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Assessing job satisfaction in the era of digital transformation: a comparative study of the first wave of tasks digitalization in Japan and France

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Abstract
This paper aims at analysing the diverse effects of the first wave of digitalization (2000s) on job satisfaction through a comparison between Japan and France. We propose a simplified mediation model that incorporates work organization characteristics and synthesizes the different relations at stake. We do not find substantial differences between the two countries regarding the impact of digital use on work organization practices. Then, we find no direct effect of digital use on job satisfaction. However, digital use is correlated to some work organization practices (mainly autonomy and flexibility; learning), through which it has positive mediated effects. Finally, the major source of the digital divide, in terms of satisfaction, is, in both countries, related to the perceived absence of digital skills by some workers.

Keywords Digital use · Job quality · Job satisfaction · Work organization

JEL Classification J28 · O33

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1 Introduction

Digitalization has attracted a lot of attention because of its capacity to transform the competitive environment of firms, and increase their performance, but also to create and destroy many jobs (Acemoglu & Restrepo, 2019; Elliott, 2017; Frey & Osborne, 2017; Mcafee & Brynjolfsson, 2017; OECD, 2019; Soete, 2001). In this context, few studies focus on more qualitative dimensions of the impact of increasing digital use on jobs and employment (Bolli & Pusterla, 2022; Eurofound, 2020a; Martin & Hauret, 2020; Mofakhami, 2021). Moreover, although the risk of a digital divide has been emphasized, the analysis of the diverse impact of digital use within one country and between countries is still relatively limited (Martin & Hauret, 2020).

The major goal of this paper is to fill the gap and investigate the qualitative impact of digital use on some dimensions of job quality, which can be decomposed into two major components, work organization practices and subjective job satisfaction (Brown et al., 2012; Clark, 2015; Martin & Hauret, 2020). A major problem that we face is that there is no unified model: the effect of new technology adoption on work organization and job satisfaction is addressed by several pieces of literature, but none of them provides a clear and comprehensive theoretical framework, from which we can derive unambiguous hypotheses (Vivarelli, 2014). The challenge is to study several simultaneous relations, at different levels of analysis, and with direct and indirect effects (mediation factors). To be able to test the relationships between digital use and job quality we introduce a simplified mediation model that synthesizes the different relations of interest.

In this context, our empirical strategy has two characteristics. The first one is to investigate jointly two intertwined relationships. First, we study the impact of digitalization on work organization (WO). The previous literature confirms the correlation but the causality is unclear and may be in two directions (Askenazy & Caroli, 2010; Martin & Omrani, 2015). We adopt a tasks-oriented point of view arguing that technology use and work organizations are co-determined, and moderated by institutional context (Fonseca et al., 2018; Mofakhami, 2021; Piva & Vivarelli, 2018a; Piva et al., 2005). More precisely, to characterize work organization at the firm level, we extend Lorenz's (Lorenz, 2015) framework by considering four broad categories of WO: autonomy and flexibility; learning activities; training; cooperation. Second, we address the role played by digitalization in job satisfaction, and how it can influence it. Our expected contribution is to look at the ways the effects of digital use on job satisfaction are mediated by WO characteristics while controlling for other work-related characteristics and employees' specific factors that determine job satisfaction (working environment and employees' characteristics).

One originality of our empirical strategy is to look at the diverse impacts of digitalization on work organization and job satisfaction through a comparison between France and Japan. In the absence of a general model, there are some obvious benefits of a cross-countries comparison to identify some general patterns and mechanisms. Previous work stresses the major role played by institutional settings in the adoption of new technology but also the effects on employment (Calvino & Virgillito,

2017; Kolade & Owoseni, 2022). From this perspective, these two countries are both relatively similar (e.g. dual labor market, spread of digital use; no polar cases in terms of job satisfaction) and different (e.g. corporate culture, work organization). Since we claim that work organization practices are key to understand the effects of digital use on job satisfaction, the differences in terms of HRM and work organization between France and Japan can enhance the understanding of the digital-labour relationship. We may thus assume that the impact of digitalization will be different between the two countries.

To proceed with this comparison, we mobilise the PIAAC 2013 survey (with data collected in 2011 and 2012).[1] This survey implemented a decade ago does not allow us to study the most recent evolutions, but rather the first wave of tasks digitalization. Consequently, we adopt a historical perspective on digital use in its basic components (Email, Internet, Word, and spreadsheet use) at a time (the early 2010s) when they were already relatively widespread but unevenly across sectors and firms. In doing so, we can capture its differentiated impact on work organization practices and job satisfaction as subjectively assessed by workers.[2]

In the rest of the paper, we proceed as follows. The next section summarizes some stylized facts and findings from the previous literature while emphasizing the absence of a general model that summarizes the effect of digital use on job quality. In Sect. 3, we introduce our dataset and our empirical methodology. Section 4 presents our results. A final section concludes.

2 Digitalization: literature survey and stylized facts

2.1 Digitalization and job quality

The relationship between digitalization and employment is a major topic, as digital technologies have become widespread at work. Digital technologies are leading the current technological cycle (Digital Revolution), and the whole productive system is transformed by the so-called "*Information and communication technologies (ICT)*" (Mcafee & Brynjolfsson, 2017). However, the interaction between digital use and employment is not so easy to define. As documented by rich literature, digital technology can be considered both a product innovation and a process innovation depending on the case (Calvino & Virgillito, 2017; Duhautois et al., 2020; Vivarelli, 2014). Product innovation is labour-friendly in terms of job creation at the firm level but in terms of the impact of working conditions and job satisfaction, process-oriented technology plays a central role (Piva & Vivarelli, 2018b).

In this regard, the "tasks model" brings some interesting insights, as it decomposes the different cases of how technology can change the tasks (Acemoglu & Restrepo, 2019; Piva & Vivarelli, 2018a). Some tasks are replaced by technology

[1] For the sake of simplicity, we call this survey "PIAAC 2013" thereafter.

