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Innovation, Workers Skills and Industrial Relations: Empirical Evidence from Firm-level Italian Data.

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Abstract

The shifting of labour demand towards relatively more skilled workers has been a hot issue in the economic field for many years. A consolidated explanation for the upskilling phenomenon is that technological-organisational changes have driven the labour demand with detrimental consequences for less skilled workers (*skill-biased technological-organisational change*). In order to upgrade the skill workforce the firm has at least two main channels at its disposal: the external labour market strategy, mainly based on hiring and firing mechanisms; the internal labour market strategies, which improve the skill base of the employees through training activities.

The main objective of the present work is to verify the relations between innovative strategies and both the workforce composition and the training activities, within an integrated framework that also leads us to consider the role of specific aspects of the industrial relations system.

The firm level analysis is based on original datasets which include data on manufacturing firms for two Italian local production systems, located in the Emilia-Romagna region.

The results suggest that the firms use both the two channels to improve their skill base, which is actually related to the innovation activities, although there is weak supporting evidence of the use of external labour markets to upgrade the workforce skills: the upskilling phenomenon seems to be associated to specific innovative activities in the technological sphere, while specific organisational aspects emerge as detrimental for blue collars. On the side of internal labour market strategies the evidence supports the hypothesis that innovation intensity induce the firms to implement internal procedures in order to upskill the workforce, confirming the importance of internal labour market strategies. Moreover, we have recognized the important role of firm level industrial relations in determining the training activities for the blue collar workers.

JEL Classification: J24, J53, L23, L6, O33

Keywords: technological change, organisational change, industrial relations, skills

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Introduction

During the last decades western developed economies have experienced increasing inequalities within the labour market. The sharp increase in wage inequality, especially in Anglo-Saxon countries, between skilled and unskilled workers has been considered as a result of the rapid spread of new technologies. The wage effect of technological change is just one side of the inequality phenomenon; the other one concerns the labour demand. The shifting of labour demand in favour of better-educated/skilled workers, with a detrimental effect for less-educated/unskilled workers, appears to be soundly verified in several empirical studies.

The causal direction of the relation between innovation and skills, above mentioned, is just one side of the coin. The flip side calls into question the role of the human capital in affecting the ability to innovate of an economic system, as put forward by the seminal work of Nelson and Phelps [1966]: the likely co-evolution between skills and innovation makes it difficult to chose a causality direction rule generally applicable. Indicators of knowledge and human capital are used as proxies of innovation "enablers" [Innobarometer, 2009], that is to say they are considered as the fertile ground that makes it easier to innovate and to create sustained competitive advantages.

Knowledge is also perceived as a crucial element for the competitiveness of production units such as firms [Nonaka, Takeuchi, 1995]. At firm level the linkage between human capital and innovation is not trivial at all, especially when the interactions between innovation and high/low skilled workers are considered. For example, on the one hand, we may question whether technological change complements the high skilled workforce performance or if it acts as a substitute for less skilled workers or both. On the other hand, it can be argued that technological change may efficaciously complements some high skilled workers performances but not others, or it may substitute for some less skilled activities but not for others [Autor *et al.*, 2001].

The same argument goes for the linkages between organizational changes and skills. It has been argued [Lindbeck, Snower, 1997] that recent trends in organizational change, involving decentralisation, reduction of hierarchical levels and introduction of high performance work practices, are potential factors explaining the increasing demand for skilled workers. At the same time, the changes in working organization may be called for supporting high levels of workers' skills [Bartel, Ichniowsi, Shaw, 2007].

In the present work we acknowledge the role of human capital and workers skills as complementary to innovation activities. The purpose of the paper is to verify the association between the skill composition of the workforce and training activities, on the one hand, and innovations in technology, organisation and ICT on the other hand. In so doing, we aim at identifying the role of the distinct strategies in augmenting the skill base each firm may rely on: recurring to the external labour markets and recomposing the workforce structure hiring new

employees (owning the desired skills); implementing training programs in order to widen the skill base of the existing workforce. The former strategy is essentially in line with the traditional skill biased technological and organisational changes literature, but it does not take into account the role of internal labour markets, which may be extremely relevant, especially for labour markets characterised by certain rigidities in the hiring and firing processes. The micro focus of the work, which relies on empirical data stemming from original surveys on manufacturing firms, allows us to use a wide set of information, also regarding industrial relations characteristics, to be intended as cooperative employment relationships at firm level as potential influencing factors of the workforce skills formation. The data at our disposal allow us to consider the role of innovation and industrial relations on training programs implemented by the firm, deepening our understanding of industrial relations influence, coupled with innovation activities, in firm strategic decisions concerning the human capital development of the workforce.

The paper is organized as follows. Section 1 presents a review of both theoretical literature and empirical evidence regarding the relation between skills and innovation, focusing traditional literature concerning the so called skill biased technological and organizational changes and to a less developed literature regarding the role of internal labour markets in the skill upgrading process. Section 2 outlines some stylised facts on the local context considered and section 3 illustrates the data and the empirical model. In the following section the main results of the empirical investigation are discussed. Section 5 is left to concluding remarks.

1. Related literature

During the last thirty years the principal OECD countries have experienced significant changes in the functioning of labour market and an increasing inequality between different types of workers [Acemoglu, 2002]. In particular, relative wages and the number of qualified (skilled) workers seem to be constantly risen [Autor *et al.*, 1998; OECD, 1996]; in the same period the number of under-qualified (unskilled) workers has strongly decreased [OECD, 2001]. By country these changes have been very heterogeneous according to different institutional characteristics of national labour markets. It appears that in Anglo-Saxon countries, characterized by more flexible labour markets, the decrease in the demand for unskilled workers has led to increasing wage differentials between skilled and unskilled workers (wage effect). On the contrary, in countries with less flexible labour markets, the change in demand has conducted to rising unemployment for unskilled workers (occupational effect) [OECD, 1996]. Not by chance some authors notice in the unemployment rise in Europe the flip side of the rise of earnings inequality in the US [Freeman, 1995].

Thus, what is the mechanism that led to this evidence?

The consolidated explanation calls for technological change and the potential bias it may induce on labour demand. Many authors see a causal relationship between technological change and the radical shift in the occupational structure [Berman *et al.*, 1994; Sanders, ter Weel, 2000; Autor *et al.*, 2001]: the so called "Skill-Biased Technological Change" (SBTC). The SBTC has spurred an abundant empirical literature[1] at international level. Focusing the attention on the empirical works regarding the Italian context we find the following bunch of studies. Casavola *et al.* [1996] demonstrate that wage dispersion does not increase in Italy by the same extent as in the Anglo-Saxon countries[2], furthermore technological progress lead to a significant increase in the employment of white collars. As Bratti and Matteucci [2004] put in evidence the SBTC in the manufacturing industry can assume different forms according to the specialization and pattern of development of a country. In Italy, for instance, the authors find that from 1995 to 2000 only the R&D expenditures (and not the ICT variable) have negative and significant impact on unskilled (production) workers[3]. Finally, a more recent work by Baccini and Cioni [2005] on the Italian textile district of Prato (an Italian province in Toscana), compares current occupation and occupation during the early Eighties. The comparison reveals that technological innovation, in particular changes introduced with ICT, is not necessarily skill biased. It appears, in fact, that technology spreads at different speeds: some of it biased in favour of skilled labour, some are neutral and some biased in favour of unskilled labour.

However, the SBTC is not the only explanation of the recent up-skilling of the workforce. Another hypothesis, suggested more recently, is deeply rooted in the evolutionary theory of the firm. This second stream of literature is based on the idea that the increasing diffusion of new organizational structures and new work organizational practices is an important explanation of the increase in the demand for skilled workers [Lindbeck, Snower, 1996; Caroli, Van Reenen, 2001]. Actually, the changes occurred in the firms organizational structure in the last decades have directly impacted on economic performances [see as examples for the Italian case: Antonioli, 2009; Antonioli, Mazzanti, Pini, 2010] and on the human capital of the firms. The theory of the "Skill-Biased Organizational Change" (SBOC) asserts that decentralization, delayering, team work, multi-tasking and all what is generally called *High Performance Work Practices (HPWP)* necessitate of

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[1] For supporting evidence see the works on Anglo-Saxon countries (e.g. Bartel, Lichtenberg, 1987; Berman *et al.*, 1994; Autor *et al.,* 1998; Morrison Paul, Siegel, 2001; Machin, 1996), while less supporting evidence is provided by empirical works on European countries (e.g. Goux, Maurin, 2000; Mairesse *et al.,* 2001; Aguirregabiria, Alonso-Borrego, 2001). Interesting results come also from recent empirical works regarding the role of SBTC in transition economies (Esposito, Steherer, 2009).

