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# Is Innovation Good for European Workers? Beyond the Employment Destruction/Creation Effects, Technology Adoption Affects the Working Conditions of European Workers

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## Abstract

This article contributes to better understanding the relations between innovation and the evolution of working conditions and employment quality. Most studies on employment and innovation focus on the impacts of innovation on employment variation and turnover. However, few empirical works explicitly study the transformative role of new technology adoption in the qualitative dimensions of jobs. This article investigates the effect of new technology adoption on job quality and working conditions. Based on the European Working Conditions Survey (EWCS) (2010), econometrics models identify at employee-level the combined influence of innovation with work organization practises on several job quality dimensions. We observe that new technology adoption is generally associated with better employment quality for workers in some ways, but, simultaneously, it leads to higher physical constraints and work-time intensity. Furthermore, our study highlights the heterogeneity of innovation diffusion effects according to work organization's practices. Our results suggest that more consideration should be given to the impact of technology diffusion on job quality. The increasing constraints on working conditions from innovation and information and communication technology use call for regulation setting. This article is an original contribution in answering the claims for more in-depth research on the links between employment variation and work transformations due to technological change.

**Keywords** Innovation · Technological change · Job quality · Working conditions · Work organization

**JEL code** J24 · J53 · J81 · L22 · O32 · O33

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This article investigates the direct impact of innovation related to work organization practices on job quality. It studies the effects of the adoption of innovation by workers in the workplace over different dimensions of job quality. Based on a microanalysis at the employee level, this study shows how innovation interacts with working conditions, work organization practices, and job quality. This article contributes to supplementing research on technological change–employment nexus. Following a knowledge-based economy perspective (as driven by European strategy Horizon 2020),[1] understanding the role of innovative dynamics in employment is a central issue. The growing concern for innovativeness in both firms' strategies and public policies made industries call for more detailed academic research on this issue. More accurately, tackling the multiple indirect effects of new technology adoption is essential to promote adapted recommendations. The relationship between job quality and innovation through the work organization practices has been little studied, while this is a determinant aspect to understand the employment-technological change nexus better. Thus, our study analyses the relationship between new technology adoption, work organization and working conditions in the European context. To do so, we articulate the framework of job quality and work organization with innovation. This article builds a detailed examination of this relation. Henceforth, we shed new light on this new concern, especially by opening up "the black-box" concept of "job quality" and illustrating its several dimensions. This article brings an original contribution to understanding the influence of new technology diffusion on working conditions, which represents a significant issue for knowledge economy strategies.

The abundant empirical literature on the technology-employment nexus mainly focuses on the impact of innovation on variation in employment level (the net effect of the creation/destruction mechanism of technological change). These studies are diverse in methodology and approach; indeed, we find both theoretical and empirical contributions at different levels, such as country, industry, and firm analysis (Calvino & Virgillito, 2017; Vivarelli, 2014). However, despite this apparent diversity, the emphasis on job creation/destruction's net effect conceals part of the employment impact induced by technological change. Despite well-documented studies on employment variation, the knowledge of the effects of new technology adoption by employees on other job quality aspects (such as working conditions) is lacking. To better understand the complex impact of innovation, it seems essential to clarify the effect of innovation on employees in the workplace beyond the single impact on employment variation and turnover. This study investigates the interactions of innovation with job quality to get a clearer picture of the transformation of tasks induced by technological change and innovation. Our empirical approach's originality is to combine the economics of innovation's analytical tools with those of the job quality framework. This combined perspective constitutes a relatively new way to tackle

[1] https://ec.europa.eu/info/strategy/european-semester/framework/europe-2020-strategy_en.

the issue, both empirically and theoretically. The multidimensional framework of job quality is more comprehensive than the sole category of employment variation (Guergoat-Larivière & Marchand, 2012). Considering only one aspect of the labour issue, such as employment variations, prevents observing the differentiated effects of technological change. Job quality as a concept has the advantage to widen the traditional framework of employment measures, which are commonly based on wage or employment variations. It encompasses numerous dimensions of work, and both contractual aspect and working conditions.

To the best of our knowledge, no extensive and in-depth studies have been conducted from an economic perspective on this specific topic, notably because the interactions are complex and theoretical developments are partly missing. Along with some very recent other studies (Bustillo et al., 2016, 2017; Erhel & Guergoat-Larivière, 2016; Duhautois et al., 2020, Grande et al., 2020), our research constitutes one of the first empirical steps from this perspective within economics. Promoting innovation must be based on a comprehensive view of its impact on employment. Before designing an innovation policy, policy-makers have to consider the benefits for the firms and the net employment creation but also for the employee well-being. Through the job quality framework, our study can address these questions.

Innovation is a concept and a phenomenon that is difficult to isolate, and the scope of its analysis differs among studies, though an expansive definition is relatively easy to establish.[2] Additionally, scholars often distinguish subcategories of innovations to capture more homogeneous realities; the empirical reference is given by the Oslo Manual (2005).[3] In our empirical study, innovation is viewed as adopting and diffusion of new technology (new technology adoption by employees at the workplace). It suggests that this measure of innovation is the broader one since it considers novelty only from the employee perspective (the lower level of novelty).

This study contributes to understanding the link between innovation (as defined above), job quality, and work organization practices. To that end, based on the scheme below (Fig. 1), we aim at answering three main questions. First, how does new technology adoption by employees directly shape job quality (Relationship 1 in Fig. 1)? How do work and task organization practices interact with both innovation (Relationship 2) and job quality (Relationship 3)? Third, does innovation combined with some workplace practices have differentiated effects (Relationship 4)?

In the next section, we discuss the framework used regarding job quality, work organization practices, and innovation. Then, in the third section, we present the methodology and descriptive statistics. In the fourth section, we present the

[2] For instance, the Oxford Living Dictionaries define innovation as a phenomenon that "make changes in something, especially in introducing new methods, ideas, or products." The two manuals of reference in economics of innovation, the *Oxford Handbook of Innovation* (2004) and the *Handbook of the economics of innovation* (2010), point out the holistic and comprehensive aspects of innovation phenomenon leading to a strongly scattered field of research.

[3] The empirical literature on innovation put emphasis on several levels of distinctions between innovation production and innovation adoption, between incremental innovation and radical innovation, and regarding the level of novelty and the type of innovation (technological – process or product – organizational and even marketing), among others.

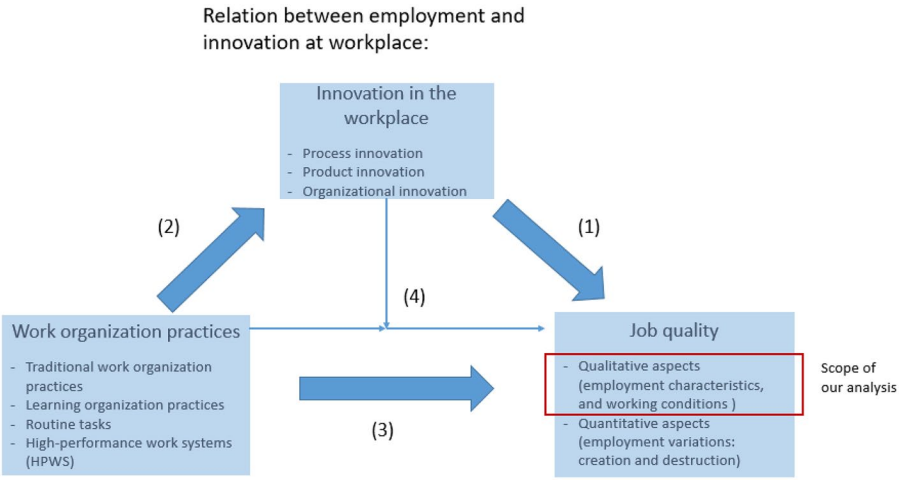


**Fig. 1** Model of the interaction between job quality, innovation, and work organization practices (defined in detail in section II)

empirical strategy followed. A fifth section is dedicated to results and their discussion. Finally, in the last section, we expose some concluding remarks.

## The Relevance of the Job Quality Concept to Observe Work Transformation?

Economic research does not directly tackle the issue of the relationship between innovation and job quality. However, as noted in the introduction, we can identify in different approaches some hypotheses that offer references and guidelines for the empirical method. Neoclassical models provide a limited framework on qualitative aspects at the employee level. The multilevel and multidimensional characteristics of job quality and the peculiar nature of innovation[4] lead us to build the study mainly on neo-institutionalist scholarship. Additionally, qualitative measures of employment and work emerge within the institutionalist approach (Green, 2006; Brown et al., 2007; Bustillo et al., 2011) and, more recently, within the economics of happiness (Clark, 2005); therefore, we have to introduce the literature review with a brief presentation of this topic's corpus. Innovation interacts through complex mechanisms in an evolutionary perspective (Winter & Nelson, 1982). For this reason, to facilitate understanding, we have to distinguish approaches that tend to rely on job quality considered as an input of innovation from those that rely on job quality as an output.

[4] From economic perspectives, innovation leads to several market failures that are difficult to deal with (great uncertainty, non-rival and, to some extent, non-excluable goods, and externalities).

### Job Quality: a Worker-Level Work-Experienced-Based Approach

The issue of job quality is somewhat recent and, since the end of the 1990s, has become a central concern in social sciences (Brown et al., 2007; Bustillo et al., 2011; Green, 2006). At the initiative of the International Labor Organization (ILO) and the European Commission (EC) during the Laeken summit (European Commission, 2001), this issue came up through the notion of "decent work" (Guergoat-Larivière & Marchand, 2012). However, this concept of job quality encompasses many research fields; its definition is broad and variable among scholars. Some focus more explicitly on working conditions, while others focus on the employment quality or the working environment. This concept is multidimensional, and many different methodologies are used. To better identify the differences between approaches, we present some seminal studies on job quality in Table 11. (in the appendix). The job quality methodology presented here is based on a multidimensional view that allows scholars to connect with other research fields, such as education, employment policy, inequality, and, obviously, technological change. By comparison, it represents a substantial departure from the firm or employment models, where all working conditions are often synthesized to the wage rate in a principal-agent case, including compensation mechanisms (e.g. Jensen & Meckling, 1976).