[2] It is indeed worth emphasizing that the effects of a given technology on job satisfaction are evolving over time: for example, the initial stress or excitement related to a new technology may vanish after some time, especially after some adjustment (Salanova et al., 2014).

but others are created. So, the content of the work changes: even if digital diffusion in the economy also destroys jobs, it creates others and brings new tasks. The effects of new technologies—especially digital ones—on working conditions and job satisfaction depend on the types of new tasks compared to those that are replaced.[3] For sure, we can make the hypothesis that digital adoption is not a homogenous phenomenon among workers. The effects rely on occupations but also institutional settings.

Understanding how technologies are adopted and their impact implies understanding the very nature of the firm. Production is a set of tasks executed by humans and technologies (labour and capital) but within an organization which has some properties. A large literature adopts institutional and evolutionary perspectives to understand the technology—employment nexus (Dosi & Nelson, 2010; Nelson & Winter, 1982). The firm is part of a specific context, by its past and its institutional environment (norms, regulations, networks, etc.); a firm has routines which can be defined by a set of organizational practices and collective capacity. From this perspective, the firm is an organization based on more or less rigid routines, which are disrupted by the diffusion and adoption of technologies, knowledge and know-how. It means that the context determines the feasible combination of tasks between labour and technology. We then can assume the relationship between digital adoption and working satisfaction is not homogenous over countries, regions, sectors, and firms.

Some previous empirical works focus on the effect of digital use on working conditions and job satisfaction but they found diverging results, as explained below.

The empirical studies dedicated to the effect of digital use on job quality and working conditions document two opposing sets of relationships. On the one hand, a first set of works supports the view of a so-called helpful relation (Bolli & Pusterla, 2022; Castellacci & Viñas-Bardolet, 2019; Martin & Omrani, 2015). Digital technologies mainly replace routine and repetitive tasks, fostering new and diverse activities (Marcolin et al., 2019). Increasing information access and adaptability also increases autonomy, saves time, and facilitates communication and thus cooperation (Castellacci & Viñas-Bardolet, 2019).

On the other hand, digital tools can contribute to the emergence of working conditions issues (Askenazy & Caroli, 2010; Berg-Beckhoff et al., 2017; Green, 2006; Green et al., 2021; Salanova et al., 2014). Digital technologies may increase anxiety, scepticism, and fatigue because they bring novelty and reorganization of work. New technology adoption increases the perceived job insecurity since it requires new skills and competencies (Salanova et al., 2014). It may also decrease working time quality, by blurring the frontiers between working, private, and rest times, and by exporting work stress outside the workplace. Furthermore, digital technologies can also be associated with the growing use of external flexibility, by encouraging more spatial flexible work (Valenduc & Vendramin, 2017), and then negatively influence job satisfaction. This second set of negative effects can be qualified as a "techno-strain" relation (Salanova et al., 2014).

[3] Moreover, how it is perceived is at least as important than the "objective" transformation, which makes relevant the mobilization of subjective data (Vannutelli et al., 2022).

Thus, empirically as well as theoretically, digital technology has unclear relationships with job satisfaction (Charalampous et al., 2019; Dengler et al., 2022; Eurofound, 2020b). The effect of digital use is ambiguous. The dimensions of the working conditions affected can be various: some seem to be improved (more autonomy and reduction of physical and repetitive tasks) but others are deteriorated (stress, blurring the work-life balance frontier, and increasing work intensity). Thus, we agree with Martin and Hauret (2020) regarding the necessity to take into account diverse dimensions of job quality and the institutional context, while carefully discussing the different measures of digital use, in order to better analyse its impact on job satisfaction.

In addition, a shared characteristic of this diverse literature—either focusing on the techno-strain relation or the helpful one—is the role played by changes in work organization practices. New technologies impact working conditions not by themselves but through the reorganization of tasks and jobs (Bolli & Pusterla, 2022; Castellacci & Viñas-Bardolet, 2019; Marcolin et al., 2019; Piva et al., 2005; Sarti et al., 2020). To put it differently, changes in the work organization are essential to leverage the benefits of digitalization (Mustafa et al., 2022). From this perspective, digital technologies can produce direct effects but also indirect effects through changes in organizational practices. Technology per se does not make people more productive or happier; these are the induced changes that matter.

A last characteristic of digital technology is its evolutionary effect (Mofakhami, 2021). Digital technologies are considered new and innovative but over time, after having been introduced and incorporated into the work organization of the firm, they are not new anymore. Also, the adoption of digital technologies induces two effects, which should be differentiated: a perturbative effect due to novelty (changes in organizational practices) and a technological effect per se. Over time, the first effect tends to disappear as soon as the workers have adapted to the technology and become used to it, while the second effect will persist. This dynamic is a key characteristic of the impact of technology on work and labor. It is then often difficult to distinguish effects from the technology by itself from the perturbative effect of the novelty. For instance, anxiety about novelty or lack of competence due to new digital technologies can disappear over time.

2.2 A synthetic theoretical model

Thus, the literature does not provide a clear comprehensive theoretical framework, from which we can derive unambiguous hypotheses. The challenge lies in the nested relationships between digital technology use, work organization practices and working conditions, and satisfaction. There are several simultaneous relations, at different levels of analysis, and with direct and indirect effects (mediation factors). The major difficulty comes from the relationship between organizational practices and digital use. Identifying which one causes the other is difficult: some research supports that innovative workplaces and High-performance work systems (HPWS) or Innovative workplaces (OECD, 2010) are needed to foster the adoption of new technologies, but other studies claim that the adoption of new technologies is a way to change the