[2] Probably both the shift in the supply of skills and the features of the Italian wage bargaining system counteracted the rise in earnings dispersion (Casavola *et al.*, 1996).

[3] Maybe this result is due to the specific traditional Italian sectors, composed prevalently by small and medium enterprises and where the formalized innovative activity is not intense and has low capacity to absorb qualified workers (Bratti, Matteucci, 2004).

more responsible and autonomous workers, with higher skills. Because the SBOC interpretation is more recent than the SBTC the empirical evidence supporting the it is less abundant[4]. For the Italian economy two important empirical studies provide evidence of the SBOC. Piva *et al.* [2005], estimating a SUR model with over 400 manufacturing firms, show not just that OC is more important than R&D expenditures on the skill structure (it affects negatively the blue collars workers), but also that OC and R&D together have a super-additive effect on skill composition. Furthermore Piva *et al.* [2006], adopting a dynamic panel data analysis for a sample of 22 of the largest machinery firms, emphasize a positive link between OC and skilled workers and confirm some evidence of super-additive effects.

It is worth stressing that SBTC and SBOC hypotheses are not substitute, but they can go together because of the complementarities among firm activities involving technological innovation and organisational change as shown by some contributions [Aghion *et al.*, 1999; Bresnahan, 1999; Caroli, 2001; Milgrom, Roberts, 1990].

Although both SBTC and SBOC hypothesis have been tested and proved as relevant, we may argue, in line with Behaghel, Caroli and Walkowiak [2007] that the provision of more skilled workers may come from another channel, different from the external labour markets, which act through recruiting processes settled up by the firm in order to change the workforce composition. Such different channel is the internal labour market: training activities provide new skills that complement innovations. This two strategies to improve and extend the skill base of the workforce, in order to complement the innovations introduced, are not strictly substitutes. Each firm can decide the appropriate strategy according to the relative costs and benefits, which may also depend on the types and intensity of innovative activities implemented.

As we have empirical evidence for the SBOC and SBTC hypothesis, which imply changes in the workforce composition through the use of external labour markets strategies, there is also empirical support, from international studies, for the use of internal labour market strategies, which imply a linkage between technological/organisational innovations and training activities [Black, Lynch, 1998; Walsworth, Verma, 2007; Behagel, Greenan, 2005; Behaghel, Caroli, Walkowiak, 2008]. An interesting result stemming from the international literature is that manufacturing firms are more likely to adopt internal labour market strategies, that is to say training activities, to complement the implemented innovations.

Turning the attention to the Italian economy two examples of empirical works on the subject here discussed are those by Guidetti and Mazzanti [2007] and Antonelli, Antonietti and Guidetti [2010]. Guidetti and Mazzanti recognize the importance of structural characteristics of the firm in

[4] Some interesting empirical works that confirm the SBOC hypothesis are: Caroli, Van Reenen (2001), Falk (2001) Caroli *et al.* (2001) and Bauer, Bender (2004).

explaining training activities. Moreover, some practices related to HRM seems to play a pivotal role as drivers of training intensity within the firm. This analysis provides important results for the present work because it is conducted on two local systems of Emilia-Romagna region as we do here. The difference in time and in the local systems analysed may induce different results and interpretation; maintaining, to some extent, the possibility of a comparison. The contribution by Antonelli, Antonietti and Guidetti [2010] regards the entire Italian context. The authors put in evidence the role of innovation in impacting the propensity to invest in training. The same positive impact of innovation seems to emerge also for other two measure of training: training form and training intensity in terms of share of employees involved. The importance of technological and organisational innovations is assessed, but in both of the studies the role of industrial relations system has been neglected, although relevant for firm level decision about training.

Indeed, the role of internal labour markets in providing skills that complements innovation, depending on the relative costs of recurring to external labour markets, rises the issue of the influence the firm level industrial relations exert on training strategies adopted by the managers. The importance of this piece of analysis, which represents an additional value added of the paper, is also suggested by a specific, idiosyncratic characteristic of the two local production systems here analyzed (see 2.2 that follows): the deep-rooted unionism. The decline in unionisation has been seen as a consequence of the SBTC, especially for anglo-saxon countries [Acemoglu, Aghion, Violante, 2001], and also as an element that amplifies the inequality generated by the technical change itself. Because the local context we are analyzing is characterized not only by a high rate of unionisation, but also by institutional elements that support social inclusion and favor social dialogue, we make a step forward trying to verify whether an association between workforce skills, acquired on the basis of training programs, and the quality of the firm level industrial relations exists, acknowledging that not only technical change but also the introduction of the so called *high performance work practices* challenge the traditional role of unions.

2. Innovation, skills and productivity: some stylised facts for the Emilia-Romagna

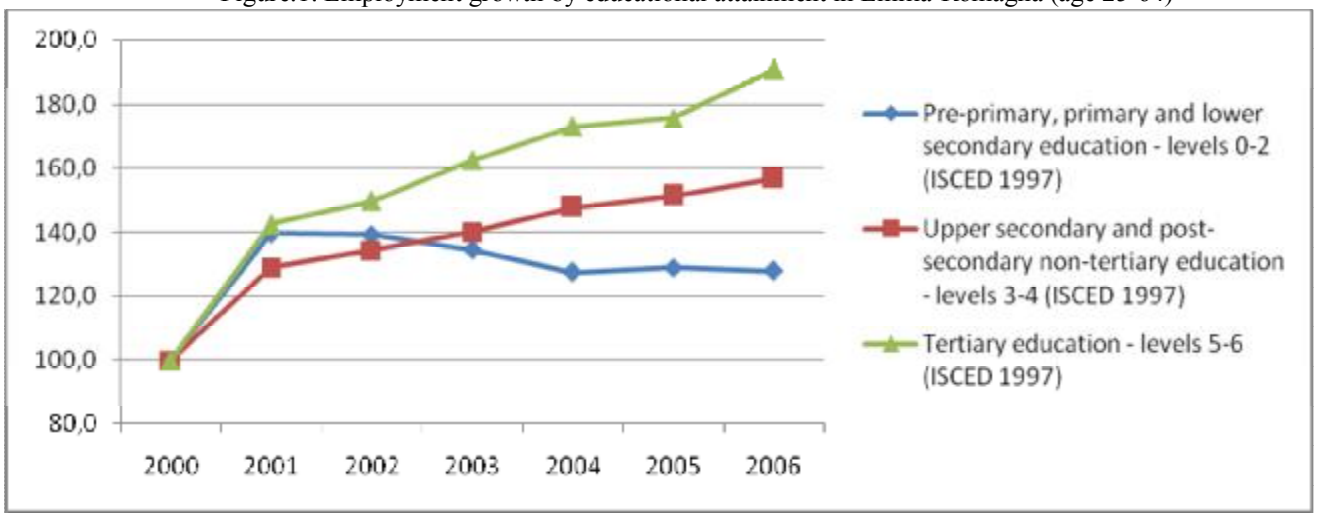
As briefly sketched above with the review of some empirical works, the Italian context seems to lack of strong evidence about the upskilling phenomenon. Such a general result can be interpreted as the outcome of a substantially stable demand for skills in the past decades that has crowd out the workforce [for evidence over the period 1993-2004 see Naticchioni, Ricci, Rustichelli, 2008]: there is a trend showing that highly skilled workers are employed in low-medium skilled job. In other words, from the beginning of the 90s we have assisted to a sort of compression in the quality of labour demand with a consequent "skill-loss effect" [London, Brida, Risso, 2008]. Coupled with the

compression in the quality of labour demand we can also acknowledge the role and functioning of internal labour markets, which allow an increase in the skill base of the workforce through training activities instead of hiring process.

But if this is true for Italy we might expect something different for Emilia-Romagna, because it is a leading region in Italy in terms of innovation performance and also in terms of productivity; hence, we aim at testing the existence of the upskilling phenomenon, obtained both through internal and external labour markets strategies, in two of the most industrialized provinces of the region: Reggio Emilia and Modena. In synthesis, we hypothesise that the quality in labour demand increases as the innovation intensity increases and, thus, the upskilling phenomenon exists.