### A Job Quality Framework Built at the Work Level

In our study, we follow the approach developed by Bustillo et al. (2011) and the European Foundation for the Improvement of Living and Working Conditions (Eurofound, 2012, 2017a), which focus mainly on jobs' characteristics at the worker level. The seminal research of Bustillo et al. (2011) restricts the methodology to a narrower definition, focused on worker job quality and omit the institutional setting of the labour market in the definition of job quality. Their empirical framework is based on the European Working Conditions Survey (EWCS), an employee-level survey. Bustillo et al. (2011) retain five dimensions of job quality: pay, intrinsic quality of work (autonomy and skills), employment quality (contract quality and opportunities), physical constraints, working time, and work-life balance. This perspective is work experience-based, and it leaves out institutional settings of job quality, especially at the national level, that are included in most European definitions. Unlike institutionally oriented frameworks such as the seminal analysis by Davoine et al. (2008), Bustillo et al. (2011) include additional individual aspects of job quality, such as autonomy and skills or learning practices. The European Foundation for the Improvement of Living and Working Conditions (Eurofound) provides a similar methodology (Eurofound, 2012, 2017a).

### The Related Concept of Job Satisfaction: Why Both Job Satisfaction and Job Quality Framework Are Complementary

Some recent studies (Clark, 2005, 2015) have developed the concept of job satisfaction within the economics of happiness. Based on the tools of job quality, these

studies seek to measure an employee level of satisfaction for a job and thus relate an objective measure of job quality to a certain level of satisfaction to make policy recommendations. This methodology is convincing since it offers a direct measure of the final goal (satisfaction).[5] However, the empirical work based on this methodology encounters difficulties such as the weak degree of comparability (across countries, times, industries but also individuals), the weak interpretability of the underlying theoretical mechanism and, consequently, its ambiguous implications for public policy (Guergoat-Larivière & Marchand, 2012). Moreover, regardless of workers' satisfaction due to new technology adoption, objectively identifying the changes in working conditions for workers induced by new technology is central. Nevertheless, Clark (2015) recently demonstrated the benefits of articulating both perspectives, subjective and objective measures. The two provide different aspects of job experiences and should be articulated to balance one's limits by the other.

## Does Innovation Lead to Better Job Quality?

### The Overall Effects of Innovation on Employment Variation

The standard innovation models based on the firm-employee model do not explicitly focus on the innovation impact on job quality, neither do the new endogenous growth models (Aghion et al., 1998). Work quality parameters are absent in these models. However, agency theory, once coupled with the direct and positive impact of innovation on productivity, suggests that innovation at the firm level increases wages. This effect comes from an innovation rent-sharing mechanism; it represents neoclassical economics's main argument supporting the positive effect of innovation on job quality.

Most empirical research studying the relationship between employment and innovation focuses on employment variation and aims at evaluating the net employment impact of innovation. This strategy is first confronted with a problem stemming from the numerous differentiated effects among the analysis levels chosen. Theoretically, the net effect comes from two decomposed effects: the labour-saving effect resulting from productivity gains (mainly from process innovation) and compensation effects, such as a new demand via a decrease in prices, an increase in investments, and an increase in incomes or new products from innovation (Calvino & Virgillito, 2017; Vivarelli, 2014).[6]

Empirical studies lead to different conclusions depending on their methodology.[7] Most studies point out a net positive impact of product innovation on the level

[5] Besides it is not a proxy as are job quality framework or wage measures, since it is the direct measure of well-being.

[6] For more detail, see the "Introduction" section of this article, especially "The European Working Conditions Survey" that presents these mechanisms in greater details.

[7] Depending on the level of analysis (firm, industry or country-level), on the types of innovation used, and on the data collected, results could be substantially different: for further details, see the critical review by Calvino and Virgillito (2017).

of employment and a more ambiguous effect of process innovation (Van Reenan et al., 1997; Piva & Vivarelli, 2005, 2017; Harrison et al., 2014; Van Roy et al., 2015; Calvino & Virgillito, 2017). However, these effects decrease for higher levels of analysis (industry and country-level). At the macro (or country) level, the effect is more ambiguous, and even if the literature seems to exhibit a positive effect (Vivarelli, 2014), one can argue that, under a free-trade regime, this positive impact could be compensated by negative externalities in other countries, as shown at the industry level.

Ugur et al. (2017) present a meta-analysis of studies on the relationship between employment and technological change. They conclude that even if product and process innovations seem to increase employment and notably skilled labour demand, the empirical measure is probably smaller than what is frequently claimed due to overlooked selection bias. Moreover, Ugur and coauthors shed light on very heterogeneous results because of the complex measures of innovation (R&D, information and communication technology—ICT—investment, patents, self-reported innovation, etc.). Beyond the limits arising from the aggregation of employment and the measure of innovation, this set of studies mainly focuses on employment variation and not on the impact of innovation on change in work characteristics. Therefore, it neglects a large part of job quality dimensions.

### Firm Environment and Work Organization Practices Interact With Innovative Behaviours

The second set of empirical studies in the neo-institutional framework focuses less on the direct impacts of innovation than on the suitable firm environment for innovation. Through their contribution to the national system of innovation (NSI) concept, Lundvall and Johnson (1994) analyse the interaction between innovation and learning practices at the workplace. Several empirical studies (Fonseca et al., 2018; Lorenz, 2015; Lorenz & Lundvall, 2011; OECD, 2010) support the fact that innovation requires a creative work organization with learning practices and a certain degree of employees' autonomy. We find similar approaches in routine theory or neo-Schumpeterian research (Becker et al., 2005; Dosi et al., 2006; Winter, 2004; Winter et al., 1998) the routine adaptation and the work organization should encourage and foster innovation and technological change.

Finally, some research in management science also highlights how new forms of human resource management (HRM) support innovative behaviour without claiming any exhaustiveness. High-Performance Work System (HPWS) concept stemming from human resource management confirms the relationship between new technology and new HRM. HPWS has several benefits for employees: their minds and decisions are better considered because the main goal is to achieve higher performance through better involvement, motivation, and job satisfaction (Guest, 1997; Laursen & Fauss, 2003; Boxal & Macky, 2009). More recently, Eurofound (2017b) has synthesized the work organization literature hypotheses with those from management sciences, focusing more on case studies and HRM practices. The positive

impact of some work organization practices on innovation is corroborated besides the well-known positive effect on performance (Eurofound, 2013, 2017b). These studies show how learning workplace organization and practices could influence innovation beyond performance.

More precisely, involvement and autonomy practices tend to improve the firm's capacity to better react to environmental changes and innovate, and thus, they increase the probability of innovation adoption. In a slightly different way, learning practices, by improving the knowledge and skill accumulation, instead increases the absorptive innovation capacity of employees and their capacity of innovation production.

However, these works partly neglect the transformative effect of technological change on employment and omit work polarization issues and the upgraded skill effect on the workforce. Indeed, some of these recent analyses suggest the effect of innovation could be related to the employee's absorptive capacity, leading to a better job for some workers but not for all. This mechanism is summarized by the concept of "innovation-conducive job quality" (ICJQ) (Gallie, 2018; Mako & Illéssy, 2018). Thus, to better understand the complex interactions between innovation in the workplace with work practices and employment, we decide to use a triptych, mixing the job quality framework to work organization practices and innovation analysis.

Finally, empirical studies that directly relate to innovation and job quality, including some recent studies such as Bustillo et al. (2016, 2017), Erhel & Guergoat-Larivière (2016), and Duhautois et al. (2020), show, in overall, a positive relationship between job quality and innovation at the country, industry, and employee level. Erhel and Guergoat-Larivière demonstrate the complementarities between sound labour institutions and an efficient innovation system at the country level, represented by Nordic countries. Bustillo et al. (2016) use the EWCS and show a positive link between their job quality index and innovation. Their methodology is particularly relevant because it is the first analysis at the employee level; however, they do not refer empirically to the work organization framework. One issue of our study is thus to extend the scope of the investigation at the employee level and to introduce in the empirical analysis a broader view of job quality with more disaggregated dimensions.

## The Tasks-Based Framework a Way to Combine Work Organization Practices, Innovation, and Job Quality

On the one hand, it appears that a large number of scholarly research focuses on work organization practices, learning activities, and innovation capabilities (routine change, learning organization, high-performance work system—abbreviated HPWS, workplace innovation) from a knowledge economy perspective. On the other hand, employment is related to innovation mainly in terms of employment variation. From these two sets of studies, there is significant evidence that innovation diffusion and adoption, related to work organization practices, play a central role in work transformations and job quality characteristics.

The originality of the empirical work presented in this article stems from the fact that it interrelates these different literature streams in a mediating model directly derived from the conceptual scheme (Fig. 1). To articulate the different approach presented, we assert the tasks-based framework developed by Acemoglu & Restrepo (2018, 2019) based on the seminal article of Zeira (1998). They define a production function based on a combination of tasks provided by labour or capital. In this perspective, new technologies change the tasks carried out but also the distribution of tasks between labour and capital. In our empirical perspective, work organization is the visible task arrangement for a worker. We cannot fully open the black box and observe how new technology rearranges the tasks performed for a worker, but we can assume the change is related to the work organization and induce effects on job quality dimensions since it changes the work's content. This tasks model framework offers a theoretical view that links work organizations (considered as the empirical observation of production function) with new technology adoption. Thus, innovation considered as a new technology adoption directly affects some job quality dimensions (relation 1). However, given that innovation is related to work organization (relation 2), we could assume that innovation indirectly affects job quality (relation 3 is stronger than the 1) or mainly by a combination with the work organization practices (relation 4). Therefore, we show how these interrelations could affect individual performance in terms of job quality.

Besides, a direct analysis at the employee level allows us to observe the dominant effect of innovation in the workplace and whether there are different mechanisms or differentiated effects at stake. Indeed, one hypothesis, which is raised by the aforementioned literature, is the heterogeneous effect of new technologies according to the task content of jobs.

## The European Working Conditions Survey: an Employee-Level Survey Highlighting Job Quality, Work Organization, and Innovation Issues

### The European Working Conditions Survey

Our econometric analysis relies on the European Working Conditions Survey (EWCS) dataset, provided by Eurofound. The data from this survey were collected from European employees working in all industries. We use the fifth wave of the survey conducted in 2010 in all European Union (EU) countries and six neighbour countries (Norway, Macedonia, Turkey, Albania, Kosovo and Montenegro). This survey covers broad aspects of working conditions such as the physical environment, social relationships, and work organization, and it, therefore, corresponds to our research perspective.