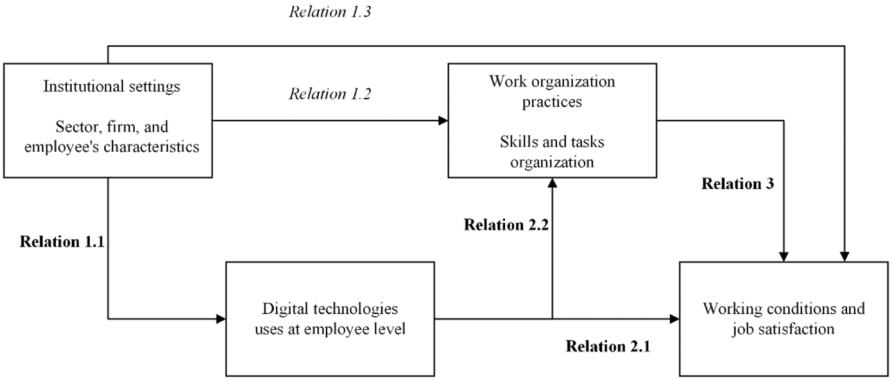

Fig. 1 Conceptual framework of digital use and satisfaction based on an evolutionary tasks-based approach. *Source*: Authors

work and task organization (Marcolin et al., 2019). We may thus assume that they are partly codetermined. Beyond this major difficulty in the conceptual framework, the rest of the relations that are studied are more robust and clearer. For instance, institutional setting (macro- and meso-level), firm and employees' socio-economics characteristics determine digital technology use and job satisfaction, as well as digital use and work organization determine job satisfaction.

Based on this literature review we adopt an operational synthetic model derived from the "evolutionary tasks-based approach" (Eurofound, 2017a; Lorenz & Valeyre, 2005; Mofakhami, 2021). Figure 1 presents the framework we adopt to analyse the effect of digital use at the employee level on job satisfaction.

Based on this scheme, our empirical analysis will investigate more particularly, in France and Japan, the determinants of digital use (Relation 1.1), the direct relation of digital use on job satisfaction (Relation 2.1), and the mediated relation of digital use on job satisfaction through work organization practices (Relation 2.2 combined with Relation 3). The following sub-section discusses this conceptual framework in the context of a comparison between France and Japan. Table 1 summarises, within our conceptual framework, the empirical articles presented in the literature review that explicitly address the relationship between digitalization and job quality (we exclude the systematic review articles). It provides an overview of contributions to each component of the broad picture of our issues. It shows that few papers analyse the effect of digital use at work on job quality through work organization pathways (Relation 2.2 combined with Relation 3).

2.3 Digitalization, job satisfaction, work organization, and labour market institutions: Comparing France and Japan

To be able to formulate some hypotheses on the possible impact of digital use on job quality in France and Japan, we briefly review the literature on work and labour in these two countries. To avoid stereotypical images, we take into account the fact

Table 1 Overview of the empirical literature review's contribution to the conceptual framework. Source: Authors Selected empirical articles referring to our conceptual framework are reported in the table (systematic review articles, as well as conceptual articles cited, are excluded)

Article	Relations		Hypothesis	Level of analysis	Proxy of variables	Main results
Acemoglu & Restrepo, 2019	Relation 2.2	Digital technologies affects skills, tasks and work organization practices	The decomposition of tasks allows us to understand how new technology impacts labor variation	Sector level	Wages, productivity and labor share	The recent stagnation in demand for labor is explained by an acceleration in automation, particularly in manufacturing, and a slowdown in the creation of new tasks
Askenazy & Caroli, 2010	Relation 2.2	Digital technologies affects skills, tasks and work organization practices	The adoption of ICT technologies are implemented through new work practices and leads to higher mentral strain	Individual level	Set of work organization practices that encompasses ICT-Set of mental strain variables (subjective difficulties at work)	Individuals working under the new practices face greater mental strain, but ICT contribute to make the workplace more cooperative and to reduce occupational risks and injuries
Bolli & Pusterla, 2022	Relation 2.2×Relation 3	Digital technologies affects working condition and job satisfaction through ther relation with work organization practices	Digital technology adoption positively influence job satisfaction in a heterogeneous manner, through multiple channels	Individual level	Self-declared influence of digital use on job satisfaction	Digital use improve job satisfaction mainly trhough increase of productivity and more intresting work

Table 1 (continued)

Article	Relations		Hypothesis	Level of analysis	Proxy of variables	Main results
Castellacci & Viñas-Bardolet, 2019	Relation 2.2×Relation 3	Digital technologies affect working condition and job satisfaction through their relation with work organization practices	Digital use affects well-being at work in an indirect manner: it mediates the effect of some important work characteristics on job satisfaction	Individual level	Internet use and self-declared job satisfaction	The results show that Internet technologies improve job satisfaction by facilitating access to data and information, creating new activities and opportunities, and facilitating communication and social interactions
Dengler et al., 2022	Relation 3	Digital technologies directly affect working conditions and job satisfaction	The use of computers in the workplace relates to subjective health and work-related health complaints	Individual level	Use of computer—Subjective health and work-related health complaints	Employees using the computer frequently report better subjective health and a significantly lower prevalence of back pain and physical exhaustion. While digital transformation seems to foster physical health, there are hints that mental health could deteriorate

Table 1 (continued)

Article	Relations		Hypothesis	Level of analysis	Proxy of variables	Main results
Duhautois et al., 2020	Relation 3	Digital technologies directly affect working conditions and job satisfaction	Innovation at the firm level can improve job quality (rent-sharing mechanisms) but can also be labour-saving	Firm-level	Declared innovation(product and process) as proxy of technological innovation—Wages, worked hours and employment variation	Product innovation is labour-friendly and improves job quality at the firm level
Eurofound, 2020a, 2020b	Relation 2.2×Relation 3	Digital technologies affect working conditions and job satisfaction through their relation with work organization practices	The ICT-based mobile workers appear as new forms of work flexibility that could affect workers' health and well-being	Individual level	Measure of degree of ICT-based flexibility—Set of health and well-being variables	ICT-based flexibility arrangements report greater autonomy, better work-life balance, higher productivity, and reduced commuting times. However, there can be disadvantages: they can lead to longer working hours, the overlapping of work and home life, and increased intensity of work. They also pose some risks to the mental and physical well-being of workers

Table 1 (continued)