Emilia-Romagna is one of the two Italian regions, with Lombardia, that has been classified as medium-high innovator region at the EU27 level by the Regional Innovation Scoreboard (RIS) in 2009. This position, within the EU27 countries' regions, qualifies Emilia-Romagna as one of the two most innovating region in Italy. The top ranking position in the Italian context is occupied both in 2004 and in 2006. However, the report highlights a specific weakness of the regional system: it lacks of strong enablers of innovation (population with tertiary education per 100 population aged 25-64; participation in life-long learning per 100 population aged 25-64; public R&D expenditures as percentage of GDP; broadband access). This weakness tells us that the regional system should lack of workers skills that complement innovation, although as we can see in figure 1 the employment by educational attainment shows a net positive trend for the highly educated workers, showing as expected an increasing trend in labour demand for skilled workers. We may argue, then, that the system could lack not only those sets of skills that has to be acquired subsequently to innovation adoption, but also the human capital that can be considered as the ground over which constructing the innovation strategies.

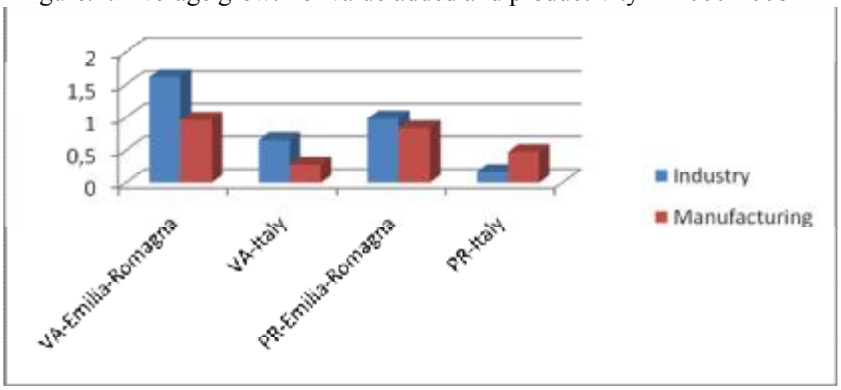
Figure.1: Employment growth by educational attainment in Emilia-Romagna (age 25-64)



Source: Our elaboration on EUROSTAT data

Despite the highlighted weakness the regional system benefits of its overall innovation capacity, which translates into high levels of productivity and value added in the industry sector, and in the manufacturing as well, which outperform the national results (fig.2).

Figure.2: Average growth of value added and productivity in 2000-2008



Source: Our elaboration on ISTAT data
Notes: VA= Value Added; PR= Productivity

On the base of the stylised facts about the Emilia-Romagna region the linkage innovation-productivity seems to hold. Indeed, we are not interested in this sort of "self-evident" relation, rather we are interested in looking inside the triangular nexus innovation-skills-productivity, focusing on the role of skills. Workers skills allow for the full exploitation of the potential benefits the innovations bring into the economic system. Innovation without skills upgrading may produce poorer results than expected in terms of economic performance[5].

Given the stylised facts provided above and the implication they seem to bring about at the outset it is interesting to verify the typologies of relations indicated in the research questions below. In synthesis, we here want to test the first link in the triangular relation innovation-skills-productivity. The Emilia-Romagna local production systems should provide evidence of the nexus between innovation and skills, as long as the innovating firms are those more prone to hire highly skilled workers and/or to train them. At the light of the literature and given the characteristics of the region where the local production systems analysed are located, we aim to answer to the following main research questions concerning both external and internal labour market strategies in the process of workforce upskilling: 1) which are the associations between occupational structure and innovations adopted?; 2) is there empirical evidence supporting the SBTC and SBOC hypotheses?; 3) is there evidence of internal labour markets strategies, which are synthesized by relationships

[5] The linkage between innovation and skills has been described above and it is supported by the SBTC and SBOC hypotheses, but the issue of reverse causation cannot be neglected. A strong skill base represents one of the main innovation enablers as put forward by the capabilities literature and evolutionary theorizing. As a matter of fact we here not take into consideration the issue of reverse causality, also because we are only able to capture associations in a multivariate environment with cross sectional data at our disposal.

between training and innovation?; 4) does industrial relations have a role in explaining training activities, also when interacted with innovations?

The first two questions pertain to the framework of external labour market strategies. On this line of analysis our aim is limited to recognize significant associations between innovations and the skilled component of the workforce, which is represented by white collars workers. The aim is more modest with respect to other international studies that are able to capture changes in workforce composition, however we are capable of analysing the issue of the relation between skills and innovation taking a broad perspective on innovation activities, ranging from technological innovation to organisational innovation, passing through the adoption of ICT.

The second two questions rest within the framework of analysis oriented to evaluate the role of internal labour markets mechanisms in influencing the process of skills upgrading. Within this line of analysis the industrial relations at firm level assume an important role; thus, it is relevant to recognize their specific linkages with training programs, which represent the main instrument of internal labour markets strategies to upgrade the workforce skills.

3. Data and Methodology

Our empirical analysis is conducted using a single data set, which results from the match of two surveys on manufacturing firms located in two central provinces of the Emilia-Romagna region in Italy, Modena (MO) and Reggio Emilia (RE). The two provinces may be considered local production systems that are paradigmatic versions of the so called "Emilian model" [Brusco, 1982; Amin, 1999], which is marked by the presence of a district-like industrial system, a well defined spirit of entrepreneurship and an equally strong and deep-rooted unionism. Indeed, unions are crucial social actors, which have shaped, along with other institutional actors, the growth and the characteristics of the two local production systems[6]. In a strategic framework in which conflicts and industrial relations problems exist, firm level relations between management and union representatives are driven by participative and cooperative behaviours in the pursuit of mutual aims and benefits in both the local systems [Antonioli *et al.*, 2004; Antonioli, Mazzanti, Pini, 2010].

As far as data collection is considered, the criteria we adopted for the identification of the population and the sample were: *(i)* firms with at least 50 employees; *(ii)* firms belonging to manufacturing sectors according to the ISTAT ATECO 2002 classification[7]; *(iii)* presence of union representatives to be interviewed. The last choice induces us to focus our attention on the firms with at least 50 employees, in order to have enough firms with elected union representatives. The data

[6]This is especially true for the role of CGIL, the most relevant trade union.

[7] The sectors are: food, textiles and clothing, wood, chemicals, non-metallic mineral products, machinery, other industries. The ISTAT ATECO classification coincides with the NACE Rev1.1 and thus with ISIC Rev3.1.

were provided by union representatives, through face-to-face interviews, and refer to 2004 - 2006 period. Both the surveys are unique sources of information about firms' structural characteristics, workforce composition, innovation activities and industrial relations[8]. MO data refer to the period 2004-2006, while RE data are related to the single year 2004. This discrepancy is captured in the analysis by a dummy variable, because we are not interested in strict comparison between the two provinces and because the time span 2004 – 2006 is short enough to ensure that structural characteristics of the firm do not vary.

Tables A.1a and A.1b show the population and the sample used in the empirical analysis. A version of the Cochran test [Cochran, 1977] proves that the population is well represented by the sample of firms interviewed (tab.A.2), although some distortions mainly related to the relatively sparer presence of union representatives within smaller firms (50-99 employees) remain.

In the empirical analysis we follow two different directions of investigation. At first, in line with the usual literature on the SBTC, we set up a reduced form of a "labour demand equation", where the skill-ratio (ratio between white collars and blue collars workers) and the white collars and blue collars workers are the dependent variables. In doing so we provide evidence about associations between the occupational structure and the innovative activities. Despite some inherent weakness given by the cross sectional nature of our data and by some information shortening, the simple OLS estimation is robust enough to provide evidences of associations between the dependent variables and the regressors. Indeed, we are not strictly interested in deepening the issue of causal nexus and the focus cannot be on the labour demand trend, rather it is on the "stock" in a point in time of the workforce components: white and blue collars, or non-manual and manual workers[9]. The second regression equation aims at providing evidence of the existence of internal labour market mechanisms that are used to improve the workforce skill base, without necessarily recurring to the external labour markets. This regression has training indexes as dependent variables, one capturing the extension of the training programs in terms of employees involved and the other capturing the extension of the competences such training programs aim to develop: technical, about informatics, economic and juridical skills, organisational and relational competencies. In doing so we are able to disentangle the relationships linking training of WC and BC workers with the specific innovative activities implemented by the firm, looking at the role of internal labour markets in developing the skill base of the two different groups of workers, according to the specific innovation introduced.

