT innovations are outside the union sphere of interest, but that they are mainly used strategically by the management (*managerial driven*), with almost no room for consultation and negotiation with union delegates. The overall relations point to a role of innovation drivers hold by the cooperative aspects of the industrial relations.

In addition to participative/like industrial relations we also test the role of flexibilities on the innovation intensity. The main result is that training and organizational innovation are linked to flexibility variables. The mere diffusion of flexible contracts (short-term contracts) does not appear to affect innovation intensity of the firm. Instead, the conversion of flexible contracts in long-lasting ones is a complementary element of training as the flexibility in wages is. Training intensity seems to be an instrument to make more stable the relations workers have with the firm. The links with organizational innovation and flexibilities induce to hypothesize that organizational changes require flexible workforce and working environment at multiple levels.

Another main result of the empirical analysis is given by the importance of innovation activities as drivers of superior labour productivity. Innovations can be ranked in terms of their significant relations with productivity: 1) training activities; 2) technological innovation; 3) organizational innovation; 4) ICT. The top ranking position of the training may be interpreted at the light of the increasing importance human capital is acquiring in economies where knowledge is one of the main sources of competitive advantage. At the opposite side of the ranking we have the ICT innovations. Their position may be due to the relatively scarce integration with other innovation types that leads to an undersized exploitation of the synergies between ICT and the other innovations. Thus, we can argue that the ICT potential impact on labour productivity is not fully exploited yet. Indeed, the ICT significance "reemerges" when they are interacted with other kinds of innovations, capturing the likely existence of complementarities. Furthermore, the relevance of the ICT as innovation driver of high productivity emerges more neatly when we address the potential endogeneity of the innovation variables. Our results show that there is evidence of multiple drivers of productivity. Thus narrowing the attention to a single innovation area could be misleading. Furthermore, when

innovation variables are interacted each others the relations with productivity are always positive and significant suggesting the potential existence of complementarities among innovation drivers.

Combining the results of the analysis we can state that cooperative aspects of the industrial relations system work as indirect drivers of higher productivity through their influence on innovation activities.

Finally, we can draw a note on policy implications of our results for the SME based Reggio-Emilia local production system. Fostering the diffusion of a production "model" jointly based on (1) union-delegates/management cooperative relations and on (2) innovation intensity should be of primary interest for policy makers because of the positive nexus, indirect and direct respectively, the two aspects have with productivity. As far as policies addressed to sustain innovation activities are concerned, besides focusing on each single innovation activity, they also have to foster complementary innovations in order to maximize the efficiency and efficacy of the policy effort.

Appendix

TAB.A.1 – Firms percentage distribution: firms population with RSU and interviewed firms.

Population with RSU (376)						
	Dimensional classes 31.12.2004					
Sectors	20-49	50-99	100-249	250-499	>499	Total
Food	1.60	1.33	1.86	0.27	0.53	5.59
Other Industries	1.60	0.27	0.00	0.00	0.27	2.13
Chemical	4.52	1.86	2.39	0.00	0.27	9.04
Wood	1.06	1.33	1.06	1.06	0.00	4.52
Machineries	23.14	16.49	12.23	3.46	2.39	57.71
Non-metallic mineral	3.72	4.26	4.52	2.66	1.86	17.02
Textile	1.06	1.60	0.53	0.80	0.00	3.99
Total	36.70	27.13	22.61	8.24	5.32	100.00
Interviewed firms (192)						
	Dimensional classes 31.12.2004					
Sectors	20-49	50-99	100-249	250-499	>499	Total
Food	1.56	2.08	3.13	0.52	0.52	7.81
Other Industries	2.08	0.00	0.00	0.00	0.52	2.60
Chemical	4.69	1.56	3.13	0.00	0.52	9.90
Wood	1.04	1.04	1.56	1.56	0.00	5.21
Machineries	15.10	13.54	14.06	3.65	3.65	50.00
Non-metallic mineral	4.69	3.13	5.21	4.17	2.08	19.27
Textile	1.04	2.08	1.04	1.04	0.00	5.21
Total	30.21	23.44	28.13	10.94	7.29	100.00

Cochran Test *Margin of error* θ *	*Interviewed firms vs. Population with RSU*	*Interviewed firms with balance sheets 2004 (171 obs.) vs. Population with RSU*	*Interviewed firms with balance sheets 1998-2003 (156 obs.) vs. Population with RSU*
$\theta = \sqrt{\frac{N}{(N-1)n} - \frac{1}{N-1}}$	**0.05**	**0.05**	**0.05**

* Margin of error θ "usually" tolerated: 0.05. Restrictive test for small population: the smaller is N, the lesser the distance between N and *n* has to be in order to generate an acceptable θ .