Article	Relations		Hypothesis	Level of analysis	Proxy of variables	Main results
Green et al., 2021	Relation 2.2 × Relation 3	Digital technologies affect working conditions and job satisfaction through their relation with work organization practices	ICT facilitates more efficient organizations of tasks during the workday by diminishing gaps, enabling multi-tasking, and streamlining workflows, but it could also enforce higher work intensity requirements and lower efficiency wages	Individual level	Work intensification—Several variables of effort-biased technological change (incl. ICT use)	Work intensification is linked to effort-biased technological change such as ICT use
Marcolin et al., 2019	Relation 2.1	Skills, tasks and work organization practices affect working conditions and job satisfaction	Organizational change as well as technological change affect the level of routine intensity	Sector-occupation level	Measure of the routine content of occupations based on information about the sequence and flexibility of the tasks performed on the job	Suggests the importance of both technological and organizational considerations in the measure of routine intensity
Martin & Omrani, 2015	Relation 3	Digital technologies directly affect working conditions and job satisfaction	Digital use and innovative work practices support firm performance and employee positive attitudes	Individual level	Computer and Internet use—Self-declared job satisfaction, social support and extra effort	Internet use is positively related to employees' job satisfaction and extra effort. We find that computer use is not related to employees' behaviours

Table 1 (continued)

Article	Relations		Hypothesis	Level of analysis	Proxy of variables	Main results
Mofakhami, 2021	Relation 2.2 × Relation 3	Digital technologies affect working conditions and job satisfaction through their relation with work organization practices	Technology adoption and digital use affect job quality differently according to the form of work organisation	Individual level	Technology adoption at workplace level—ICT use at work—Set of job quality variables (incl. Job satisfaction)	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
Piva & Vivarelli, 2018a	Relation 2.2	Digital technologies affect skills, tasks and work organization practices	Different form of innovation (creation of new technology and diffusion of innovation) leads to different effect on labor variation	Sector level	Creation of innovation proxied by R&D expenditure—Diffusion of innovation proxied by capital formation	Creation of innovation is rather labor friendly while diffusion of innovation is labor-saving
Piva et al., 2005	Relation 2.1	Skills, tasks and work organization practices affect working conditions and job satisfaction	Organizational changes can have more influence on the workforce structure (by skill level) than technological change	Firm-level	Investment in R&D (for technological change)—Significant organisational change occurred (organizational change)	Reorganizational strategies influence more the skill structure of the workforce than technological changes

Table 1 (continued)

Article	Relations		Hypothesis	Level of analysis	Proxy of variables	Main results
Sarti et al., 2020	Relation 2.2 × Relation 3	Digital technologies affect working conditions and job satisfaction through their relation with work organization practices	ICT use mediates the relationship between work changes and job satisfaction	Individual level	Computer use and self-declared job satisfaction	Work organization change interacts with Computer use (in both directions)

that both countries have experienced substantial transformations in their respective labour markets and work organization patterns during the last three decades.

Regarding their labour markets, both countries have been considered as characterized by a dual structure and 'rigid' institutions (Lechevalier, 2014; Thomas Le Barbanchon, 2013; Watanabe, 2018). However, the lines of cleavage and the composition of the two tiers are different. Duality is more about male vs female workers or manufacturing vs. services in Japan (Kambayashi & Kato, 2012, 2017), while it is more based on the level of occupation in France (Askenazy, 2018; Green et al., 2013).

However, this dual structure has evolved. By the end of the 1990s, France had experienced a polarization between white-collar and blue-collar workers, reinforced by skilled-biased technological change (Greenan, 2003). By contrast, until the mid-1990s, Japan was characterized by a "white collarization" of blue-collar workers (Koike & Saso, 1994), thus less polarization among workers (Lechevalier, 2014). During the 2000s, France experienced a flexibilization of the labor market, mainly concentrated on low-skilled workers and service sectors (Askenazy, 2018). To some extent, a similar trend can be observed in Japan, but in a more limited manner and mainly through the increase of the share of non-regular workers, which are mainly women and are partly replacing independent workers (Kambayashi & Kato, 2012; Yun, 2011).

In terms of human resource management (HRM) practices (and thus in terms of work organization), the contrast between the two countries has been much emphasized, although we should recognize some diversity within each country, between sectors and within sectors (Dosi & Nelson, 2010). To summarize, HRM practices in Japan have been characterized by lean management practices where teamwork is efficient, cooperation is key, autonomy is high, and training level is high (Ikenaga & Kambayashi, 2016; Kambayashi & Kato, 2012; Morris et al., 2021; Takeuchi et al., 2007). By contrast, during the 2000s, several studies showed that, even if France had protective labor market institutions (at the macro-level), the quality of HRM was poor, by comparison to similar developed European countries: the training level was low, the management was conflictual and could be characterized as a discretionary hierarchized organization (Davoine et al., 2008; Eurofound, 2017a, 2020b; OECD, 2010).

In addition, the rotation of tasks and job content, which was central in Japan, did not exist in France (except for high-skilled workers and civil servants). Although investment in training has dramatically decreased in Japan (Yokoyama et al., 2019), it is still much higher than in France and less polarized (see Sect. 3).

Lastly, although, France and Japan are no polar cases from the viewpoint of job satisfaction, recent data show a higher level of job satisfaction for French workers.[4] Besides the differences in the average level of job satisfaction, more importantly, the literature emphasizes different determinants. Job quality and job satisfaction in

[4] Some previous studies based on the 2005 International Social Survey Program showed that Japanese and French workers have really similar level of job satisfaction, but more recent data from OECD PIAAC data show that French workers experienced higher level of job satisfaction than Japanese one (see Sect. 3).