This survey has the advantage of encompassing broad dimensions of working conditions while simultaneously providing a variable on new technology adoption. It is a dominant reference for job quality empirical analysis in Europe. However, the major limitation of the EWCS comes from the cross-sectional nature of data, which prevents strictly causal econometric analysis. In contrast, the high number of individuals in the EWCS (36,457 observations) offers a perspective for analysing

the relevant interdependencies. Another argument for using this survey comes from its frequent use by scholars, which allows for comparison and reproducibility. For instance, Holm et al. (2010) use it to capture different work organization patterns, as do Bustillo et al. (2011) and Eurofound (2012, 2017a) to measure job quality empirically.

This survey provides, for 2010, two questions related to technological or organizational change. The first question addresses product or process innovation: "During the last 3 years, have new processes or technologies been introduced at your current workplace that affected your immediate working environment?" (Question 15a). The second question addresses organizational change (rather than innovation): "During the last 3 years, has substantial restructuring or reorganization been carried out at your current workplace that affected your immediate working environment?" (Question 15b). We should thus note that the first question is a more explicit and narrow measure of innovation than the second question, which can encompass very different changes. However, one of the main advantages of these questions comes from the direct relation to the employee work environment; this relation allows us to measure innovation experienced conversely to measures of firm-level innovation, which can induce very different effects among types of employees in the firm. Unfortunately, in the last wave of this survey (2015), the question about technological changes was removed.

To summarize, this survey carries some noticeable advantages, letting us obtain rich information about working conditions and work organization practices and measure workplace innovation. Nonetheless, this dataset raises other concerns: first, it is built cross-sectionally without the possibility of matching individuals with the previous waves of the survey. Second, it tends to get information from workers in a cross-sectional way; thus, it is difficult to deduce causality between variables with certainty. This problem is stressed by the nature of the interrelated phenomena observed, as we observed in the literature review (innovation can cause better or worse working conditions; however, some work organization practices can also improve the level or the occurrence of innovation). However, questions 15a and 15b refer to a past period (they are the only temporal question in the survey); thus, we can assume that these changes occurred before the situations reported by other questions.

Second, the survey is unbalanced regarding the relative attention granted to our topics of interest; employment dimensions are predominant, while just two questions measure innovation.[8] An alternative survey, the Company Innovation Survey (CIS), dedicated to firms' innovation behaviours, yields almost nothing about employment practices and working conditions. The European Company Survey appears to be a good tradeoff, but the survey focuses more on work organizations and less on job quality. Further, there is no information directly reported by employees. The EWCS, thus, seems to be the best option to answer our research questions.

[8] As we pointed out at the beginning of this article, the limited number of previous studies linking qualitative aspects of work and innovation dynamics could explain the weakness of surveys mixing the two.

We consider employees from only 27 EU countries (we excluded Croatia from the dataset as it was not in the EU in 2010). We restrain the analysis to employees in firms with at least five employees (to identify work organization aspects correctly). The dataset is sizeable since it contains 26,232 observations, supporting the robustness of our analysis, although we have to emphasize that the relative share observations by country do not represent their actual population share. Indeed, France, Belgium, Germany, and Italy have larger sample sizes than the other countries.[9]

The dataset lets us implement the empirical strategy to study the impact of new technology adoption on working conditions at the employee level and evaluate the different combinations of innovation and job quality. From this perspective, we present indicators and variables that measure different dimensions of the quality of jobs, work organization practices, and innovation diffusion. Most of these variables are constructed by combining several raw variables (employees' answers from the survey). We build synthetic indexes at the employee level to capture different dimensions of job quality and work organization practices; all our indicators are based on the research of Bustillo et al. (2011) and Eurofound's (2012) methodologies. Work organization practices' measures follow the work of Holm et al (2010). The dataset also provides outstanding control variables based on employee attributes such as age, gender, education, occupation, industry, and country.

Indexes are obtained through two steps. First, a selection of relevant questions is identified for each variable. These questions are first transformed into dummy variables or ordinal variables from 0 to 1 (1 is the maximum value and 0 the minimum). In a second step, each final index is an arithmetic mean of the initial transformed questions. The final indexes vary between 0 and 1. Table 12 (in the appendix) sums up all our variables and presents the questions from the fifth EWCS, which was used to build our aggregate indexes.[10] This index construction methodology is also used because it is similar to those from Eurofound (2012, 2017a) and Bustillo et al. (2011),[11] allowing for comparison.

### Tasks and Work Organization Practices

The first set of variables focuses on work organization practises (Holm et al., 2010), with five indexes; three encompass the learning organization methodology (based on the learning organization concepts), and the two others encompass the more traditional work organization constraint through task division and standardized tasks (measures of more classical HRM and work organization present in the workplace).

[9] We have to note that all samples are as representative as possible in each country, with at least 1000 individuals; thus, the misinterpretation is not too great. Furthermore, to minimize this issue, our regressions, as well as all our descriptive statistics, are weighted by the sample weight variable provided.

[10] For each index, we also conducted a multiple correspondence analysis (MCA) on the question used to check the empirical proximity of the variable and confirm the conceptual links from the questions. In all MCAs, the first dimension represents at least 80% of the inertia and the second always less than 5%. This first test confirms the relevance of our synthetic variables.

[11] For the EWCS the use of index from 0 (minimum) to 1 (maximum)–or 0 to 100–is the widespread in the literature.

In some studies, work organization practices are part of the job quality dimension; here, to test our hypothesis on the interactions among three sets of dimensions, we explicitly separate the work organization's indexes from the job quality indexes. It is important to note that the variables for work organization practices are not exhaustive; they explicitly focus on the concepts presented above in the literature review. Obviously, the boundaries between other job quality dimensions and these work organization measures are blurry; thus, we intentionally accentuate the distinction to more easily test our hypotheses.

The first dimension, involvement practices, is based on the literature on new forms of HRM. As mentioned above, some aspects of the learning organization and the HPWS should foster innovation by supporting workers' initiative and reaction to external shocks effortlessly. However, as we will see below, the relation between innovation and involvement is difficult to restrain to a single direction; thus, we can assume that the relationship is a two-way interrelation. This index contains variables about the capacity of employees to taking initiatives or to reacting to external shocks.

The second dimension contains variables on learning practices; the expected effects of these organizational forms are less reactive to the environment but have better efficiency in absorbing new technology. Learning practices are also a way to use internal more than external flexibility when a new technology is adopted in the workplace. In the case of frequent innovations, we can assume that a firm will foster these practices to improve innovation performance. The dimension contains variables based on both the tasks carried out in a job (such as problem-solving or task complexity) and more formal practices such as training.

The third dimension seems close to the first but refers more to workers' autonomy and working time flexibility. It is a relevant dimension that we decide to separate because the literature relates these aspects to better work performance but not explicitly to innovation capacity. Indeed, autonomy without involvement probably brings less pressure but does not necessarily lead to a better innovation process.

For this reason, we also decide to include a dimension measuring the degree of the task interrelations inside the workplace. Simultaneously, this fourth dimension is based on both hierarchical constraints horizontal constraints; thus, it is a measure of the degree of the deepening division of tasks.

Finally, the last dimension reflects the degree of standardized tasks by measuring the repetitiveness of tasks, and the absence of need of adaptability declared for carried out tasks.

### Job Quality Indexes: a Wide View of the Work-Experienced Dimensions

The second set of variables provides six indexes on job quality directly based on the Bustillo et al (2011, 2016) and Eurofound (2012) methodologies. The dimensions selected for job quality overlap with existing dimensions in the literature and the main dimensions highlighted by Guergoat-Larivière & Marchand (2012). The job quality indexes are very close to scholars' methodologies in the job quality framework, as we presented above. Unlike several methodologies, we extracted

all the learning and autonomy dimension variables from our job quality dimensions to distinguish the two concepts clearly. The first two indexes (pay and employment stability) are focused on contract quality; they are also the closest two to traditional job quality measures. The third index on working time quality also uses a more traditional employment quality measure since it contains nonstandard working time.

The last three indexes, physical constraints, work pressure,[12] and social environment, are those based on the working environment and working conditions in the workplace. We can assume that the variability of these variables will be related to idiosyncratic aspects of the workplace.

Finally, we built an index of job satisfaction based on a subjective view of job quality to check the frequent hypothesis from the literature supporting a positive impact on motivation (one component of job satisfaction) from the HPWS. As we mentioned, some recent studies show the relationship and the complementarities between objective and subjective measures of job quality (Clark, 2015). Thus, by comparison, we wish to identify a potential psychological effect that could induce innovation in the workplace.

#### Innovation Measure: Few but Precise Questions

Additionally, we can use different variables that deal with innovation diffusion, but the survey is limited from that perspective. The Oslo Manual (2005)—the reference for innovation measures and indexes—identifies different forms of innovation (process, product, organization, and marketing) and different degrees of novelty (new to the firm or new to the market), along with different degrees of intensity, by combining different variables such as the impact of innovation within the firm.

The EWCS does not provide any precise measures of innovation; moreover, the measure of innovation is not at the firm level but the employee level and focuses either on new technology (product or process without distinction) introduced into the workplace or on organizational change (without direct mention of innovation). These measures directly result from the two questions mentioned above in the survey (q15a and q15b) as dummy variables. The technological measure is the best innovation variable of the two because more precise; thus, we retain it as our reference variable for innovation. It is a measure of innovation diffusion through new technology adoption by the employees in the workplace. However, it simultaneously encompasses different degrees of novelty and different levels of innovation intensity, as well as different technological degrees. To distinguish different forms of innovation, we use as controls the organizational change measure (provided by question q15b) and an ICT use measure (as frequently used, see, e.g. Ugur et al., 2017). It is a way of confronting the imprecision of our innovation variable by isolating the effect of technological change often coupled with organizational change

[12] Physical constraints and work pressure are two indexes that are built negatively in terms of job quality view. When these indices are high, this means that level of physical constraints and work pressure are high; then, the job quality is low on these dimensions.

and ICT use. Thus, we retain as control innovation variable an ICT use dummy and a dummy of organizational change. These two variables are positively correlated[13] to our variable of new technology adoption. Therefore, using these variables as controls to avoid biased measures of the primary explicative variable is empirically and conceptually relevant.