Alternative econometric strategies to simple OLS could have been systems of equations, treated as seemingly unrelated regressions [Zellner, 1962], because we can presume that hiring or training

[8] The two surveys are also used in a recent work by Antonioli, Mazzanti, Pini (2011), to investigate the relationship between innovation types, industrial relations and working conditions. In addition, other recent works focused the attention on the linkages between innovation types and organizational changes (Pini, Santangelo, 2005) and on the learning processes leading to different innovation types (Pini, Santangelo, 2010).

[9] In this work WC and non-manuals are synonymous as well as BC and manuals.

decisions involving manual workers are not independent on the same decisions regarding the non manuals and vice versa. However, the contexts in which seemingly unrelated regressions (SUR) models have been implemented are mainly panel datasets, which allow for first differencing in order to capture the change in the occupational structure. In a cross section environment we do not have the possibility to work with first differences and, in addition, the right hand side variables are the same for the two groups of workers in our case: WC and BC. The latter point could have made more appropriate an econometric strategy based on equation-by-equation estimates through OLS [Greene, 2005]. However, in the next section the results provided are those of simple OLS, because the equation-by-equation estimates do not give significantly different results[10].

Finally, a last point it is worth stressing regards the treatment of unobserved heterogeneity, which is usually conducible to unobserved managerial attitudes in the context of firm level studies. The relevant number of controls at our disposal that captures firm specific characteristics partially mitigate the potential problem due to heterogeneity [Michie, Sheean, 2003]. Indeed, some variables are proxies of management characteristics (e.g. variable indicating the strategic orientation of the firm), but also the industrial relations climate, more or less cooperative, represents and indirect "measure" of management attitudes.

The models used in the econometric analysis are based on the following regression functions:

(1) $[Workforce\ composition] = \alpha + \beta_{0i}[structural\ variables] + \beta_{1i}[organizational\ variables] + \beta_{2i}[technological\ variables] + \beta_{3i}[ICT] + \beta_{4i}[Innovation\ interactions] + \varepsilon_i$

(2) $[Training] = a + b_{0i}[structural\ variables] + b_{1i}[industrial\ relations] + b_{2i}[organizational\ variables] + b_{3i}[technological\ variables] + b_{4i}[ICT] + b_{5i}[Innovation\ interactions] + b_{6i}[Innovation\ and\ industrial\ relations\ interactions] + u_i$

where the dependent variables are the skill-ratio (share of White Collars (WC) on Blue Collars (BC) workers in logarithm) or the two singular components of the skill-ratio (equation 1) and different indexes of training activities (equation 2) as explained in table A.3 in Appendix; *i* represents each observation; *ß and b* represent vectors of coefficients, which are related to each vector of independent variables (covariates); *α and a* represent the constants of the models and *ε and u* represent the error terms. Within the first equation (1) the industrial relations variables are used as additional controls, without specific explicative power in terms of workforce composition, which is indeed related to other factors. On the contrary, in equation two (2) the industrial relations variables are supposed to have a more direct and interesting role on the firm's decision about training

[10] The equation-by-equation results are disposable upon request to the authors.

activities; hence, they are disjointed by the set of controls and they are used in interactions with innovation variables. Among the other covariates on the right hand side we can distinguish (see tab.A.3 and A.4 in Appendix for detailed descriptions of the variables): (i) firm structural variables (controls), which give information on sector, size, group belonging, performance, managerial strategies, as well as labour contracts (labour flexibility); (ii) technological innovation variables, which include input (R&D) and output (incremental/radical product/process innovations) of technological process; (iii) ICT variables and, finally, (iv) organisational innovation variables[11]. It is convenient to underline that frequently, in the skill bias empirical literature, the innovation variables, especially the organizational ones, have been measured as simple dummies [Caroli, Van Reenen, 2001; Bauer, Bender, 2004; Piva *et al.* 2005]. In our case, the richness of micro-level data not only reduces, to some extent, the likelihood of relevant variables being omitted, but also gives an original and essential value added to this study.

4. Results

The results stemming from the two regression equations are reported respectively in tables 1, 2, 3 (equation 1) and 4, 5, 6,7 (equation 2) [12].

From the results of the equation (1) we aim to answer the first two research questions as reported in section two above. First, it should be stressed that we settled up three different specifications for equation (1), which are presented in each table: the first one includes controls and innovative composite indexes (column 1); the second one adds to the controls the specific indexes for each innovative spheres that are used to construct the composite indexes, so that we can look to the influence of specific innovations implemented (column 2); in the third specification we use multiplicative interaction terms of innovative composite indexes (column 3)[13].

Starting from a brief comment to the controls in the three first tables (tabb.1,2,3) it is possible to recognize that firms located in MO employ less white collars (WC) than the RE firms, while the reverse holds for the blue collars (BC). Indeed, the occupational structure seems to depend on sector specificities, as several sector dummies are significant, which differ between the two local systems. Contextually, also the variable measuring the trend of flexible labour contracts (TREND_FLC) is

[11] It is worth pointing out the fact that different innovation activities and industrial relations are thought to encompass several levels. In fact, it is possible to investigate the relationship between skills and the synthetic indexes of industrial relations, organizational changes, technological change and ICT, but we can also analyse the relationship between skills and the specific variables (components) which are used to construct the composite indexes. Every composite index, indeed, is built by an additive combination of exhaustive, very specific, variables (tab. A.3 in Appendix).

[12] The presentation of the econometric results is more qualitative than quantitative, because we are not interested in finding elasticises, also because of the variables nature; rather we are interested in pointing out the main associations among the dependent and the covariates in a multivariate context.

[13] Interaction terms capture the potential need of more skilled workers in cases of a joint intense innovative activities on two innovation spheres.

significant both for WC (positively) and for BC (negatively) workers. How can we explain this outcome? If within firm an increase in the diffusion of flexible contracts[14] is essential to explain skills, it is possible that the source is a "generational effect" (or generational turnover): the diffusion of flexible contracts regards increasingly executive and office workers for the reason that there is a large increase in the supply of more educated workers due to increasing average education [Acemoglu, 2002]. Another specific relation links the BC with industrial relations variables, although the signs are not univocal. The positive sign of the intensity in union/management relations (MANUNI_REL) coupled with the negative one for the industrial relations trend (INDREL_TREND) let us to hypothesise that plants where BC workers are abundant have experienced a more intense debate between unions and management, which does not always ameliorate firm level industrial relations in the perception of the union representatives

Turning now to the variables of main interest we can proceed looking at each dependent at a time. At first, the skill ratio (tab.1) is not associated to the composite innovative indexes. However, two specific elements of the innovative activities, innovations in labour organisation (ORG_LAB) and technological input activities (TECH_INP) show a positive association with the skill ratio. No significant complementary relations emerge among innovations and among the latter and industrial relations variables. When we look at the two components of the skill ratio (tabb.2 and 3), white collars and blue collars, it is possible to single out the positive relation between the skilled component of the workforce and both ORG_LAB and TECH_INP. Moreover, the WC are linked to the composite technological innovation index (TECH) as well as with the ICT innovation index (ICT), showing a relation between skilled workers and two specific spheres of the innovation strategy of the firm. The associations of skilled workers with the adoption of ICT and with the intensity in labour organisational changes and technological input activities confirm international results concerning the complementary nature between human capital and technological and organisational innovation [Bresnahan *et al.*, 2002; Aral and Weill, 2005; Acemoglu, 2002]. In synthesis, these results support the general skill biased nature of technological and organisational changes. The effects of the latter on the less skilled component of the workforce, here identified by the BC workers, are different. More specifically, the organisational innovation seems to be detrimental for the BC. However, it is the specific outsourcing (OUTSORC) element that drives the negative sign of the composite organisational index. Although we do not know whether or not the outsourcing is international the negative relationship with the BC component of the workforce is in line with some recent studies on the effect of the international outsourcing, or offshoring, on the workforce composition in Italy [Antonietti, Antonioli, 2011].