France are strongly related to occupation with polarized situations in terms of quality of working conditions (Askenazy, 2018; Askenazy & Caroli, 2010; Green et al., 2013). On the contrary, in Japan, the working conditions and organization seem to be relatively more homogeneous within firms (Magnier-Watanabe et al., 2019; Takeuchi et al., 2007). Moreover, in Japan, cooperation and collective achievement seem to be also stronger drivers of job satisfaction, while in France, standardized tasks reduce job satisfaction (Magnier-Watanabe et al., 2019; Sasaki et al., 2019; Takeuchi et al., 2007). However, in both countries, studies show that autonomy and time flexibility are considered keys to improving job satisfaction at work, whilst long hours deteriorate job satisfaction (Eurofound, 2017b; Fujimoto et al., 2016; Kuroda & Yamamoto, 2016; Lott, 2015).

Based on the previous conceptual framework we presented and this comparison between France and Japan from the perspective of labour market dynamics, human resource management, and determinants of job satisfaction, we can derive the following hypotheses that our empirical investigation will allow us to test[5]:

1. Digital use may improve autonomy, cooperation and learning at work and, thus increase job satisfaction for both countries;
2. Work organization practices appear more heterogeneous in France than in Japan, while the digital intensity is higher. Thus, the effects of digital are expected to be stronger and more polarized in the French case than in the Japanese one;
3. Finally, both countries are characterized by dual labour markets but with different lines of cleavage, so we should find heterogeneous effects by sectors and occupations that are themselves different in each country.

Before moving to the empirical results that will confirm or not these hypotheses, we present the data used and the empirical strategy adopted in the next section.

3 Data and empirical strategy

3.1 Data

In this paper, we mobilize data from the 2013 edition of the PIAAC survey (Programme for the International Assessment of Adult Competencies or Survey of Adult Skills), which is a high-quality international cross-section database provided by the OECD, and which covers the years 2011 and 2012 for Japan and France.[6] It covers skill and competencies topics at the individual level from a comparative perspective. It is a major source to get information on skills, tasks, and lifelong education

[5] We leave aside the following hypothesis, which is recognized as important by the literature but that we are unable to test with our data: digital use can increase the work pressure and working time, and thus may decrease job satisfaction in both countries through this channel.

[6] For more information on PIAAC, the following dedicated website is very useful: https://www.oecd.org/skills/piaac/.

and training both formal and informal.[7] The survey is conducted by the OECD in all the countries of the organization and beyond (around 40 countries). It includes data on about 5,000 representative adults aged 16 to 65 in each country. The survey identifies individuals who are employed and addresses questions about digital use (adoption and frequency of use for several computer usages), job satisfaction but also most of the key sociodemographic characteristics.

For the sake of our analysis, we focus on the Japanese and French employees and we obtain a total sample of 6,977 employees (3,620 French and 3,357 Japanese).[8] The measure of digital use is an index built from several questions about the adoption and frequency of use of email, internet, spreadsheet, and Word (or similar software). The digital use that we consider in this paper does then correspond to basic tasks, which, however, were not yet fully spread in the early 2010s, depending on the countries, the sectors, the firms, and the specific occupations of employees.

The survey asks a question about the level of job satisfaction, an ordinal variable in five items (from extremely satisfied to extremely dissatisfied). This variable is used as our outcome variable (after being transformed into an index: see Table 8 in Appendix).

To capture some characteristics of work organization practices, several indexes are derived from combinations of questions that ask the organization of the tasks at the individual level. The construction of indexes adopts the methodology used by the job quality analysis (Bustillo et al., 2011; Eurofound, 2017b; Green et al., 2021; Mofakhami, 2021), especially by combining different related variables which reflects same dimension of job. In line with our conceptual framework and the literature on work organization practices—in particular, various contributions by Lorenz (e.g., Lorenz, 2015), we build three indexes that capture characteristics of work organization practices:

1. The level of learning at work (captured by variables indicating how much employees learn from the task performed, which is considered a proxy of low-level routinized tasks);
2. The autonomy and flexibility (which refer to employees' involvement in the design of work activity and their responsibility for planning and carrying out their tasks);
3. The degree of cooperation at work (which is captured through the three following variables: how much employees share information with co-workers, how much they learn from co-workers, and how much time they spend cooperating with co-workers).

Moreover, we add a dummy variable (4) that indicates if the employee participated or not, in (formal and non-formal) training activities during the 12 previous months.

The details of the original variables and the method of construction are available in Table 8 in the appendix. All the ordinal variables are transformed in indexes

[7] On the issue of task measurement and its impact on the analysis, see Rohrbach-Schmidt & Tiemann, (2013).

[8] We exclude all the self-employed workers in order to focus on employees only.

from 0 (the lowest category) to 1 (the highest category). The choice of using indexes instead of ordinal variables is motivated by the literature on job quality (Eurofound,). It enables us to keep the maximum variance, conversely to use dummies, and it also standardizes the variance of the variables. Then, the resulting indexes are aggregated (in building average measures) by similar themes after having checked that they correlate to gather and reflect the same dimension (Alpha-Cronbach tests are used). The combination of indexes allows us to capture convergent social phenomena more robustly than through only one variable.

Moreover, the PIAAC dataset provides numerous socio-economic variables that we will use for our analysis. From the initial variables, we select the following socio-economic variables: size of the workplace, hourly wage (in PPP), occupation (skill level from ISCO classification), sector of the workplace (industry and public or private sector), type of contract, education level (from ISCED classification), age, gender, structure of the household (in couple, having child, number of people in the household), health level, and a proxy of the cultural activity (number of book at home).

The survey provides also a subjective variable that indicates if the workers who use digital at work think they have a sufficient level of skills. We consider here this subjective variable as a proxy for the lack of skills related to digital use.[9] We will use it in the last part of the analysis dedicated to regression by sub-categories of workers.

Descriptive statistics present a first picture of the adoption of digital use in both countries in 2011–2012 (see Table 2). One can notice two major differences. First, the average level of adoption (independently from the frequency of use) is higher in Japan than in France: 73.5% of the Japanese workers report having experience with computer or ICT tools at work against 67.1% for the French workers. However, in terms of frequency, the index of digital use is equivalent in France and Japan (0.43). When considering only those workers who declare having computer experience, the gap is in favour of French workers (+6.7%). These statistics suggest a slightly divergent pattern between both countries. In Japan, the ICT tools at work were more widespread in the early 2010s than in France, but the usage of ICT was more intense for French workers, who were concerned by digital use.