### Checking the Robustness and Relevance of Indexes

Although these indexes derive from previous analyses, they could be conceptually but not empirically relevant to our dataset. To deal with this issue, we assess the consistency of these variables with some descriptive statistics. First, although our job quality dimensions are theoretically relevant, they can be partly related empirically. Focusing on correlations (Table 13 in the appendices), we also find expected relationships between the dimensions. Each set of variables presents the expected correlations. Work organization practices show that the first three indexes (autonomy and flexibility, learning practices, and involvement) are strongly correlated, suggesting that these practices are often implemented as a wide-ranging policy. Regarding job quality, we observe that good contractual quality leads to better working conditions except in terms of work pressure, which slightly increases on average with employment quality. It is also in line with the literature on job quality; the job quality dimensions reinforce each other (conversely to the wage compensation theory predictions).

Tables 1 and 2 (and Table 14 in the appendix)[14] show the average level of our indexes by occupation based on the one digit ISCO-08 classification. For instance, the physical constraints dimension is almost three times higher for blue-collar workers (ISCO 6 to 9) than for white collars (1 to 3 categories). The same applies (in smaller proportions) to involvement, autonomy, learning practices, pay, and contract quality, for which we observe lower scores on average when we move closer to the low-skilled occupations. Moreover, some expected exceptions improve the relevance of the indexes. For instance, autonomy is noticeably high for group 6 (skilled agricultural workers); in contrast, these workers simultaneously have a lower pay and contract quality level. The other dimensions are less occupation-influenced, as shown by the intergroup differences. For instance, the social environment, the working time quality, and work pressure dimensions have the three weakest intergroup variations.

Given that our innovation variable is declarative and covers extensive aspects of technological change, we need to assess its reliability. The Oslo Manual (OECD, 2005) sets an empirical distinction measuring the different realities of the phenomenon, such as horizontal differences across processes and products (that could also be divided into two categories, goods and services), organizational, and marketing

[13] Coefficients are 0.45 for organizational change and 0.19 for ICT use; both coefficients are significant at the 1% level.

[14] Table 14 shows the average score for each dimension by industry, results are in line with what we could expect.

**Table 1** Average score of job quality dimension by occupation

| Occupations | Pay | Employment stability and advancement | Working time quality | Physical constraints | Work pressure | Social environment | Job satisfaction |
|---|---|---|---|---|---|---|---|
| Managers (ISCO 1) | 0.59 | 0.68 | 0.81 | 0.09 | 0.47 | 0.87 | 0.69 |
| Professionals (ISCO 2) | 0.58 | 0.70 | 0.89 | 0.11 | 0.43 | 0.85 | 0.64 |
| Technicians and associate professionals (ISCO 3) | 0.56 | 0.71 | 0.88 | 0.13 | 0.43 | 0.83 | 0.62 |
| Clerical support workers (ISCO 4) | 0.55 | 0.69 | 0.91 | 0.10 | 0.41 | 0.81 | 0.57 |
| Services and sales workers (ISCO 5) | 0.52 | 0.64 | 0.80 | 0.19 | 0.43 | 0.81 | 0.54 |
| Skilled agricultural. forestry and fishery workers (ISCO 6) | 0.49 | 0.57 | 0.83 | 0.28 | 0.34 | 0.86 | 0.51 |
| Craft and related trades workers (ISCO 7) | 0.52 | 0.64 | 0.86 | 0.34 | 0.39 | 0.82 | 0.53 |
| Plant and machine operators and assemblers (ISCO 8) | 0.52 | 0.62 | 0.79 | 0.27 | 0.40 | 0.78 | 0.49 |
| Elementary occupations (ISCO 9) | 0.51 | 0.60 | 0.87 | 0.28 | 0.36 | 0.76 | 0.49 |
| Total | 0.54 | 0.66 | 0.85 | 0.18 | 0.41 | 0.82 | 0.57 |

Source: EWCS 2010, author's calculations

**Table 2** Average score of work organization practices by occupation

| Occupations | Learning practices | Autonomy and flexibility | Involvement | Degree of task division | Standardized tasks |
|---|---|---|---|---|---|
| Managers (ISCO 1) | 0.63 | 0.71 | 0.78 | 0.54 | 0.27 |
| Professionals (ISCO 2) | 0.65 | 0.54 | 0.63 | 0.48 | 0.28 |
| Technicians and associate professionals (ISCO 3) | 0.61 | 0.51 | 0.56 | 0.52 | 0.32 |
| Clerical support workers (ISCO 4) | 0.49 | 0.44 | 0.45 | 0.50 | 0.36 |
| Services and sales workers (ISCO 5) | 0.45 | 0.40 | 0.43 | 0.46 | 0.32 |
| Skilled agricultural. forestry and fishery workers (ISCO 6) | 0.40 | 0.52 | 0.52 | 0.51 | 0.50 |
| Craft and related trades workers (ISCO 7) | 0.45 | 0.37 | 0.46 | 0.61 | 0.50 |
| Plant and machine operators and assemblers (ISCO 8) | 0.39 | 0.33 | 0.37 | 0.54 | 0.54 |
| Elementary occupations (ISCO 9) | 0.30 | 0.38 | 0.35 | 0.46 | 0.51 |
| Total | 0.51 | 0.46 | 0.50 | 0.51 | 0.37 |

Source: EWCS 2010, author's calculations

innovations. However, as we will see below, we cannot apply such distinctions to the EWCS; however, we can estimate our variable's relevance regarding traditional innovation measures at the macro level. The traditional innovation measures come from several sources, such as the Community Innovation Survey (CIS)—based on the Oslo Manual methodology—but also R&D or innovation, or the number of patent applications. Finally, the European Innovation Scoreboard (EIS) methodology (European Commission, 2015), established by the European Commission, aims to measure a complete institutional set of innovation in a multidimensional manner and to provide a synthetic index titled the Summary Innovation Index (SII). The EIS is considered an influential reference in empirical measures of innovation at the country level.

Thus, intending to test EWCS innovation measure, we use a macro-level correlation between these acknowledged innovation measures and our variables as a comparative analysis.[15] Table 3 shows a positive and relatively strong correlation between the EWCS variable of innovation and the SII. Though positive, we find a lower level of correlation with R&D expenses or declarative innovation (from the CIS). The positive correlations support a certain coherence of the new technology adoption at employee-level and innovation dynamics. The most innovative countries have workers who are more likely confronted with new technology at workplaces. These correlations strengthen the use of the EWCS innovation variable.

The distribution of the new technology adoption at workplaces among occupations and industries is also strongly consistent with what one can expect (Tables 15 and 16). First, the new technology is more frequently faced by high-skilled workers (managers, professionals, and technicians) and, to a lesser extent, for clerical support, trade, and manufacturing workers. On the industry side, most innovation adoptions occurred in the manufacturing industry. Some service industries also have high rates of new technology adoption, such as information and communication and financial and insurance industries, besides public administration, education or human health, and social work sector. This finding confirms the vast scope of this variable, which is not limited to innovation production but instead extends to innovation diffusion.

Finally, observing the scores of all dimensions (not only job quality but work organization practices) by innovation variables, we obtain some first insights into the relation (Tables 4 and 5 below). We can distinguish two sets of variables: those that vary according to the new technology adoption and those that do not. The social environment, the physical constraints, and the working time do not depend on the innovation variable. These work dimensions do not seem to be associated with new technology adoption. In contrast, employment stability, pay, work pressure, and all the work organization dimensions (learning, autonomy, involvement, and task division) seem to be positively associated with innovation adoption.

However, this first descriptive analysis does not consider the structural differences between employees, nor the other variables that could simultaneously be impacted

[15] We also performed a correlation analysis and the industry level between CIS variables and the innovation measure from the EWCS: results were in line with the national level correlation (results are available on request).

by innovation and that impact job quality's dimensions (for instance, occupation). Our model could support the idea that work organization practices adapted to innovation explain the observed better job quality performance rather than a direct effect of innovation diffusion on job quality. We name this idea the mediating effect of work organization on job quality by innovation. Following an econometric perspective, we could say that work organization dimensions would be the omitted variable of the innovation – job quality relation.

### Setting a Work Organization Classification Through a Clustering Methodology

To improve the analysis's clarity, we synthesized our work organization variables in four classes: it allows us to establish an interaction between innovation variable and form of work organization. Based on the Holm et al. (2010) methodology, we conduct a latent class analysis (LCA).[16] We obtain the same classification of work organization, learning-oriented organization, lean-oriented organization, Taylorism-oriented organization, and traditional-oriented organization. The LCA relies on all the dummy variables used in the five work organization indexes; the method provides a specified number of classes[17]Table 6 below displays the average score of each of our work organization indexes for each of the classes obtained. The interpretation of innovation with a dominant form of organization is more straightforward to interpret than an effect from innovation combined with a continuous index.[18]

## Empirical Strategy: Identifying Heterogeneous Effects of Innovation by Work Organizations

Our empirical strategy (see Fig. 1 above) should play a clarifying role, providing a better overview of two relationships: the relationship between new technology adoption and job quality (relation 1) and the relation between new technology adoption and the work organization practises (relation 2). Tackling these two relations together should allow us to determine whether (i) innovation has a direct and distinct effect on job quality, alongside the effect generated by work organization (relations 1 and 3), or (ii) if innovation has heterogeneous effects according to work-organization practices (relation 4). In this respect, we test these different relations of work organization practices and innovation on our different dimensions of job quality through a multivariate linear model.

[16] Based on the following reference manual: McCutcheon (1987) and Collins and Lanza (2013). The LCA has the advantage, compared to hierarchical clustering, to be less constraining in terms of computational power required, especially when the database is large, like in our case.

[17] We check the stability of the four classes' choice (motivated by the Holm et al. (2010) analysis) by the two inertia criteria AIC and BIC. Both support the four classes' choice.

[18] Moreover, work organization experienced is the result of a combination of several work organization practices.

**Table 3** Correlation table of innovation variables at country level

| | New technology adoption (EWCS) |
|---|---|
| Number of patents per million | 0.5438* |
| Total amount of R&D (% of GDP) | 0.5885* |
| SII | 0.7142* |
| Product or process innovation (CIS) | 0.5492* |
| Marketing or organizational innovation (CIS) | 0.4534 |
| Product innovation (CIS) | 0.5749* |
| Process innovation (CIS) | 0.3970 |

Source: CIS 2012 EWCS 2010 and OECD database 2012; star means confidence at 1% level, author's calculations

Empirical literature (displayed in "Does Innovation Lead to Better Job Quality?") stresses three main findings in job quality–innovation relationship:

- The Innovation Conducive Job Quality (ICJQ) hypothesis suggests that some work organization practices (learning practices, HPWS, employee involvement, etc.) tend to increase performances, including both the innovative absorption capacity and the job quality dimensions (except intensity and pressure, which instead tend to increase): Relations 2 and 3 in Fig. 1.
- Thus, innovation could be associated with better jobs without being the direct cause, which would be work organization practices: Relation 4.
- However, the neoclassical view predicts a positive effect on wages when firms increase their profit rate, for instance, by innovating (the bargaining model): Relation 1.