[14] On the basis of the data, about 85% of flexible contracts concerns BC workers while only 15% concerns WC workers

TABLE 1 – *OLS results with Ln(WC/BC) as dependent variable*

	(1) Innovation Composite Indexes	(2) Innovation Specific Indexes	(3) Innovation Interactions
Controls	Yes	Yes	Yes
ORG	0.738		
	(0.538)		
ICT	0.620		
	(0.391)		
FIRM_REL		0.502	
		(0.532)	
ORG_LAB		0.603*	
		(0.335)	
ORG_PROD		-0.386	
		(0.337)	
TECH_INP		0.326*	
		(0.191)	
ICT_COM		0.556	
		(0.454)	
ICT_MAN		0.217	
		(0.214)	
ORG_centered			0.787
			(0.551)
TECH_centered			\
ICT_centered			0.619
			(0.396)
ORG*ICT_centered			-2.356
			(2.764)
CONS	-1.857***	-1.866***	-1.224***
	(0.434)	(0.567)	(0.314)
N	227	224	227
adj. R^2	0.143	0.163	0.141
F	3.667	4.087	3.481
VIF	1.64	1.45	1.61

Notes: *; **; *** significant at 10%; 5% and 1% respectively; standard errors in parenthesis; controls are size dummies, sector dummies, LPS dummy, group dummy, labour contracts (labour flexibility), performance; delocalization dummy and strategy dummies (see table A.3 in Appendix); regressions have been conducted with standard errors robust to heteroskedasticity; VIF is the Variance Inflation Factor and it represents a 'test' to recognize the existence of multicollinearity when the threshold of 10 is passed; a stepwise procedure has been applied in order to end up with parsimonious specifications starting from more general ones (probability threshold to keep the variable is 0.5); \ means the variable has been dropped according to the stepwise procedure; empty cells mean the variables are not included in the starting specification.

TABLE 2 – *OLS results with Ln(WC) as dependent variable*

	(1) Innovation Composite Indexes	(2) Innovation Specific Indexes	(3) Innovation Interactions
Controls	Yes	Yes	Yes
TECH	0.469**		
	(0.219)		
ICT	0.514*		
	(0.290)		
ORG_LAB		0.534**	
		(0.230)	
ORG_PROD		-0.267	
		(0.213)	
REW_TOT		-0.0983	
		(0.141)	
TECH_INP		0.386***	
		(0.147)	
ICT_PROD		0.130	
		(0.140)	
ICT_COM		0.356	
		(0.333)	
ICT_MAN		0.166	
		(0.152)	
TECH_centered			0.463**
			(0.220)
ICT_centered			0.516*
			(0.291)
CONS	4.074***	3.822***	4.718***
	(0.373)	(0.436)	(0.290)
N	229	226	229
R^2	0.607	0.634	0.606
F	15.03	13.87	15.78
VIF	1.76	1.70	1.77

Notes: *; **; *** significant at 10%; 5% and 1% respectively; standard errors in parenthesis; controls are size dummies, sector dummies, LPS dummy, group dummy, labour contracts (labour flexibility), performance; delocalization dummy and strategy dummies (see table A.3 in Appendix); regressions have been conducted with standard errors robust to heteroskedasticity; VIF is the Variance Inflation Factor and it represents a 'test' to recognize the existence of multicollinearity when the threshold of 10 is passed; a stepwise procedure has been applied in order to end up with parsimonious specifications starting from more general ones (probability threshold to keep the variable is 0.5); \ means the variable has been dropped according to the stepwise procedure; empty cells mean the variables are not included in the starting specification.

TABLE 3 – *OLS results with Ln(BC) as dependent variable*

	(1) Innovation Composite Indexes	(2) Innovation Specific Indexes	(3) Innovation Interactions
Controls	Yes	Yes	Yes
ORG	-0.626**		
	(0.247)		
ICT	0.213		
	(0.241)		
OUTSORC		-0.0653**	
		(0.0314)	
FIRM_REL		-0.358	
		(0.233)	
ICT_PROD		0.175	
		(0.115)	
ORG_centered			-0.689***
			(0.254)
TECH_centered			0.120
			(0.161)
ICT_ centered			\
ORG*ICT_ centered			2.030
			(1.501)
TECH*ICT_ centered			-1.043
			(0.900)
CONS	5.710***	5.770***	5.700***
	(0.260)	(0.250)	(0.252)
N	227	224	227
R^2	0.691	0.695	0.695
F	45.22	43.53	39.87
VIF	1.50	1.43	1.49

Notes: *; **; *** significant at 10%; 5% and 1% respectively; standard errors in parenthesis; controls are size dummies, sector dummies, LPS dummy, group dummy, labour contracts (labour flexibility), performance; delocalization dummy and strategy dummies (see table A.3 in Appendix); regressions have been conducted with standard errors robust to heteroskedasticity; VIF is the Variance Inflation Factor and it represents a 'test' to recognize the existence of multicollinearity when the threshold of 10 is passed; a stepwise procedure has been applied in order to end up with parsimonious specifications starting from more general ones (probability threshold to keep the variable is 0.5); \ means the variable has been dropped according to the stepwise procedure; empty cells mean the variables are not included in the starting specification.

As a whole our evidence weakly supports the idea that innovation activities are associated to the WC and BC components of the workforce, although the linkages between WC and specific innovation activities cannot be neglected. Despite the weak associations we can say that the empirical findings do not point to an absence of relation between the upskilling phenomenon and the innovative activities, they more plausibly mean that manufacturing firms do not modify the workers skill base through the only use of external labour market strategies. Rather, it might be the case that internal labour markets play an important role in explaining the upskilling phenomenon, which is only partially captured looking to the workforce (re-)composition due to hiring processes subsequently to innovations, as the main part of the literature does. Relying on internal labour markets strategies, such as the implementation of training programs, could be equally or more important for certain sectors, as the manufacturing one [Behaghel, Caroli, Walkowiak, 2008].

For this reason the second line of analysis, represented in equation (2), aims to single out the relationships between training and innovation, paying attention also to the role of firm level industrial relations, in order to answer the last two research questions as reported in section two above. On this purpose, five specifications are implemented: the first one includes controls and industrial relations variables (column 1); the second one adds innovative composite indexes to the variables included in the first specification (column 2); the third one adds to the first specification the specific indexes for each innovative spheres that are used to construct the composite indexes (column 3); in the forth specification we add multiplicative interaction terms of innovative composite indexes (column 4); finally, the last specification (column 5) includes multiplicative effects between innovative composite indexes and a composite industrial relation index, capturing good quality aspects (the higher the index, the more participative/cooperative like elements are present in the workplace).

We can start again providing a brief description of the significant results concerning the control variables (tabb.4-7). Sector specificities emerge both for the coverage and for the competences covered by training. The local production system seems to matter especially for the coverage of BC in training activities: higher in MO than in RE. As expected the firm size matters: the larger the firm, the higher the diffusion of training activities and the range of competences covered by such activities, both for WC and BC. Profitability is positively linked to the training activities, meaning that a sound financial background represents a driving factor behind the diffusion of training. However, the revenues are negatively linked to training inducing to hypothesised that in the workplaces where revenues are high there is less incentive to adopt training programs. An important linkage, emerging from the controls, is the positive one between the rate of conversion of short term contracts in permanent ones with training activities, which is in line with the human capital theory: extending the time horizon of the relationship between employees and firms increases the incentives for both players to invest in training [e.g. Arulampalam, Booth, 1998 and Antonioli, 2009 for recent empirical evidence on this point].

Turning now the attention to the innovation and industrial relations variables in tables 4 and 5, which have training coverage for WC and BC as dependents, the following results emerge.

Technological innovation (TECH) is positively related to the training for WC. Technological innovation is related to WC training coverage, but not to BC coverage. This means that internal labour market strategies are activated for WC, but not for the BC, workers once the firm introduces technological innovation. However, both BC and WC, are widely interested by training activities contextually to the adoption of general purpose ICT (ICT_COM), which encompass the use of internet, intranet, e-mail and web pages, and to the introduction of changes in labour organisation

(ORG_LAB). The introduction of ICT and of labour organisational changes needs a wider use of training activities spanned over the two components of the workforce.