TAB.A.2 – Descriptive statistics

Variables	*Description*	*Min*	*Max*	*Mean*
	Structural Variables			
Sectors Dummies (Food , Other Industries, Chemical, Wood, Machineries, Non-metallic minerals)	Binary variables (0,1)	0	1	/
Size Dummies (20-49, 50-99, 100-249, 250-499, >499; and 20-99, >99)	Binary variables (0,1)	0	1	/
Firm Typology Dummies (private firm, industrial group, cooperative firm, cooperative group; private firm/group, cooperative firm/group)	Binary variables (0,1)	0	1	/
Employees (log) (**EMPL**)	Logarithms of the number of employees at 2004	2.99	7.49	4.55
Percent of Turnover Abroad (**TURN_ABR**)*	Percentage of turnover made on international markets	0	0.9	0.42
White Collar/Blue Collar (**WC/BC**)	White collar workers (managers and clerks) over blue collar workers	0.05	71	0.99
Social Responsibility Balance (d) (**SRB**)	Binary variable (0,1)	0	1	0.21
Delocalization (d) (**DELOC**)	Binary variable (0,1)	0	1	0.17
Cost-Price Strategy (d) (**CP_STR**)	Binary variable (0,1)	0	1	0.62
Technology-Quality Strategy (d) (**TQ_STR**)	Binary variable (0,1)	0	1	0.87
Brand Strategy (d) (**BR_STR**)	Binary variable (0,1)	0	1	0.3
Variety Strategy (d) (**VA_STR**)	Binary variable (0,1)	0	1	0.45
Performance Indicators from questionnaire: Productivity (PROD_QUEST), Revenue (TURN_QUEST), Profit (PROF_QUEST), Investment (INV_QUEST)	Indexes: each type of performance is ranked on a -5 (worse than the preceding year)+5 (better then the preceding year) scale	-5	5	/
	Balance Sheets Variables			
Value Added per employee 2004 (**VA/EMP2004**)	Value added over employment	2.81	126.95	48.49
Labour Cost per employee (**LC/EMP2004**)	Labour cost over employment	10.41	52.62	32.37
ROE2004	Returns on equity	-158.9	122.51	3.54
Average Value Added per employee 98-03 (**M_VA/EMP98-03**)	The average value of value added over employees on the period 1998-2003	19.1	265.28	23.39
Average Turnover per employee 98-03 (**M_TURN/EMP98-03**)	The average value of turnover over employees on the period 1998-2003	33.13	1500.2	182.81
Average Labour Cost per employee 98-03 (**M_LC/EMP98-03**)	The average value of labour cost over employees on the period 1998-2003	13.71	54.48	28.59
Average ROE98-03 (**M_ROE98-03**)	The average value of return on equity on the period 1998-2003	-5.09	82.18	5.44
	Training: Variables used to construct INNO_TRAIN			
Training Coverage (**COV_TRAIN**)	Index: percentage of employees involved in training programmes (0 nobody; 1=1-24%; 2=25-49%; 3=50-74%; 4=75-100%)	0	4	1.02
Training Modalities (**MOD_TRAIN**)	Index: modalities of training (side-by-side training with structured programmes, internal and external to the firm programmes)	0	0.76	0.17
Training Advantages (**ADV_TRAIN**)	Index: advantages for employees involved in training activities	0	1	0.19
Total Index of Training Competencies (**COMP_TRAIN**)	Index: based on the whole competences the training programmes aim to develop	0	1	0.2
Informatics Competences (**INF**)	Index: based on the competences in informatics training programmes aim to develop	0	1	0.17
Techno-specialist Competences (**TEC**)	Index: based on the technical competences training programmes aim to develop	0	1	0.39
Juridical-economics Competences (**EC**)	Index: based on the juridical and economic competences training programmes aim to develop	0	1	0.09
Relational-organizational Competences (**ORG**)	Index: based on the organizational and relational competences training programmes aim to develop	0	1	0.17
	Technology: Variables used to construct INNO_TECH			
Synthetic index of innovation output (**INNO_OUTPUT**)	Index: it synthesizes the information about innovation output (product and process innovations, radical and incremental innovations, innovations of quality control)	0	1	0.36
Process Innovation (d) (**PROC**)	Binary variable (0,1)	0	1	0.49
Product Innovation (d) (**PROD**)	Binary variable (0,1)	0	1	0.55