Based on this empirical knowledge and the task-based framework, we make several hypotheses that this empirical analysis will evaluate.

- First, new technology adoption probably increases productivity, displaces some tasks from the labour to the capital, and creates new tasks. These new labour-oriented tasks will increase demand then the stability and wage. This effect would be more pronounced in learning work organization where the labour tasks are more creative and less substitutable. On the contrary, we can observe the opposite effect in standardized work organization for which new technology can increase the division of tasks and reduce the skills need (as is the case for logistic workers, for instance).
- Second, similarly, the physical constraints can be increased or decreased according to the change of tasks content. If task division enhanced, the physical constraints will grow, while if the workers can focus on more creative tasks, they will decline.
- Third, in terms of working time and work pressure, we can assume that new technologies disrupt the work organization then bring new constraints (at least initially). Moreover, the digital dimension of new technology increases the pos-

**Table 4** Scores of the job quality dimensions by the innovation variable

| | | Pay | Employment stability and advancement | Working time quality | Physical constraints | Work pressure | Social environment | Job satisfaction |
|---|---|---|---|---|---|---|---|---|
| New technology adoption in the workplace | Yes | 0.56 | 0.69 | 0.85 | 0.18 | 0.44 | 0.83 | 0.60 |
| | No | 0.53 | 0.65 | 0.86 | 0.19 | 0.39 | 0.81 | 0.55 |
| Total | | 0.54 | 0.67 | 0.85 | 0.18 | 0.42 | 0.82 | 0.58 |

Source: EWCS 2010, author's calculations

**Table 5** Scores of the work organization dimensions by the innovation variable

| | | Learning practices | Autonomy and flexibility | Involvement | Degree of task division | Standardized tasks |
|---|---|---|---|---|---|---|
| New technology adoption in the workplace | Yes | 0.61 | 0.50 | 0.57 | 0.56 | 0.35 |
| | No | 0.44 | 0.43 | 0.46 | 0.47 | 0.38 |
| TOTAL | | 0.51 | 0.46 | 0.50 | 0.51 | 0.37 |

Source: EWCS 2010, author's calculations

sibility of new forms of working time arrangement and internal flexibility whatever the form of work organization.

- Fourth, the social working environment should be only slightly directly affected by new technology. However, two mechanisms could play a role; we can assume that learning organization workers, more prepared for novelty than the other ones, will welcome more positively innovation. Also, new technology adoptions could reflect a positive environment in terms of projects and activities for the workers. Finally, the expected effects on job satisfaction are uncertain; similar mechanisms to the social environment can be assumed. More generally, it mostly depends on the relationship between job satisfaction and job quality dimensions.

To test these hypotheses, we implement multivariate OLS regressions, where job quality indexes are the dependent variables and the innovation variable (new technology adoption by the employee at the workplace) is the primary explanatory variable of job quality.

Even if the variable of innovation adoption refers to the three previous years, we cannot fully provide a causality analysis since the database is built cross-sectionally. Instead, we perform a controlled correlation analysis between new technology adoption and the variables of work organization practices with job quality. Multivariate weighted regressions are run with the ordinary least squares (OLS) method performed by maximum likelihood[19]In all our regressions, we control not only by countries and industries (NACE rev 2 – one digit) but also by education (three levels), occupations (ISCO-08, one digit), firm size, gender, and age. The use of multivariate OLS regression is both motivated by the structure of the dataset and our variables' characteristics. Each variable varies from 0 to 1 (indexes and dummies), and all are self-reported by employees; hence, the variation is homogeneous. The multivariate regression allows correlation between standard errors and then address issues from the interdependencies of the different job quality dimensions. Our specification assumes linear

[19] The regressions are weighted by the survey weight provided to take into account the selections bias of the dataset. It is also a way to reduce the heteroscedasticity, even if in our case the use of normalized indexes and dummy variable already partly manage it.

**Table 6** – Scores of the work organization dimensions by classes

| Classes | Learning practices | Autonomy and flexibility | Involvement | Degree of task division | Standardized tasks |
|---|---|---|---|---|---|
| Taylorism oriented organization | 0.27 | 0.20 | 0.23 | 0.42 | 0.45 |
| Traditional oriented organization | 0.35 | 0.52 | 0.40 | 0.29 | 0.37 |
| Learning oriented organization | 0.66 | 0.58 | 0.64 | 0.49 | 0.29 |
| Lean oriented organization | 0.50 | 0.36 | 0.51 | 0.75 | 0.48 |
| Total | 0.51 | 0.46 | 0.50 | 0.51 | 0.37 |

Source: EWCS 2010, author's calculations

relationships for each explanatory variable.[20] We focus the analysis on the interaction term between work organization and innovation. The OLS method is entirely appropriate to observe heterogeneous relations of innovation according to different work organization practices. Robustness checks based on different specifications are presented after the results.

For each dimension of job quality, we conduct three regressions. The first one contains only the innovation variable and socio-economic control variables (age, gender, level of education, occupation, firm size, industry, and country). In the second set of regressions, we add the two complementary innovation variables (organizational change and ICT use) and all the work organization practice variables. It allows to identify the variation of the effects stemming from the first model and each direct relationship of these new variables with job quality dimensions. In the last set of regressions, we add the interaction terms between the work organization practices and innovation.

Compared to the first regression model, the second one distinguishes the own effects of new technology adoption from the effects of work organization practices, which are often related, on job quality outcomes. The third set of regressions (based on the third model) tries to identify innovation effects from how implemented. By combining the innovation variables with the work organization class, we can identify more clearly the differentiated innovation impact according to the work environment.

## Model (OLS)

$$\textit{First model}: \quad Y_{i=\beta_0+\beta_1 X_i+\beta_2 C_i+\varepsilon_i} \tag{1}$$

$$\textit{Second model}: \quad Y_{i=\alpha_0+\alpha_1 X_i+\alpha_2 Z_i+\alpha_3 C_i+\varepsilon_i} \tag{2}$$

[20] Except for the age, we assume a quadratic relation, especially because age as a proxy of career advancement is known to have nonlinear effects on employment characteristics.

$$Third\ model: \quad Y_{i=\mu_0+\mu_1 X_i+\mu_2 Z_i+\mu_3 X_i Z_i+\mu_4 C_i+\varepsilon_i} \tag{3}$$

where

$Y_i$: Job quality indexes.

$X_i$: Innovation variable (new technology adoption).

$Z_i$: Work organization variables (or classes) and ICT use.

$C_i$: Structural control variables (industry, occupation, firm size, level of education, country, gender, and age of the employee).

$\varepsilon_{i.}$ The residual that follows a normal distribution with a mean of 0 and a stable standard deviation.

## Results: the Mediating Role of Work Organization Practices

### Innovation Is Associated with Better Employment Conditions but Higher Pressure at Work

Our regression focuses on job quality dimensions and job satisfaction as dependent variables (Tables 7, 8, and 9 below at the end of this section[21]). First, without controlling for work organization practices, we find results that are in line with previous studies. Innovation in the workplace is associated with better employment conditions (better pay and more contractual stability). Simultaneously, the work requires more investment for the employee since, on average, new technology adoption leads to more pressure, more health and physical constraints and weaker working time quality at work. This ambivalent first effect supports the well-known concept of wage compensation: jobs are more demanding, and consequently, the employer has to offer better contractual conditions. However, innovation also seems related to better job satisfaction and a better social environment. This observation could result from the motivating dimension of the innovative workplace. Indeed, as frequently pointed out,[22] an innovative environment can be viewed by some employees as a source of motivation. For instance, this effect is particularly relevant in the case of startups.

However, these effects from the broad innovation variable probably cover very different realities of innovation. As seen at the beginning of the article, innovation is often jointly implemented with different organizational practices. We add innovation control variables (ICT use and organizational change) and work organization variables in the model to refine these preliminary results.

[21] Tables 5.1, 5.2, and 5.3, show the regression without the controls for the structural employee's characteristics. All econometric results, complete tables and codes are available on request.

[22] A rich literature on workplace innovation stresses the link between an innovation environment and employees' motivation and well-being (Aalbers et al., 2013; Eurofound, 2013 and Fu et al., 2015).

**Table 7** Econometric results with the job quality dimensions (intrinsic dimensions) as dependent variables (linear regression, OLS)

| Explicative variables | Pay | | | Employment stability and advancement | | | Working time quality | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Model 1** | **Model 2** | **Model 3** | **Model 1** | **Model 2** | **Model 3** | **Model 1** | **Model 2** | **Model 3** |
| New technology adoption at workplace | 0.00472*** | 0.00420** | 0.00939*** | 0.0249*** | 0.0209*** | 0.0226* | −0.0161*** | −0.00833* | −0.00289 |
| | (3.43) | (98) | (3.35) | (7.01) | (5.25) | (2.44) | (−4.44) | (−2.05) | (−0.30) |
| Substantial reorganization at workplace | | 0.0000772 | 0.00000413 | | −0.0194*** | −0.0180*** | | −0.0204*** | −0.0225*** |
| | | (0.05) | (0.00) | | (−4.78) | (−4.43) | | (−4.93) | (−5.41) |
| ICT use | | 0.00500** | 0.00533*** | | 0.0231*** | 0.0221*** | | 0.0401*** | 0.0324*** |
| | | (3.20) | (3.36) | | (5.49) | (5.25) | | (9.62) | (7.81) |
| Learning practices | | 0.00480 | | | 0.0830*** | | | 0.00546 | |
| | | (1.72) | | | (11.01) | | | (0.71) | |
| Autonomy and flexibility | | 0.00873* | | | −0.0450*** | | | −0.0443*** | |
| | | (2.41) | | | (−5.31) | | | (−5.26) | |
| Involvement | | 0.00269 | | | 0.0383*** | | | 0.00825 | |
| | | (1.17) | | | (6.16) | | | (1.33) | |
| Degree of tasks division | | −0.0112*** | | | −0.00936 | | | −0.0434*** | |
| | | (−4.01) | | | (−1.25) | | | (−5.72) | |
| Degree of standardized tasks | | −0.00434 | | | 0.000917 | | | 0.0649*** | |
| | | (−1.27) | | | (0.10) | | | (7.12) | |
| **Taylorism organization (reference)** | | | **Reference** | | | **Reference** | | | **Reference** |
| Traditional organization | | | 0.00758** | | | 0.00817 | | | 0.0280*** |
| | | | (3.21) | | | (1.11) | | | (4.22) |
| Learning organization | | | 0.0100*** | | | 0.0331*** | | | 0.0153* |
| | | | (4.81) | | | (5.01) | | | (2.55) |
| Lean organization | | | 0.00336 | | | 0.0176* | | | −0.0173* |
| | | | (1.35) | | | (2.43) | | | (−2.54) |