TABLE 4 – OLS results with share of WC involved in training activities as dependent: TRAIN_COV_WC

	(1) Industrial Relations	(2) Innovation Composite Indexes	(3) Innovation Specific Indexes	(4) Innovation Interactions	(5) Innovation and Industrial Relations Interactions
Controls	Yes	Yes	Yes	Yes	Yes
MANUNI_REL	0.376**	0.219	0.135	0.219	
	(0.181)	(0.178)	(0.177)	(0.178)	
FL_BARG	0.319	0.244	0.189	0.244	
	(0.209)	(0.203)	(0.212)	(0.203)	
TECH		0.931**			
		(0.381)			
ORG		1.256			
		(0.801)			
ICT		0.731			
		(0.505)			
INSOURC			-0.0987		
			(0.120)		
FIRM_REL			0.663		
			(0.535)		
ORG_LAB			1.016*		
			(0.551)		
TECH_OUT			0.331		
			(0.372)		
TECH_INP			0.448		
			(0.280)		
ICT_COM			1.094**		
			(0.449)		
ORG_centered				1.256	1.384*
				(0.801)	(0.795)
TECH_ centered				0.931**	0.958**
				(0.381)	(0.378)
ICT_ centered				0.731	0.749
				(0.505)	(0.508)
INDREL_ centered					0.576
					(0.424)
ICT*INDREL_centered					-3.324
					(2.283)
CONS	-0.365	-1.182***	-1.512***	0.149	0.660***
	(0.437)	(0.450)	(0.478)	(0.372)	(0.188)
N	229	229	226	229	229
adj. R^2	0.208	0.243	0.247	0.243	0.244
F	6.616	7.808	7.083	7.808	8.174
VIF	1.75	1.68	1.59	1.68	1.65

Notes: *; **; *** significant at 10%; 5% and 1% respectively; standard errors in parenthesis; controls are size dummies, sector dummies, LPS dummy, group dummy, labour contracts (labour flexibility), performance; delocalization dummy and strategy dummies (see table A.3 in Appendix); regressions have been conducted with standard errors robust to heteroskedasticity; VIF is the Variance Inflation Factor and it represents a 'test' to recognize the existence of multicollinearity when the threshold of 10 is passed; a stepwise procedure has been applied in order to end up with parsimonious specifications starting from more general ones (probability threshold to keep the variable is 0.5); \ means the variable has been dropped according to the stepwise procedure; empty cells mean the variables are not included in the starting specification.

A specific relation for the training coverage of BC is with changes in production organisation (ORG_PROD). The job and tasks of manual workers are more influenced by changes in production organisation, with respect to the tasks and job of WC, thus their training coverage is positively associate to ORG_PROD. Moreover, the industrial relations variables are positively linked only to the coverage of BC, but not to that of WC. Non adversarial firm level industrial relations seems to be an important factor, as hypothesised, in influencing internal labour market strategies: more specifically, the training decision involving BC passes through the union/management relations. Finally, we can notice the negative relation between the technological and ICT (TECH*ICT_centered) innovations interaction and the diffusion of training for BC: "too much" innovation may subtract resources to training. Hence, those firms that jointly and intensely innovate on the technological and ICT spheres do not have financial resources to devote to training, possibly following a not equilibrate strategy focused on innovation, but not on the complementary training activities, which are vital in order to support the full exploitation of the technological innovation potential.

TABLE 5 – *OLS results with share of BC involved in training activities as dependent: TRAIN_COV_BC*

	(1) Industrial Relations	(2) Innovation Composite Indexes	(3) Innovation Specific Indexes	(4) Innovation Interactions	(5) Innovation and Industrial Relations Interactions
Controls	Yes	Yes	Yes	Yes	Yes
MANUNI_REL	0.583***	0.462**	0.362**	0.450**	
	(0.198)	(0.189)	(0.182)	(0.188)	
INDREL_TREND	0.307**	0.280*	0.242*	0.280*	
	(0.149)	(0.147)	(0.145)	(0.148)	
TECH		0.363			
		(0.398)			
ORG		1.778**			
		(0.820)			
ICT		1.081**			
		(0.532)			
OUTSOURC			0.117		
			(0.117)		
INSOURC			-0.165		
			(0.111)		
ORG_LAB			1.834***		
			(0.558)		
ORG_PROD			1.124**		
			(0.438)		
REW_TOT			-0.328		
			(0.293)		
TECH_INP			0.185		
			(0.267)		
ICT_PROD			0.490		
			(0.299)		
ICT_COM			1.254**		
			(0.509)		
ICT_MAN			-0.264		
			(0.278)		
ORG_centered				1.731**	1.923**
				(0.800)	(0.867)
TECH_centered				0.326	0.548
				(0.396)	(0.378)
ICT_centered				1.090**	1.107*
				(0.534)	(0.570)
ORG*ICT_centered				5.557	
				(3.942)	
TECH*ICT_centered				-3.206*	
				(1.755)	
INDREL_centered					1.192***
					(0.452)
CONS	-1.698***	-2.905***	-3.168***	-1.784***	-0.180
	(0.445)	(0.483)	(0.551)	(0.574)	(0.393)
N	229	229	226	229	229
adj. R^2	0.174	0.214	0.271	0.217	0.195
F	6.305	8.391	9.317	7.930	8.163
VIF	1.47	1.23	1.26	1.22	1.18

Notes: *; **; *** significant at 10%; 5% and 1% respectively; standard errors in parenthesis; controls are size dummies, sector dummies, LPS dummy, group dummy, labour contracts (labour flexibility), performance; delocalization dummy and strategy dummies (see table A.3 in Appendix); regressions have been conducted with standard errors robust to heteroskedasticity; VIF is the Variance Inflation Factor and it represents a 'test' to recognize the existence of multicollinearity when the threshold of 10 is passed; a stepwise procedure has been applied in order to end up with parsimonious specifications starting from more general ones (probability threshold to keep the variable is 0.5); \ means the variable has been dropped according to the stepwise procedure; empty cells mean the variables are not included in the starting specification.

The specifications in tables 6 and 7 have as dependent can index of wideness of competencies generated by training programs (TRAIN_COMP) for WC and BC. In using such dependent we are able to capture whether or not specific innovations need internal labour markets strategies oriented to increase workforce competencies over a wide range of dimensions. Looking, at first, at those covariates that are contextually related to the dependent we notice the technological sphere, whose sign is mainly driven by the input dimension (TECH_INP) of the technological innovation. The relevance of acquiring new skills when R&D projects, which represent a fundamental element of the technological input dimension, are implemented is witnessed also by the relation the TECH_INP variable shows with the skill ratio and with the WC component of the workforce, as reported above. When a firm is particularly active on the technological sphere and especially on the input dimension of it, then it needs to implement both external and internal labour markets strategies in order to upgrade the skill base. The same need of widening the competencies both for WC and BC is perceived once the firm jointly and intensely innovate in ICT and organization, as captured by the positive and significant sign associated to the interaction variable ORG*ICT_centered. The strategy implemented by the firms when innovate in organization and in ICT recognizes the importance of the complementary human capital, while it seems that those firms jointly innovating in technology and ICT neglect to some extent the importance of improving the skill base. Although such a results is in line with that obtained with training coverage as dependent variable it might be the case that associated to such innovative strategy there is a more intense exploitation of external labour markets channels in order to improve the skill base of the BC, despite the lack of evidence in this direction from our results by equation (1). Finally, also for the development of BC competencies the intensity in unions/management relationships matters: training processes involving BC workers pass through the “mediating element” represented by the union representatives at firm level. A model of non adversarial industrial relations, based on consultation and negotiation between unions and management, represents a positive element for the development of the BC human capital.

TABLE 6 – *OLS results with intensity in training competencies for WC as dependent: TRAIN_COMP_WC*

	(1) Industrial Relations	(2) Innovation Composite Indexes	(3) Innovation Specific Indexes	(4) Innovation Interactions	(5) Innovation and Industrial Relations Interactions
Controls	Yes	Yes	Yes	Yes	Yes
MANUNI_REL	0.0790*	0.0501	0.0361	0.0460	
	(0.0421)	(0.0425)	(0.0424)	(0.0441)	
FL_BARG	0.0630	0.0531	0.0521	0.0727	
	(0.0475)	(0.0458)	(0.0450)	(0.0471)	
INDREL_TREND	\	-0.0283	-0.0287	-0.0369	
		(0.0305)	(0.0304)	(0.0305)	
TECH		0.261***			
		(0.0973)			
ORG		0.185			
		(0.186)			
ICT		0.108			
		(0.130)			
ORG_LAB			0.312***		
			(0.116)		
TECH_OUT			0.133		
			(0.0888)		
TECH_INP			0.116*		
			(0.0619)		
ICT_PROD			0.0538		
			(0.0629)		
ORG_centered				0.126	0.163
				(0.175)	(0.182)
TECH_ centered				0.274***	0.246***
				(0.0951)	(0.0939)
ICT_ centered				0.116	0.0972
				(0.119)	(0.129)
ORG*TECH_ centered				0.605	
				(0.734)	
ORG*ICT_ centered				1.808*	
				(1.052)	
INDREL_ centered					0.0980
					(0.102)
INDREL*ORG_ centered					-1.632*
					(0.860)
CONS	0.169	0.0736	0.102	0.306**	0.422***
	(0.146)	(0.164)	(0.129)	(0.132)	(0.120)
N	229	229	226	229	229
adj. R^2	0.250	0.281	0.299	0.298	0.284
F	7.311	8.323	8.590	9.002	8.688
VIF	1.59	1.76	1.65	1.69	1.69

Notes: *; **; *** significant at 10%; 5% and 1% respectively; standard errors in parenthesis; controls are size dummies, sector dummies, LPS dummy, group dummy, labour contracts (labour flexibility), performance; delocalization dummy and strategy dummies (see table A.3 in Appendix); regressions have been conducted with standard errors robust to heteroskedasticity; VIF is the Variance Inflation Factor and it represents a 'test' to recognize the existence of multicollinearity when the threshold of 10 is passed; a stepwise procedure has been applied in order to end up with parsimonious specifications starting from more general ones (probability threshold to keep the variable is 0.5); \ means the variable has been dropped according to the stepwise procedure; empty cells mean the variables are not included in the starting specification.