In terms of Job satisfaction (see Table 2), we also observe some differences between the workers of the two countries. The French workers are on average more satisfied at work than Japanese ones: satisfaction is 8.4% higher for French workers and it confirms the previous works showing a relatively low level of job satisfaction in Japan in comparison to other OECD countries (see Sect. 2).

The work organization practices also differ (Table 3). Japanese workers are more likely autonomous and flexible (34% more) and they get more training than French workers (+8.7%). Conversely, French workers learn more at work (less routinized tasks, +8.8%). The level of cooperation at work is close in both countries.

Nevertheless, all these differences can be due to institutional differences such as labour and industrial relations, but they can also be explained by differences in

[9] It might be considered as a subjective measure of skill mismatch. See McGuinness et al. (2018) for a survey of the literature on this issue.

Table 2 Digital use and job satisfaction in France and Japan. Source: PIAAC data—2011. French (4,095) and Japanese (3,717) employees. Statistics with corrected by sample weight

Standardized from 0 to 1 (mean, confidence interval)	Index of digital use	Index of satisfaction
France	0.43	0.80
CI at 95%	[0.42; 0.44]	[0.79; 0.8]
Japan	0.43	0.71
CI at 95%	[0.42; 0.45]	[0.71; 0.72]
Total	0.44	0.76

Table 3 Work organization practices and tasks, in France and Japan. Source: PIAAC data—2011. French (4,095) and Japanese (3,717) employees. Statistics with corrected by sample weight

Standardized from 0 to 1 (mean, confidence interval)	Autonomy and flexibility index (score)	Learning index (score)	Cooperation index (score)	Participated in formal or non-formal training (dummy)
France (mean)	0.46	0.62	0.71	0.46
CI at 95%	[0.45; 0.47]	[0.61; 0.63]	[0.70; 0.72]	[0.44; 0.48]
Japan (mean)	0.62	0.57	0.72	0.50
CI at 95%	[0.61; 0.63]	[0.56; 0.58]	[0.71; 0.73]	[0.48; 0.52]
Total (mean)	0.56	0.59	0.69	0.48

industry and workforce structures. Table 4 confirms that there are substantial differences between the two countries from this perspective. The Japanese workforce is less skilled in terms of occupation than the French. Another distinction is the education level: the Japanese workforce is less polarized, with most of the workers with Upper Secondary and Tertiary bachelor's degrees, while French workers are more likely Lower Secondary or Upper Tertiary (Master's degree). Finally, these differences reflect also two patterns of economic sector structure. The Japanese economy is more manufactured industry oriented while the French economy is mainly led by services activities. To go further, it is thus necessary to lead multivariate analysis and compare workers with controlled characteristics.

3.2 From theory to empirics: statistical methods

Our analytical framework is based on a so-called mediation model (VanderWeele, 2016) and follows the (conceptual) Fig. 1 presented in Sect. 2. This empirical approach is based on a theoretical framework according to which digital use has direct effects on job satisfaction, but also indirect effects. Digital use is associated with certain work organization practices, which in turn can influence job satisfaction. Thus, we adopt a mediation model that allows distinguishing quantitatively the part of the relationship directly attributable to digital use from that resulting from interactions between digital use and organizational practices (Minardi et al., 2023).

Table 4 Socio-economic characteristics of employees in France and Japan. Source: PIAAC data—2011. French (4,095) and Japanese (3,717) employees. Statistics with corrected by sample weight (mean and confidence interval at 95%)

in %	France	Japan	Total
High-skilled workers	0.443	0.359	0.383
	[0.427; 0.460]	[0.342; 0.376]	
Middle-skilled workers	0.272	0.342	0.322
	[0.258; 0.288]	[0.325; 0.359]	
Low-skilled workers	0.284	0.299	0.295
	[0.269; 0.300]	[0.283; 0.316]	
Lower secondary or less	0.196	0.101	0.128
	[0.183; 0.210]	[0.090; 0.112]	
Upper secondary	0.459	0.433	0.441
	[0.443; 0.476]	[0.416; 0.451]	
Tertiary prof or bachelor's degree	0.235	0.427	0.372
	[0.222; 0.249]	[0.410; 0.445]	
Tertiary master's degree and more	0.110	0.039	0.059
	[0.100; 0.120]	[0.033; 0.046]	
Female	0.485	0.427	0.443
	[0.468; 0.502]	[0.409; 0.444]	
Agriculture	0.012	0.010	0.011
	[0.009; 0.017]	[0.007; 0.014]	
Industry	0.167	0.243	0.221
	[0.155; 0.180]	[0.228; 0.259]	
Construction	0.075	0.059	0.064
	[0.066; 0.085]	[0.051; 0.068]	
Services sectors	0.690	0.628	0.646
	[0.674; 0.705]	[0.611; 0.646]	
Transport	0.056	0.060	0.059
	[0.049; 0.064]	[0.052; 0.069]	
In fixed term contract	0.173	0.218	0.205
	[0.161; 0.187]	[0.204; 0.233]	
In part-time	0.203	0.271	0.252
	[0.190; 0.217]	[0.256; 0.287]	
Age (in years)	40.5	41.5	41.2
	[40.1; 40.9]	[41.1; 41.9]	
Hourly net wage with bonuses (in $ PPP)	15.66	15.70	15.69
	[15.41; 15.92]	[15.36; 16.05]	
Working hours (in hours)	36.0	40.4	39.1
	[35.7; 36.3]	[39.9; 40.8]	

The mediation model analysis involves three sets of variables: a predictor variable, a mediator variable, and an outcome variable (Imai et al., 2010; VanderWeele, 2016). The predictor variable is the one that is believed to influence the outcome

variable; the mediator variables are the ones that are supposed to be the mechanism through which the predictor variable exerts its influence on the outcome variable; the outcome variable is the one that is being predicted or explained. This approach is strongly dependent on the conceptual framework since it is based on an ex-ante structure of relationships. In our case, however, the cross-section nature of our data does not allow us to identify causal mediation analysis.