**Table 7** (continued)

| Explicative variables | Pay | | | Employment stability and advancement | | | Working time quality | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Model 1** | **Model 2** | **Model 3** | **Model 1** | **Model 2** | **Model 3** | **Model 1** | **Model 2** | **Model 3** |
| New technology adoption at workplace* Traditional organization | | | −0.00649 | | | 0.0295* | | | −0.00155 |
| | | | (−1.48) | | | (2.28) | | | (−0.12) |
| New technology adoption at workplace* Learning organization | | | −0.00485 | | | 0.00177 | | | −0.00796 |
| | | | (−1.44) | | | (0.17) | | | (−0.74) |
| New technology adoption at workplace* Lean organization | | | −0.00865* | | | 0.00139 | | | −0.00537 |
| | | | (−2.26) | | | (0.12) | | | (−−0.45) |
| Intercept | 0.438*** | 0.442*** | 0.435*** | 0.535*** | 0.517*** | 0.523*** | 0.924*** | 0.933*** | 0.920*** |
| | (49.47) | (47.74) | (48.24) | (24.86) | (23.85) | (23.99) | (48.80) | (47.92) | (47.44) |
| Number of Obs | 20,035 | 20,035 | 20,035 | 23,408 | 23,408 | 23,408 | 23,408 | 23,408 | 23,408 |
| Control variables | Age, Age$^2$, Gender, Education, Occupation, Country, Firm size, Industry | | | | | | | | |

Source: EWCS 2010, author's calculations. t-statistics in parentheses, *** $p<0.001$, ** $p<0.01$, * $p<0.05$

**Table 8** Econometric results with the job quality dimensions (working environment dimensions) as dependent variables (linear regression, OLS)

| Explicative variables | Physical constraints | | | Work pressure | | | Social environment | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Model 1** | **Model 2** | **Model 3** | **Model 1** | **Model 2** | **Model 3** | **Model 1** | **Model 2** | **Model 3** |
| New technology adoption at workplace | 0.0261*** | 0.0168*** | 0.0386*** | 0.0337*** | 0.00902* | 0.0170 | 0.0149*** | −0.00233 | −0.00385 |
| | (7.43) | (4.40) | (3.46) | (7.93) | (2.01) | (1.58) | (3.61) | (−0.53) | (−0.31) |
| Substantial reorganization at workplace | | 0.0120** | 0.0117** | | 0.0248*** | 0.0286*** | | −0.0117** | −0.00448 |
| | | (3.08) | (3.00) | | (5.48) | (6.25) | | (−2.62) | (−0.94) |
| ICT use | | −0.0497*** | −0.0527*** | | 0.0319*** | 0.0335*** | | −0.00585 | 0.00935 |
| | | (−13.18) | (−14.21) | | (6.47) | (6.82) | | (−1.25) | (1.91) |
| Learning practices | | 0.00357 | | | −0.00311 | | | 0.0696*** | |
| | | (0.48) | | | (−0.36) | | | (8.25) | |
| Autonomy and flexibility | | −0.0588*** | | | −0.0405*** | | | 0.0427*** | |
| | | (−7.72) | | | (−4.35) | | | (4.60) | |
| Involvement | | 0.0128* | | | −0.0273*** | | | 0.178*** | |
| | | (2.21) | | | (−3.70) | | | (25.84) | |
| Degree of tasks division | | 0.117*** | | | 0.173*** | | | 0.0342*** | |
| | | (16.49) | | | (20.54) | | | (4.13) | |
| Degree of standardized tasks | | 0.0414*** | | | −0.126*** | | | 0.00223 | |
| | | (4.94) | | | (−12.88) | | | (0.23) | |

**Table 8** (continued)

| Explicative variables | Physical constraints | Work pressure | Social environment |
|---|---|---|---|
| **Taylorism organization (reference)** | **Reference** | **Reference** | **Reference** |
| Traditional organization | −0.0163** | −0.0475*** | 0.0433*** |
| | (−2.75) | (−6.28) | (5.42) |
| Learning organization | 0.0148* | 0.00417 | 0.0770*** |
| | (2.56) | (0.59) | (10.63) |
| Lean organization | 0.0876*** | 0.0745*** | 0.0541*** |
| | (12.17) | (9.58) | (6.69) |
| New technology adoption at workplace* Traditional organization | −0.0206 | −0.0183 | 0.0125 |
| | (−1.56) | (−1.25) | (0.73) |

**Table 8** (continued)

| Explicative variables | Physical constraints | | | Work pressure | | | Social environment | | |
|---|---|---|---|---|---|---|---|---|---|
| New technology adoption at workplace* Learning organization | | | −0.0272* | | | −0.00380 | | | 0.00929 |
| | | | (−2.32) | | | (−0.31) | | | (0.69) |
| New technology adoption at workplace* Lean organization | | | −0.0242 | | | −0.0132 | | | 0.0208 |
| | | | (−1.80) | | | (−1.00) | | | (1.41) |
| Intercept | 0.138*** | 0.0738*** | 0.113*** | 0.335*** | 0.294*** | 0.318*** | 0.881*** | 0.796*** | 0.840*** |
| | (6.64) | (3.56) | (5.48) | (14.66) | (12.54) | (13.97) | (40.00) | (37.09) | (37.51) |
| Number of obs | 23,408 | 23,408 | 23,408 | 23,408 | 23,408 | 23,408 | 23,407 | 23,407 | 23,407 |
| Control variables | Age, Age$^2$, Gender, Education, Occupation, Country, Firm size, Industry | | | | | | | | |

Source: EWCS 2010, author's calculations. t-statistics in parentheses, *** $p<0.001$, ** $p<0.01$, * $p<0.05$

**Table 9** Econometric results with the job satisfaction as dependent variables (linear regression, OLS)

| Explicative variables | Job satisfaction | | |
|---|---|---|---|
| | **Model 1** | **Model 2** | **Model 3** |
| New technology adoption at workplace | 0.0157** | 0.00714 | −0.0116 |
| | (2.61) | (1.12) | (−0.65) |
| Substantial reorganization at workplace | | −0.0390*** | −0.0323*** |
| | | (−6.18) | (−4.89) |
| ICT use | | 0.0110 | 0.0313*** |
| | | (1.66) | (4.58) |
| Learning practices | | 0.111*** | |
| | | (8.93) | |
| Autonomy and flexibility | | 0.0983*** | |
| | | (7.48) | |
| Involvement | | 0.209*** | |
| | | (21.25) | |
| Degree of tasks division | | −0.0571*** | |
| | | (−4.86) | |
| Degree of standardized tasks | | 0.0376** | |
| | | (2.69) | |
| **Taylorism organization** | | | **Reference** |
| Traditional organization | | | 0.0622*** |
| | | | (5.22) |
| Learning organization | | | 0.0851*** |
| | | | (7.90) |
| Lean organization | | | 0.0355** |
| | | | (2.91) |

**Table 9** (continued)

| Explicative variables | Job satisfaction | | |
|---|---|---|---|
| | **Model 1** | **Model 2** | **Model 3** |
| New technology adoption at workplace* Traditional organization | | | 0.0365 |
| | | | (1.54) |
| New technology adoption at workplace* Learning organization | | | 0.0328 |
| | | | (1.69) |
| New technology adoption at workplace* Lean organization | | | 0.0394 |
| | | | (1.84) |
| Intercept | 0.688*** | 0.605*** | 0.644*** |
| | (20.55) | (18.34) | (18.92) |
| Number of Obs | 23,405 | 23,405 | 23,405 |
| Control variables | Age, Age$^2$, Gender, Education, Occupation, Country, Firm size, Industry | | |

Source: EWCS 2010, author's calculations. t-statistics in parentheses, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

### The Innovation Effects on Satisfaction and Social Environment Are Partly Due to Work Organizational Practices

From the second set of regressions, the first interesting result comes from the possible indirect effect of new technology adoption. Once work organization practices are added as control, the innovation variable has lower effects on job quality, even though they remain significant for all dimensions except for the social environment dimension of job quality and job satisfaction.

Regarding work organization practices, we find the traditional and well-known positive relationship with job quality. Involvement, autonomy and flexibility, and learning practices have relatively positive relations with job quality indexes and job satisfaction. Nevertheless, some negative associations must be noticed. Autonomy and flexibility are related to higher pay but lower job stability and working time quality. Similarly, employee involvement has a positive relationship with physical constraints. As the literature on work organization practices points out (Eurofound, 2013; Fu et al., 2015; Greenan et al., 2012; OECD, 2013), the learning organization practices can be a means to counterbalance the negative effect of the in-depth degree of tasks division. An enhanced division of tasks is indeed associated with lower job quality dimensions except for the social environment. The standardized tasks have ambiguous effect; it is linked to a better working time quality and a lower level of work pressure, but a higher level of physical constraints. These effects are partly in line with routine tasks theory. Indeed, routine is a way to reduce uncertainty (then work pressure and unexpected working time) by increasing the physical constraints (especially ergonomic ones from repetitiveness).

Moreover, we observe either negative relations or the absence of relation from the reorganization variable[23] on all job quality dimensions (no effect on the contractual dimension, pay, and employment). The social environment, quality of working time, pressure at work, physical constraint, and job satisfaction seem to deteriorate when reorganization occurs. These observations are relatively difficult to interpret, although the literature on organizational change (Lam, 2004) underlines different strategies according to the innovator's status. In cases where new technology adoption seeks to increase cost-efficiency, organizational restructuring is more binding for the employee (efficiency's goals) than in cases of new technology production (new product strategy), where new organizational practices aim to increase the innovativeness of employees (creativity goals). We could assume that, here, we capture the first effect. Also, some recent organizational change, mainly in services, aims to increase internal and external flexibility; for instance, such a strategy could explain some decreases in job quality (Michie & Sheehan, 2003; Miles, 2010; Preenen et al., 2015).