TABLE 7 – *OLS results with intensity in training competencies for BC as dependent: TRAIN_COMP_BC*

	(1) Industrial Relations	(2) Innovation Composite Indexes	(3) Innovation Specific Indexes	(4) Innovation Interactions	(5) Innovation and Industrial Relations Interactions
Controls	Yes	Yes	Yes	Yes	Yes
MANUNI_REL	0.0836***	0.0583***	0.0557**	0.0589***	
	(0.0244)	(0.0223)	(0.0217)	(0.0219)	
TECH		0.174***			
		(0.0668)			
ORG		0.0989			
		(0.114)			
ICT		0.0711			
		(0.0781)			
OUTSOURC			-0.0208		
			(0.0134)		
ORG_LAB			0.192**		
			(0.0785)		
ORG_PROD			0.112**		
			(0.0524)		
TECH_OUT			0.0878		
			(0.0567)		
TECH_INP			0.0661*		
			(0.0369)		
ICT_PROD			0.0461		
			(0.0380)		
ICT_MAN			-0.0286		
			(0.0409)		
TECH_centered				\	0.158
					(0.112)
ORG_ centered				0.183***	0.177***
				(0.0639)	(0.0626)
ICT_ centered				0.0643	0.0664
				(0.0742)	(0.0791)
ORG*TECH_ centered				0.479	
				(0.449)	
ORG*ICT_ centered				1.196**	
				(0.579)	
TECH*ICT_ centered				-0.417*	
				(0.228)	
INDREL_ centered					0.139**
					(0.0659)
INDREL*TECH_ centered					0.479*
					(0.270)
CONS	0.0610	-0.0106	0.000836	0.160*	0.248***
	(0.0746)	(0.0989)	(0.0827)	(0.0840)	(0.0817)
N	229	229	226	229	229
adj. R^2	0.149	0.185	0.225	0.206	0.185
F	4.180	4.845	5.877	5.750	4.686
VIF	2.05	1.90	1.85	1.75	1.89

Notes: *; **; *** significant at 10%; 5% and 1% respectively; standard errors in parenthesis; controls are size dummies, sector dummies, LPS dummy, group dummy, labour contracts (labour flexibility), performance; delocalization dummy and strategy dummies (see table A.3 in Appendix); regressions have been conducted with standard errors robust to heteroskedasticity; VIF is the Variance Inflation Factor and it represents a 'test' to recognize the existence of multicollinearity when the threshold of 10 is passed; a stepwise procedure has been applied in order to end up with parsimonious specifications starting from more general ones (probability threshold to keep the variable is 0.5); \ means the variable has been dropped according to the stepwise procedure; empty cells mean the variables are not included in the starting specification.

5. Conclusions

The present work has shed (further) light on the important issue concerning the innovation/skill relationship. The complementary nature of human capital to innovations and the upskilling phenomenon due to technological and organisational changes are acknowledged and they are taken as a first step along which we move our research questions. Indeed, we have provided empirical evidence on the specific channels, represented by external and internal labour markets strategies, utilized by the firms in order to improve their skill base. Our focus has been especially directed toward internal labour market mechanisms, which are captured by training activities implemented within the firm for the two main components of the workforce: white collars and blue collars.

At first, we recognize by our analysis that innovation activities are related to forms of skill upgrading. The more skilled component of the workforce (WC) and the skill ratio are related to specific types of innovations: both technological and organisational. This general result, although quite weak, lead us to consider external labour market strategies as an instrument for the workforce upskilling utilised by the manufacturing firms of the local systems analysed. However, internal labour market strategies emerge as very relevant as well, with a clear complementary nature of training activities to the firm's innovation strategies. When the latter are intense they call for new skills, which are provided by means of training activities, both for white collars and blue collars, although with specificities that are linked to the mansions and tasks performed by the two different components of the workforce.

Both the two channels of upskilling are not influence by potential synergies among innovation activities. Doing more of different types of innovations does not lead to more intense training activities, in terms of workers coverage and in terms of competencies wideness, as well as it does not affect the workforce composition. Although the construction of blue collars competencies seems to depend on the joint innovative activities on organisational and ICT spheres, our results lead us to hypothesised that it is not always clear to the firm the strategic need to conjugate intense level of innovation on more than one innovative sphere and training activities.

In the analysis of the internal labour market channel we have found a positive role of participative, non adversarial industrial relations in the development of blue collars skills: the firm level union representatives seems to constitute an important mediating element in influencing the human capital development of the blue collars. On the contrary the participative nature of industrial relations is less important for the white collar component of the workforce, whose member are more likely to have enough bargaining power to individually rise and manage their issues.

Although this contribution provides further evidence on the relation between workforce composition and innovation activities, as well as on the linkage between training activities and

innovations, thus reaffirming the complementary nature of innovation and skills, with an interesting look to the role of firm level industrial relations, there are future lines of analysis deserving further attention. For example we could study the role of the geographical location of the firms, which may change the relative costs of external and internal labour market strategies. Dense labour markets may be associated to a diffused use of external labour market strategies, because finding the right skills on the external labour market becomes easier and less costly [Behaghel, Caroli and Walkowiak, 2007]. In addition our analysis about external labour market channels has suffered from some data shortcoming, mainly due to the cross sectional nature of the dataset, which can be overcome by panel datasets. Finally, the white and blue collars proxies for skilled and un-skilled workers are quite rough, although we have obtained interesting results, which could be refined once a better proxy for skilled and unskilled will be at our disposal.

Appendix

TABLE A.1A – Firms population in Modena and Reggio Emilia (% and absolute value)

Sectors	Size classes			Total	Abs. val.
	50-99	100-249	>249		
Food	4,52	3,14	1,18	*8,84*	*45*
Textile and Clothing	4,91	1,18	1,38	*7,47*	*38*
Wood, Other Industries	4,52	1,57	1,38	*7,47*	*38*
Chemical	3,93	3,14	0,59	*7,66*	*39*
Non-metallic mineral	6,68	5,89	4,13	*16,70*	*85*
Machineries	29,67	14,73	7,47	*51,87*	*264*
Total	*54,22*	*29,67*	*16,11*	*100,00*	
Absolute value	*276*	*151*	*82*		*509*

TABLE A.1B – Interviewed firms in Modena and Reggio Emilia (% and absolute value)

Sectors	Size classes			Total	Abs. val.
	50-99	100-249	>249		
Food	2,83	5,30	2,12	*10,25*	*29*
Textile and Clothing	2,83	1,41	1,06	*5,30*	*15*
Wood, Other Industries	2,12	2,83	2,47	*7,42*	*21*
Chemical	4,24	3,53	1,06	*8,83*	*25*
Non-metallic mineral	7,07	10,60	7,07	*24,73*	*70*
Machineries	14,84	19,08	9,54	*43,46*	*123*
Total	*33,92*	*42,76*	*23,32*	*100,00*	
Absolute value	*96*	*121*	*66*		*283*