To conduct a mediation model analysis, we first test for the presence of a direct relationship between the predictor and outcome variables. We then test for the presence of a relationship between the predictor and mediator variables and between the mediator and outcome variables. The mediation model analysis allows understanding the specific mechanisms through which a predictor variable influences an outcome variable, which can provide insights into the underlying processes at work and inform the interrelationships of social phenomenon.

By reference to Fig. 1, our mediation analysis identifies the direct effects (Relation 2.1) of digital use on job satisfaction and then observes the association between digital use and organizational practices (mediation variables: Relation 2.2) and organizational practices on satisfaction (Relation 3.1). Finally, by combining these two latter relations we can identify the indirect effects of digital use on job satisfaction (Relation 2.2 × Relation 3.1). Also, to go deeper into the comparative analysis of digital use between both countries, we first analyze the determinant of digital use (Relation 1.1).

All the results presented are controlled for differences in employees' characteristics, allowing for all other things to be equal analysis. The effects are neutralized for possible relationships arising from the socioeconomic variables presented above. All of these characteristics are likely to affect digital use, organizational practices, and job satisfaction. In what follows, we focus on the employees who have answered all the questions. Our final sample is thus limited to 6,386 (3,281 French and 3,105 Japanese).

We obtain the first set of regression of determinants of digital use and then the second set of mediation analysis regressions on job satisfaction. Then, we extend the second set of mediation analysis by adding interaction terms of digital use to identify some heterogeneity. We carry out multivariate analysis by interacting digital use with under-skilled in digital tools dummy, education level, gender, sector, and occupation. All regression sets are performed on the full sample, the French and the Japanese sub-samples to identify different patterns (Fig. 2).

4 Results

4.1 Determinants and patterns of digital use in Japan and France

As for the determinants and patterns of digital use, there are no major differences between Japan and France, even if it is a little more homogenous in Japan. There are some signs of a digital divide in both countries from the viewpoint of digital use, especially when one looks at the size of the workplace, the skills, or the education level. This is all the more important that there is a strong correlation between digital

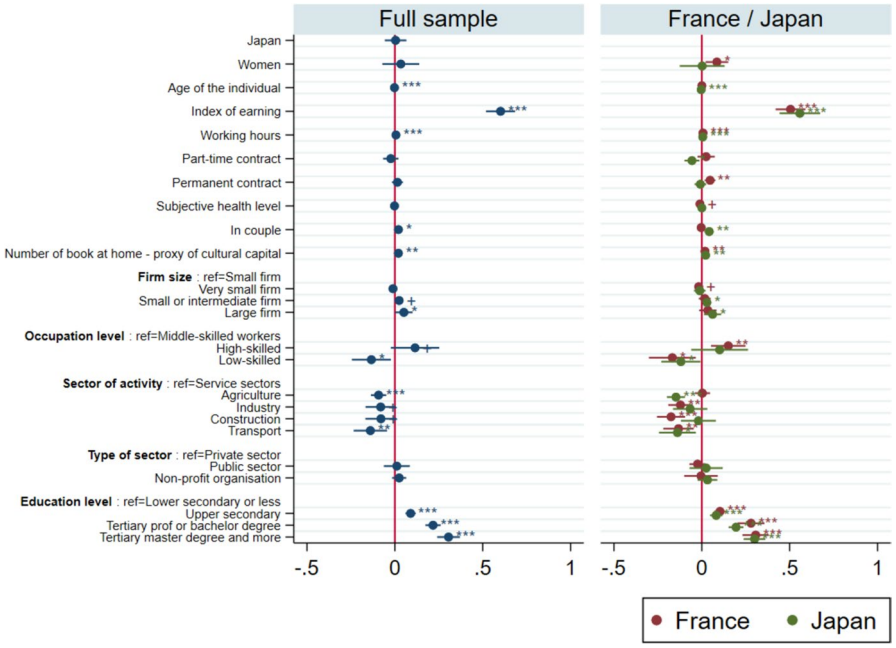

Fig. 2 Determinant of digital use in France and Japan (Relation 1.1). *Source*: PIAAC data—2011. French (4,095) and Japanese (3,717) employees. Regression analysis (OLS) on the index of digital use. Marginal effects reported, with confidence intervals (95%). ***$p<0.001$, **$p<0.01$, *$p<0.05$, +$p<0.1$

use and wages (index of hourly earnings): respectively 0.558 and 0.505 in Japan and France.

In more detail, the larger the size of the workplace, the more important is digital use, and this is particularly true in Japan. In addition, digital use is significantly lower for lower-skilled workers and significantly higher for the higher level of education from the upper secondary level, for both countries, but more in France. There are also differences across sectors with different patterns between France and Japan: digital use is significantly less important in Japanese agriculture as well as in French manufacturing and construction. It is also worth mentioning that being a woman or having a permanent contract in France significantly increases the probability of digital use, whereas digital use decreases with age in Japan but not in France.

4.2 Analyzing the (direct) impact of digital use on job satisfaction

In Table 5, we first confirm that, all other things equal, Japanese workers are less satisfied at work, as shown by the significant unexplained lower level of job satisfaction (-0.060); moreover, it is interesting to note that, when work organization variables are introduced (column 2), the job satisfaction of Japanese workers is even lower by comparison to French workers. It means that differences in work organization practices between France and Japan reduce the job satisfaction gap: if France and Japan had the

Table 5 Direct relations of digital use and work organizations practices on job satisfaction in France and Japan (Relation 2.1 and Relation 3.1). Source: PIAAC data—2011. Regression analysis (OLS) on the index of job satisfaction. Marginal effects reported