Otherwise, ICT use is relatively in line with what we could expect from previous works (Greenan et al., 2012; Rubery & Grimshaw, 2001). It has a somewhat positive effect on employees simultaneously in pay and employment stability and

[23] Note that this variable of organizational change is strongly correlated with our main variable of innovation (technology adoption).

most working conditions, except work pressure. Indeed, ICT use seems to be associated with more pressure at work that may come from the continuous and permanent links with colleagues and managers. Moreover, the capacity to work remotely could lead to more pressure in terms of deadlines (Eurofound, 2020). In a similar vein, we could think about the effects of digital platforms leading to more control for workers (Eurofound, 2018a, 2018b; Greenan et al., 2012; ILO, 2018; Pesole et al., 2018).

#### Different Work Organization Could Lead to Different Innovation Implementation

Finally, in the last set of regressions, we try to refine our measure of innovation by combining it with work organization classes; we aim at obtaining measures of different types of implemented innovation. We can assume that new technology adoption has heterogeneous effects on job quality depending on work organization strategies. This third model confirms that the innovation variable has different relations with specific job quality dimensions, whereas others are not impacted. The third set of regressions displays interaction terms between work organization classes and the innovation variable to observe differentiated effects of adopting new technology among these classes. As Taylorism is the class reference, the full effect of innovation is a combination of the direct effect with interaction effects (except for Taylorism organization, the reference). First, we see that innovation has a more substantial effect on the contractual dimensions of job quality than on the working environment ones. Pay and employment stability are reinforced when technology adoption occurs, but in lean organization, the effect on pay is almost null. Otherwise, traditional organization workers benefit more from innovation in terms of employment stability. The effect of new technology adoption remains positive on the work pressure for all organizational forms except for learning organization, where the effect is reduced. The other dimensions do not appear significant.

These results confirm the ambiguous effects that new technology adoption may have on employees and their jobs. Generally, heterogeneous effects of new technology adoption depending on work organization form do not appear clearly. Concerning the hypotheses previously presented, several attention-getting findings arise.

First, the labour-friendly aspect of new technology is common to all forms of work organization. Of course, this relation is expected and consistent at the employee level, given that the potential technology-replaced jobs are not observed in the survey. It, however, reflects the view of a skill-increased dynamic instead of a deepen tasks division from technology adoptions. This positive association on contractual aspects (pay and stability of jobs) seems less pronounced for lean organization workers, maybe due to the skill reduction from task standardization. Second, higher physical constraints due to technology adoption are not associated with learning organization, as expected. This finding is in line with our second hypothesis, for the more tasks' division-oriented organizations, innovation implies higher physical constraints for their workers. In the previous model, we confirm our hypothesis concerning the work pressure and the working time arrangement; innovation seems to deteriorate the working time quality and increase the work pressure. Nevertheless,

we do not find clear and distinct patterns for work organization forms. These innovative constraints seem not interrelated to work organization practices. Finally, as expected, the social environment and job satisfaction are not influenced by innovation once work organization practices considered.

However, this interpretation, coming from the preliminary results, must be approached with caution. First, our empirical analysis does not provide causality but correlation, and second, innovation, as defined in this article, is a broad concept that includes very different realities, such as radical innovation close to the technology frontier and more incremental (or adoption) innovation processes with a goal of cost reduction.

Otherwise, the direct relations of the four classes of work organization are in line with our second model. Taking Taylorism-oriented organization as a reference, we see that learning organization always has better job quality dimensions except for work pressure—that is weakly higher.[24] The traditional form of organization also seems to be associated with better quality in terms of pay and working environment[25]; however, it does not offer better employment stability and advancement than the Taylorism form. Finally, the lean organization is the form that is closer to the job compensation model. It represents better employment conditions with investment in the social environment. As a counterpart, lean organization induces higher constraints in working time, work pressure, and physical constraints. All these three forms of organization, in comparison with Taylorism, are associated with better subjective job quality.

In terms of control variables,[26] the usual relationships are observed. Job quality is, on average, higher in larger firms and for high-skilled workers with a high level of education. The agricultural sector has a lower job quality, and the manufacturing sector is riskier and offers the lowest employment stability. Finally, as expected, the workers in service sectors experience the most intense work pressure. Furthermore, age presents concave effects as frequently outlined in employment studies.

To synthesize the insights from the three sets of regressions, we could assume that the significant positive link between innovation and job quality is, in reality, strongly mediated by work organization practices such as learning, involvement, and autonomy, especially for the work environment. Depending on these work organization practices, innovation could contribute to a virtuous circle or a vicious circle.

### Robustness of the Results

Results come from multivariate regressions; hence, dependent variables are simultaneously regressed on the same independent variable allowing correlation between

[24] This is in line with several studies confirming that new forms of work organization (HPWS) offer better contractual conditions, and better work environment, but at the same time increase demand and pressure through the higher involvement and level of responsibility offered (Rubery & Grimshaw, 2001; OECD, 2010; Greenan et al., 2012; Eurofound, 2015; Gallie, 2018).

[25] It is the less restrictive form of organization for the employee.

[26] Because control variables are numerous, they are not reported here but available upon request.

standard errors. Besides, the variance—covariance matrix of the estimators—is obtained through the observed information matrix based on the log-likelihood function (which is robust to nonconstant variance). More, other specifications were used to assess the stability of our results. Alternative sets of regressions with clustered error (on countries and sectors) or multilevel specifications give similar results. Also, some differences in the variables used, such as interaction terms between innovation variable with work organization dimensions instead of work organization classes, give similar results. Finally, we also performed regressions on subsamples by country, industry, and occupation. We do not notice significant differences in innovation effect among industries and countries, reflecting somewhat homogeneous relations. European countries do not seem to have noticeable divergent innovation models, at least when we consider a broad measure of technology diffusion. The effects observed by occupation (high-skilled, middle-skilled, and low-skilled) are close to those obtained by work organization, as these two variables are related.[27]

## Concluding Remarks

From the perspective of improving our understanding of the global effect of innovation on employment practices, our article focuses on the qualitative impact of innovation in the workplace. In this respect, we discuss the different contributions of the literature regarding the link between innovation and job characteristics to formulate our hypotheses. Based on an empirical methodology, which comes from the job quality and work organization practices frameworks, we try to build a new model that underlines the controlled relationships among innovation, work organization practices, and job quality dimensions. As revealed above, the main limits of our work concern, on the one hand, the difficulty of conducting analyses for causality and, on the other hand, the relative weakness of the innovation variable. These limits require new research able to overcome these issues. This analysis also underlines the need to develop improved databases that should deeply relate employment (working conditions and work organization practices) to the innovation environment (input, output, strategy, types of innovation, etc.).

However, our study offers an original empirical analysis that relies upon broad aspects of jobs and employment with technological change at employee-level. It turns out that our empirical analysis emphasizes some noteworthy and new empirical facts. The final table (Table 10) sums up all the results from our different models; it highlights some robust and reliable relations that we have to present.

First, it confirms that innovation must be studied as a multidimensional phenomenon interrelated to employment institutions, working conditions, and work organization practices. From this perspective, innovation diffusion seems to have heterogeneous effects according to the types of innovation and the firm environment where it occurs, but also the dimensions of job quality studied. This finding supports the research program of complexity in studying the effect of innovation on employment (Robert and Yoguel, 2016).

[27] As presented in Table 2, the work organization practices are strongly influenced by the occupation.

**Table 10** Summary of the findings from the different models

| | | Pay | Employment stability and advancement | Working time quality | Physical constraints | Work pressure | Social environment | Job satisfaction |
|---|---|---|---|---|---|---|---|---|
| Innovation | Direct effect | (+) | (+) | (−) | (+) | (+) | NS | NS |
| | Heterogeneous effects from organizational forms | No more effect for lean organization | Higher effect for traditional organization | NS | Reduced effect for learning organization | NS | NS | NS |
| Tasks and work organization practices | Direct effect | Learning practices (+)<br>Autonomy and flexibility (+)<br>Degree of tasks division (−)<br>ICT use (+) | Learning practices (+)<br>Autonomy and flexibility (-)<br>Involvement (+)<br>ICT use (+) | Autonomy and flexibility (−)<br>Degree of tasks division (−)<br>Standardized tasks (+)<br>ICT use (+)<br>Involvement (+) | Autonomy and flexibility (−)<br>Degree of tasks division (+)<br>Standardized tasks (+)<br>ICT use (−) | Autonomy and flexibility (−)<br>Involvement (−)<br>Degree of tasks division (+)<br>Standardized tasks (−)<br>ICT use (+) | Learning practices (+)<br>Autonomy and flexibility (+)<br>Involvement (+)<br>Degree of tasks division (+) | Learning practices (+)<br>Autonomy and flexibility (+)<br>Involvement (+)<br>Degree of tasks division (−)<br>Standardized tasks (+) |

Source: EWCS 2010. Summary of the econometrics results

Second, as some scholars describe it, innovation, particularly new technology adopted by employees, is associated with organizational practices, especially those that stimulate involvement, autonomy, and learning practices (learning organization/HPWS), as well as more traditional forms of work task division (*relation 2 on our scheme*). These associations have to be considered when one studies the effect of innovation on employment outcomes and job quality. It leads to the claim of direct effects of innovation and indirect ones from the work organization practices.

Third, from this perspective, innovation seems to have mixed direct effects on job quality dimensions. Contractual aspects and physical constraints are more directly related to new technology adoption by employees (relation 1*)*, unlike the other dimension of job quality (more oriented to the working environment), mainly related to work organization practices (relation 3*)*. Thus, the frequent positive relationship stressed by previous studies could partly come from the good work organization practices associated with innovation.