TABLE A.2 – Cochran test for the interviewed firms

	N=population size	n=sample size	Margin of error θ
Sectors			
Food	45	29	0,1120
Textile and Clothing	38	15	0,2036
Wood, Other Industries	38	21	0,1479
Chemical	39	25	0,1214
Non-metallic mineral	85	70	0,0505
Machineries	264	123	0,0660
Size classes			
50-99	276	96	0,0826
100-249	151	121	0,0407
>249	82	66	0,0547
Local Production Systems (LPS)			
Modena	291	150	0,0558
Reggio Emilia	218	133	0,0543
Total	509	283	*0,0396*

TABLE A.3 – Variables description

Variables	*Description*
Dependent Variables	
Occupational composition	
Ln(WC/BC)	Logarithms of the White Collars/Blue Collars ratio
Ln(WC)	Logarithms of the number of White Collar workers within the local unit
Ln(BC)	Logarithms of the number of Blue Collar workers within the local unit
Training	
Training Coverage (**TRAIN_COV_BC; TRAIN_COV_WC**)	Percentage of WC or BC involved in training programs: 0 nobody; 1=1-24%; 2=25-49%; 3=50-74%; 4=75-100%
Index of Training Competencies (**TRAIN_COMP_BC; TRAIN_COMP_WC**)	Additive index based on the whole competencies the training programs aim to develop: technical, informatics, economic and juridical, organisational and relational. The higher the index the higher the number of competencies.
Covariates	
Structural Variables	
Local Production System Dummy (**MORE**)	Binary variables (0,1)
Sectors Dummies (Food , Textile, Wood and Other Industries, Chemical, Non-metallic minerals, Machineries)	Binary variables (0,1)
Size Dummies (50-99, 100-249, 250-499, >499)	Binary variables (0,1)
Group dummy (**GROUP**)	Binary variables (0,1)
Performance Indicators from questionnaire: Productivity (**PERF_PROD**), Revenue (**PERF_PROV**), Profit (**PERF_REV**), Investment (**PERF_INV**)	Trend, perceived by the respondents, of the economic performance: ranked on a -5 (worse than the preceding year)+5 (better then the preceding year) scale
Percent of International Turnover (**FOR_PROF**)	Percentage of turnover made on international markets. Rescaled on interval (0-1)
Delocalization (d) (**DELOC**)	Binary variable (0,1)
Cost-Price Strategy (d) (**CP_STR**)	Binary variable (0,1)
Other (Technology, Quality, Brand and Variety) Strategy (d) (**OTHER_STR**)	Binary variable (0,1)
Labour Contract Flexibility - ratio (**RATIO_LCF**)	Share of employees with flexible labour contracts on total employees
Conversion of Flexible Labour Contracts in Long-lasting Ones (**CONV_LCF**)	Percentage of workers who are hired permanently after the flexible contract expires
Variation in Internal Flexibility (**TREND_LCF**)	Index capturing the variation in several forms of short term labour contracts: 1 diminished; 2 unchanged; 3 increased.
Industrial Relations	
IND_REL	Synthetic index of good quality industrial relations
Management/Union Interaction on Issues (**MANUNI_REL)**	Interaction between management and union representatives (no interaction, information, consultation, negotiation) on several issues (e.g. production, quality, employment, working hours, etc…): 1 no relation; 2 information; 3 consultation; 4 bargaining
Bilateral Technical Commissions (d) (**BTC**)	Binary variable (0,1): 1 if a BTC exists; 0 otherwise
Firm Level Bargaining (d) (**FL_BARG**)	Binary variable (0,1): 1 if a firm level formal agreement between unions and management; 0 otherwise
Trend in Industrial Relations (**INDREL_TREND**)	Trend of the industrial relations compared to the preceding year: 1 worse, 2 unchanged, 3 better
Organizational Innovation	
ORG	Composite index capturing the intensity in organizational innovations. Construction based on the following organizational indexes: the higher the values of the following indexes the higher the composite index
Out-sourcing (**OUTSORC**)	Intensity of out-sourcing in ancillary activities, production support activities and production activities. The higher the number of activities outsourced the higher the index
In-sourcing (**INSORC**)	Intensity of in-sourcing in ancillary activities, production support activities and production activities. The higher the number of activities insourced the higher the index
Relations with Client and Suppliers (**FIRM_REL**)	Relations with clients and/or suppliers on furniture, assistance, changing technological equipment, exchange of technical and commercial knowledge/information etc… The higher the numbers of relations the higher the index
Organizational practices in production	Changes in organizational practices in production (quality circles, team working,

(**ORG_PROD**)	just in time, total quality management). The higher the number of changes the higher the index
Organizational practices in labour services (**ORG_LAB**)	Index: Changes in organizational practices in labour services (job rotation, delegation, continuous training, etc…). The higher the number of changes the higher the index
Reward System (**REW_TOT**)	Presence of individual and collective rewards by occupational category
Technological Innovation	
TECH….	Composite index capturing the intensity in technological innovations Construction based on the following organizational indexes: the higher the values of the following indexes the higher the composite index
… Input technological innovations (**TECH_INP**)	Synthesis of 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 for Reggio Emilia; formal R&D division and collaborations with other firms on R&D for Modena). The higher the number of activities the higher the index
… Output technological innovations (**TECH_OUT**)	Synthesis of the information about innovation output (dummies on: Process Innovation, Product Innovation, Quality Control Innovation, Radical Innovation, Incremental Innovation). The higher the number of innovations the higher the index
ICT	
ICT…	Composite index capturing the intensity in ICT adoption Construction based on the following organizational indexes: the higher the values of the following indexes the higher the composite index
….ICT in Production (**ICT_PROD**)	Implementation of ICT in production. The higher the number of ICT introduced the higher the index
ICT in Communication (**ICT_COM**)	Implementation of (general purpose) ICT for communication purposes. The higher the number of ICT introduced the higher the index
ICT in Management-Integration (**ICT_MAN**)	Implementation of systems that use ICT such as EDI, Electronic Data Interchange, EDI (Electronic Data Interchange); MRP (Material Requirements Planning) etc… The higher the number of ICT introduced the higher the index

Notes: all the indexes are standardized on the (0-1) interval unless otherwise specified.

Tab.A.4: Descriptive statistics of the variables

Variables	*Min*	*Max*	*Mean*
Dependent Variables			
Occupational composition			
lnWC/BC	*-4,37*	*4,26*	*-0,83*
lnWC*	*0*	*6,93*	*3,60*
lnBC*	*0*	*7,52*	*4,42*
Training			
TRAIN_COV_BC	*1*	*4*	*1.08*
TRAIN_COV_WC	*1*	*4*	*1.15*
TRAIN_COMP_BC	*0*	*1*	*1.15*
TRAIN_COMP_WC	*0*	*1*	*1.26*
Covariates			
Structural Variables			
MORE	*0*	*1*	*/*
Sectors Dummies	*0*	*1*	*/*
Size Dummies	*0*	*1*	*/*
GROUP	*0*	*1*	*/*
PERF_PROD, **PERF_PROV, PERF_REV**, **PERF_INV**	*-5*	*5*	*/*
FOR_PROF	*0*	*1*	*0,44*
DELOC	*0*	*1*	*0,25*
CP_STR	*0*	*1*	*0,58*
OTHER_STR	*0*	*1*	*0,92*
RATIO_LCF	*0*	*95.27*	*13,40*
CONV_LCF	*0*	*100*	*49,41*
TREND_LCF	*1*	*3*	*2,27*
Industrial Relations			
IND_REL…	*0,15*	*0,94*	*0,56*
MANUNI_REL	*1*	*3,57*	*2,00*
BTC	*0*	*1*	*0,25*
FL_BARG	*0*	*1*	*0,78*

INDREL_TREND	*1*	*3*	*2*
Organizational Innovation			
ORG…	*0*	*0,75*	*0,26*
OUTSORC	*0*	*3,79*	*1,27*
INSORC	*0*	*3,89*	*0,34*
FIRM_REL	*0*	*0,72*	*0,24*
ORG_PROD	*0*	*1*	*0,22*
ORG_LAB	*0*	*0,91*	*0,28*
REW_TOT	*0*	*1*	*0,40*
Technological Innovation			
TECH….	*0*	*1*	*0,55*
TECH_INP	*0*	*1*	*0,65*
TECH_OUT	*0*	*1*	*0,46*
ICT			
ICT…	*0*	*1*	*0,67*
ICT_PROD	*0*	*1*	*0,58*
ICT_COM	*0*	*1*	*0,91*
ICT_MAN	*0*	*1*	*0,53*

Notes: one firm declares to have only 1 white collar and one firm declares to have only 1 blue collar; two firms declare they have not blue collars.

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