TAB.A.2 – Continue

Quality Control Innovation (d) (**QUAL**)	Binary variable (0,1)	0	1	0.61
Radical Innovation (d) (**RAD**)	Binary variable (0,1)	0	1	0.27
Incremental Innovation (d) (**INC**)	Binary variable (0,1)	0	1	0.61
Synthetic index of innovation input (**INNO_INPUT**)	Index: it synthesizes the information about innovation input (formal R&D division, R&D activities, resources and employees involved in R&D activities, collaborations with other firms on R&D)	0	1	0.49
R&D and/or Planning Formal Division (d) (**R&D_PLAN**)	Binary variable (0,1)	0	1	0.76
	Organization: Variables used to construct INNO_ORG			
Organizational practices in production (**ORG_PROD**)	Index: Changes in organizational practices in production (quality circles, team working, just in time, total quality management)	0	0.8	0.19
Organizational practices in labour services (**ORG_LAB**)	Index: Changes in organizational practices in labour services (job rotation, job enrichment, delegation, continuous training, evaluation systems etc…)	0	0.83	0.26
Reward System (**REW**)	Individual and collective reward in 2004	0	1	0.4
Out-sourcing (**OUT**)	Index: intensity of out-sourcing in ancillary activities, production support activities and production activities (store management, cleaning, planning, research, etc)	0	3.53	1.16
In-sourcing (**INS**)	Index: intensity of in-sourcing in ancillary activities, production support activities and production activities (store management, cleaning, planning, research, etc)	0	2.53	0.29
Relations with Client and Suppliers (**REL_SUPPCLI**)	Index: relations with clients and/or suppliers on furniture, assistance, changing technological equipment, exchange of technical and commercial knowledge/information etc…	0	0.78	0.25
Relations with Suppliers (**REL_SUPP**)	Index: relations with suppliers on furniture, assistance, changing technological equipment, exchange of technical and commercial knowledge/information etc…	0	0.89	0.28
Relations with Clients (**REL_CLI**)	Index: relations with clients on furniture, assistance, changing technological equipment, exchange of technical and commercial knowledge/information etc…	0	0.89	0.21
	ICT: Variables used to construct INNO_ICT			
ICT in Production (**ICT_PROD**)	Index: introduction of ICT in production	0	1	0.57
ICT in Communication (**ICT_COMM**)	Index: introduction of ICT for communication porposes	0	1	0.82
ICT in Management-Integration (**ICT_MANINT**) *	Index: introduction of systems that use ICT such as EDI, Electronic Data Interchange, EDI (Electronic Data Interchange); MRP (Material Requirements Planning) etc…	0	1	0.52
	Flexibility			
Labour Contract Flexibility (**LCF**)	Index: captures the characteristics of the contractual flexibility (number of contracts, typology of contracts, trend of the flexible contracts diffusion etc…)	0	1.21	0.66
Conversion of Flexible Labour Contracts in Long-lasting Ones (**CONV_LCF**)	Index: percentage of workers who are hired permanently after the flexible contract expires	0	100	39.46
Variation in Temporal Flexibility (**TEMP_FLEX**)	Index: within firm numerical flexibility both individual and collective (overwork, flexible working hours etc…) (three points scale: diminished, unchanged, augmented)	1	3	2.23
Variation in Wage Flexibility (**WAGE_FLEX**)	Index: individual and collective wage flexibility (three points scale: diminished, unchanged, augmented)	1	3	2.08
Variation in Functional Flexibility (**FUNC _FLEX**)	Index: flexibility in professional roles, in job tasks, job rotation, etc... (three points scale: diminished, unchanged, augmented)	1	3	2.21
Variation in Organizational Flexibility (**ORG_FLEX**)	Index: internal (flexibility in organizing labour, in labour practices etc…) and external (delocalization, externalization etc…) to the firm flexibility (three points scale: diminished, unchanged, augmented)	1	3	2.11
	Industrial Relations			
Union Density (**UNION_DENS**)	Index: number of unionized employees	0.33	0.94	0.44
Firm Level Bargaining (d) (**FL_BARG**)	Binary variable (0,1): 1 if a second level formal agreement has been signed in 2004	0	1	0.68
Bilateral Technical Commissions (d) (**BTC**)	Binary variable (0,1): 1 if a BTC exists	0	1	0.32
Trend in Industrial Relations (**INDREL_TREND**)	Index: trend of the industrial relations if compared to the preceding year (three points scale: worse, unchanged, better)	1	3	2.03

TAB.A.2 – Continue

Evaluation of Industrial Relations (**INDREL_EVAL**)	Index: evaluation of the industrial relations system (five points scale from very bad to very good)	1	5	2.81
Managemen/Union Interaction on Issues (**INTERAC_ISSUES)**	Index: interaction between management and union representatives (no interaction, information, consultation, negotiation) on several issues (eg. production, quality, employment, working hours, etc…)	1	3.43	1.92
Managemen/Union Interaction on Flexibility (**INTERAC_FLEX**)	Index: interaction between management and union representatives (no interaction, information, consultation, negotiation) on the different types of flexibility	0.12	0.87	0.47
Managemen/Union Interaction on Innovation (**INTERAC_INNO**)	Index: interaction between management and union representatives (no interaction, information, consultation, negotiation) on the different types of innovations/changes (technology, organization, contractual flexibility, ICT)	1	3	1.47
Synthetich Index of Industrial Relations (**INDREL**)	Index: synthesizes the information of the several factors that constitute the industrial relations system	0.16	0.77	0.4

Notes: The descriptives refer to the 192 interviewed firms but for balance sheets variables the numbers of observations are 171 for 2004 and 156 for 1998-2003; the descriptive statistics for the two sub-sample of interviewed firms with balance sheets are not reported but they are available upon request and they almost do not differ from those reported in the table; "(d)" stands for a binary variable (dummy); * 191 observations.

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