Fourth, we confirm previous studies' results regarding the positive impact of the learning organization and the HPWS on job quality aspects (relation 3*)*. However, this study underlines some mixed effects. All work organization practices—gathered under the name HPWS—positively affect working environment aspects, especially social environment and job satisfaction. Conversely, more traditional organizational practices such as task division and teamwork increase the physical constraints, the work pressure and reduce the quality of working time quality. Regarding the contractual aspect of job quality, employee involvement and learning practices have relatively positive effects. Our analysis also confirms the ambivalent role of ICT use on job quality. If it improves contractual aspects of jobs and some working conditions (improves working time quality and reduces physical constraints), ICT use amplifies the work pressure. Finally, if some effects are reduced or disappear when work organization practices mediate innovation, new technology adoption has relatively few pronounced effects according to the organizational form (relation 4).

To conclude, this study brings some worthy of interest evidence and fits well with the different views of innovation concerning employment; however, further research remains necessary. Our methodology contains several limits that we presented; it, however, allows a more complex and detailed analysis. Our empirical model requires further studies based on better measures of innovation following the Oslo Manual methodology. Further work in this field must distinguish innovation diffusion and innovation production as well as types and intensity of innovation, considering that different characteristics of innovation lead to different implications. Similarly, measuring innovation especially based on new ICT diffusion such as digital platforms could be particularly relevant. Such distinctions would make it possible to investigate the causality of the effect more precisely. Finally, the impact of innovation on work organization practices and job quality in the workplace should be articulated with the quantitative impact of innovation on employment (destruction and creation of employment) to get a clearer picture of the total effect to better respond to political and societal expectations.

## Appendix

**Table 11** Summary of key studies on job quality

| Author | Objective | Dimensions | Level of analysis |
|---|---|---|---|
| Guergoat-Larivière, Marchand (2012) | Literature review | –Health and working conditions<br>–Earnings<br>–Working times and work-life balance<br>–Security employment and Social protection<br>–Social dialogue and collective representation<br>–Life-long learning | Literature review |
| Erhel, Davoine (2008) | Improve Laeken methodology, a new reference of the quality of jobs analysis | –Socio-economic security (i.e. decent wages and secure transitions)<br>–Skills and training<br>–Working conditions<br>–Ability to combine work and family life, and promotion of gender equality | National level with macro variables |
| OECD (2013) | Proposal of a tridimensional measure of Job quality | –Earnings quality<br>–Labor market security<br>–Quality of the working environment | National level with macro variables |
| Bustillo et al. (2011) | Provide an individual measure of job quality-focused of personal features | –Pay<br>–Intrinsic quality of work<br>–Employment quality<br>–Workplace risks<br>–Working time and work-life balance | Individual-level with micro variables (from survey EWCS) |
| Eurofound (2012, 2017) | Establish a measure of job quality backed on the European Working Conditions Survey | –Earnings<br>–Prospects<br>–Intrinsic job quality<br>–Working time quality | Individual-level with micro variables (from survey EWCS) |

**Table 12** Summary of the variables constructed using the EWCS 2010

| | Index | Questions used in EWCS 2010 | Source | Construction |
|---|---|---|---|---|
| Work organization practices variables | Involvement practices | q49b/q51c/q51d/q51o | Derived from Bustillo et al. (2016), Eurofound (2012), and Holm et al. (2010) | Mean of dummy or categorical variables (0 to 1) |
| | Learning practices | Cognitive dimension: q49c/q49d/q49e/q49f/q51i | Derived from Bustillo et al. (2016), Eurofound (2012), and Holm et al. (2010) | Mean of dummy or categorical variables (0 to 1) |
| | | Training: q61a/q61c | | |
| | Autonomy and internal flexibility | Internal Flexibility q37d/q37a/q39/q43 | Derived from Bustillo et al. (2016), Eurofound (2012), and Holm et al. (2010) | Mean of dummy or categorical variables (0 to 1) |
| | | Work autonomy: q50a/q50b/q50c/q51e/q51f | | |
| | Degree of task division | q46a/q46c/q46e/q49a/q55a/q56/q62a | Derived from Bustillo et al. (2016), Eurofound (2012), and Holm et al. (2010) | Mean of dummy or categorical variables (0 to 1) |
| | Standardized tasks | q24f/q44a/q44b/q46b/q46d/q47/q54 | Inspired by Autor et al. (2003, 2013) | Mean of dummy or categorical variables (0 to 1) |
| Job quality dimensions | Earnings index (from hourly income) (+) | ef10/ef11/q18 | Derived from Eurofound (2012) | Normalized index from 0 to 1 |
| | Contract quality and career progression (+) | Employment statute: q6/q7 | Derived from Bustillo et al. (2016) and Eurofound (2012) | Mean of dummy or categorical variables (0 to 1) |
| | | Job security: q12/q14a/q37b/q77a | | |
| | | Prospects: q14b/q77c | | |
| | Working time quality and work intensity (+) | Duration quality: q18/q19/q36 | Derived from Bustillo et al. (2016) | Mean of dummy or categorical variables (0 to 1) |

**Table 12** (continued)

| | Index | Questions used in EWCS 2010 | Source | Construction |
|---|---|---|---|---|
| | | Atypical working time: q32/q34/q35/q37f | | |
| | | Working time constraints: q40/q41 | | |
| | Risks and physical constraints (-) | Ergonomic constraints: q23a to q23e | Derived from Bustillo et al. (2016) and Eurofound (2012) | Mean of dummy or categorical variables (0 to 1) |
| | | Ambient exposure risks: q23f to q23i | | |
| | | Bio and chemical risks: q24a/q24b/q24c/q24e | | |
| | Work pressure (-) | Work intensity: q42/q45a/q45b/q48/q51g | Derived from Bustillo et al. (2016) and Eurofound (2012) | Mean of dummy or categorical variables (0 to 1) |
| | | Emotional work pressure: q24g/q51p/q51l | | |
| | Social environment ( +) | Social support: q51a/q51b | Derived from Eurofound (2012) | Mean of dummy or categorical variables (0 to 1) |
| | | Adverse social behaviour: q71a/q71b/q71c | | |
| | | Management quality: /q58a/q58b/q58c/q58d/q58e | | |
| Job satisfaction index | Job satisfaction | q76/q77b/q77d/q77f/q77g | Used subjective perception of job quality | Mean of dummy or categorical variables (0 to 1) |
| Innovation indicator | New technology or process in the workplace (dummy) | q15a | Directly provided by the survey | Dummy variable |

**Table 12** (continued)

| | Index | Questions used in EWCS 2010 | Source | Construction |
|---|---|---|---|---|
| Innovation control indicators | Index of ICT use | q24i/q24h | Created | Dummy variable as a Combination of the q24h AND q24i |
| | Substantial reorganization in the workplace (dummy) | q15b | Directly provided by the survey | Dummy variable |

Source: EWCS 2010. When sub-indexes are used, they are named in the third column.

This graphic synthesizes the conceptual model of our article; it is defined in detail in "Does Innovation Lead to Better Job Quality?."

**Table 13** Correlation table of our indexes

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Pay | 1 | | | | | | | | | | | |
| (2) Employment stability and advancement | 0.2639* | 1 | | | | | | | | | | |
| (3) Working time quality | 0.1235* | 0.1149* | 1 | | | | | | | | | |
| (4) Physical constraints | −0.1733* | −0.1364* | −0.1904* | 1 | | | | | | | | |
| (5) Work pressure | 0.0807* | −0.0154 | −0.2636* | 0.1582* | 1 | | | | | | | |
| (6) Social environment | 0.0277* | 0.1038* | 0.1068* | −0.1257* | −0.1163* | 1 | | | | | | |
| (7) Job satisfaction | 0.3036* | 0.3251* | 0.1548* | −0.2005* | −0.1044* | 0.3633* | 1 | | | | | |
| (8) Learning practices | 0.2648* | 0.2304* | −0.0022 | −0.1561* | 0.1233* | 0.2015* | 0.2623* | 1 | | | | |
| (9) Autonomy and flexibility | 0.2621* | 0.0803* | −0.0008 | −0.2317* | −0.0123 | 0.1737* | 0.2844* | 0.3355* | 1 | | | |
| (10) Involvement | 0.2023* | 0.1444* | 0.0321* | −0.1325* | 0.0342* | 0.3642* | 0.3398* | 0.3969* | 0.4549* | 1 | | |
| (11) Degree of tasks division | −0.0312* | 0.0299* | −0.0815* | 0.2182* | 0.2199* | 0.0808* | −0.0183* | 0.1632* | −0.0996* | 0.1187* | 1 | |
| (12) Standardized tasks | −0.1978* | −0.1030* | 0.0479* | 0.2498* | −0.1611* | −0.0891* | −0.1443* | −0.2880* | −0.2584* | −0.2026* | 0.0912* | 1 |

EWCS 2010, star means confidence at 1% level, author's calculations.

**Table 14** Average score of job quality dimension by industry

| Industries | Pay | Employment stability and advancement | Working time quality | Physical constraints | Work pressure | Social environment | Job satisfaction |
|---|---|---|---|---|---|---|---|
| Agriculture | 0.49 | 0.60 | 0.84 | 0.25 | 0.33 | 0.82 | 0.50 |
| Manufacturing | 0.53 | 0.65 | 0.86 | 0.24 | 0.39 | 0.81 | 0.53 |
| Construction | 0.54 | 0.62 | 0.85 | 0.32 | 0.41 | 0.83 | 0.57 |
| Services | 0.55 | 0.67 | 0.85 | 0.16 | 0.42 | 0.82 | 0.59 |
| Total | 0.54 | 0.66 | 0.85 | 0.19 | 0.41 | 0.82 | 0.57 |

Source: EWCS 2010, author's calculations.

**Table 15** New technology adoption by occupations

| | New technology adoption |
|---|---|
| Armed forces occupations | 53.9% |
| Managers | 59.5% |
| Professionals | 53.2% |
| Technicians and associate professionals | 53.4% |
| Clerical support workers | 48.5% |
| Services and sales workers | 32.8% |
| Skilled agricultural. forestry and fishery workers | 33.9% |
| Craft and related trades workers | 41.0% |
| Plant and machine operators and assemblers | 41.0% |
| Elementary occupations | 23.0% |
| Total | 44.3% |

Source: EWCS 2010, author's calculations.

**Table 16** New technology adoption by industries

| Industries | New technology adoption |
|---|---|
| Agriculture | 34.5% |
| Manufacturing | 50.8% |
| Construction | 34.7% |
| Services | 43.7% |
| Total | 44.3% |

Source: EWCS 2010, author's calculations.

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## Declarations

**Disclaimer** The views expressed in this article are the sole responsibility of the author and do not necessarily reflect the views of the European Commission.

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