	M1_full_a b/se	M1_full_b b/se	M1_fr_a b/se	M1_fr_b b/se	M1_jp_a b/se	M1_jp_b b/se
Dep. Var. Index of satisfaction						
Japan (ref. France)	−0.060***	−0.073***				
	(0.003)	(0.003)				
Index of digital use	0.012	−0.007	0.031*	−0.001	0.009	−0.003
	(0.009)	(0.005)	(0.014)	(0.012)	(0.008)	(0.004)
Training (ref. No training)		0.000		−0.008*		0.003
		(0.006)		(0.004)		(0.008)
Autonomy and flexibility (index)		0.083***		0.106***		0.075***
		(0.009)		(0.016)		(0.009)
Learning practices (index)		0.050***		0.072***		0.040**
		(0.009)		(0.011)		(0.014)
Cooperation at work (index)		0.027***		−0.005		0.038***
		(0.007)		(0.016)		(0.009)
Controls						
Gender, Firm size, Wage, Occupation level, Contract characteristics, Education level, Sector, Age, Family situation, and Health level						
Number of Obs	6386	6386	3281	3281	3105	3105

Standard errors in parentheses: $+p<0.10$, $*p<0.05$, $**p<0.01$, $***p<0.001$

same work organization characteristics, the job satisfaction gap between the two countries would be higher. To put it differently, this is because work organization characteristics are different in France and Japan that the job satisfaction gap is smaller.

We now move to the analysis of the direct impact of digital use on job satisfaction (Table 5). For the full sample, we did not find any significant effect of digital use on job satisfaction, which confirms the results of previous studies (e.g. Berg-Beckhoff et al., 2017). This is true whatever the specification we consider but it is worth noting that the sign changes (turning negative) when one introduces work organization variables. This is also true in the case of the subsample of Japanese workers. In the case of French workers, digital use has a positive effect on job satisfaction, which disappears when work organization characteristics are introduced, confirming the relationships between work-organization practices and digital use (Table 6).

4.3 Analyzing the impact of digital use on work organization and its indirect impact on job satisfaction

We then move to the analysis of the indirect (mediated) impact of digital use on job satisfaction through work organization variables. We start our investigation by the analysis of the correlation between digital use and work organization variables. In the case of the full sample, we find a positive and significant correlation between

Table 6 Relations of digital use and work organizations practices (Relation 2.2).

Source: PIAAC data—2011. Regression analyses (OLS) on the work organization practices. Marginal effects reported

	M1_full b/se	M1_fr b/se	M1_jp b/se
Dep. Var. Training (ref. No training) (logit model)			
Japan (ref. France)	0.042*		
	(0.017)		
Index of digital use	0.216***	0.198***	0.233***
	(0.034)	(0.029)	(0.039)
Dep. Var. Autonomy and flexibility (index) (OLS)			
Japan (ref. France)	0.160***		
	(0.014)		
Index of digital use	0.218***	0.236***	0.208***
	(0.027)	(0.031)	(0.027)
Dep. Var. Learning practices (index) (OLS)			
Japan (ref. France)	−0.039**		
	(0.013)		
Index of digital use	0.059***	0.125***	0.035+
	(0.016)	(0.018)	(0.019)
Dep. Var. Cooperation at work (index) (OLS)			
Japan (ref. France)	0.018		
	(0.032)		
Index of digital use	−0.010	0.081***	−0.039
	(0.032)	(0.023)	(0.036)
Controls			
Gender, Firm size, Wage, Occupation level, Contract characteristics, Education level, Sector, Age, Family situation, and Health level			
Number of Obs	6386	3281	3105

Standard errors in parentheses: $+p<0.10$, $*p<0.05$, $**p<0.01$, $***p<0.001$

digital use on the one hand and three work organization variables: training, autonomy and flexibility, and learning practices but no correlation with cooperation at work.

When one looks at the subsample, we get similar results for France and Japan in the case of training as well as for autonomy and flexibility. However, there are differences between the two other work organization variables. Learning practices are much more significantly positively correlated to digital use in the case of France (0.125) than in the case of Japan (0.035). Moreover, French workers experience higher cooperation at work when they increase their digital use (0.081) unlike Japanese workers (non-significant coefficient).

Given these results regarding the correlation between digital use and work organization, are we able to identify the indirect effects of digital use on job satisfaction through work organization? In the case of the full sample, we indeed find a positive and significant correlation between job satisfaction on the one hand and learning

practices, autonomy and flexibility on the other hand. This holds for French and Japanese workers but the coefficients are much higher in the first case. As for training and cooperation, we find some substantial differences between France and Japan. As for training practices, it is not correlated with job satisfaction in the Japanese case but it is associated with a lower level of job satisfaction in the French case. Even more interestingly, if we remember the results of the first step (positive correlation between digital use and cooperation for French workers but not for Japanese workers), we find a positive correlation between cooperation and job satisfaction in Japan but not in France.

To summarize (Fig. 3), while there is no direct relation between digital use on job satisfaction, there are indirect impacts, through work organizations, in a similar way for France and Japan for autonomy and flexibility, which is positive. As for other work organization characteristics (learning and training), the patterns are different between the two countries. If these two practices are more frequent for workers, who are exposed to digital use, training tends to be associated with a lower level of job satisfaction conversely to learning practices which is related to better satisfaction in France but not in Japan.

4.4 Which digital divide in France and Japan from the perspective of job satisfaction?

The existence of a digital divide during the process of digitalization has attracted a lot of attention from the perspectives of infrastructure, usage, and income. Here, we investigate the existence of this digital divide from the perspective of job satisfaction by comparing French and Japanese patterns of interactions with several individual characteristics such as skills in digital use, gender, education level, occupation, sectors and type of contract (Table 7). To analyse potential heterogeneities by sector, we have two sectoral divisions which could influence the relation between digital use and satisfaction. First, Calvino et al. (2018) established a digital sector taxonomy by digital intensity. They divided the sector classification (NACE, 2-digits) into four categories (High digital intensive sectors, medium–high digital intensive sectors, medium–low digital intensive sectors, and low digital intensive sectors). Second, we also use the conceptual distinction made by Dosi et al. (2021) between the upstream sectors, which produce the new technologies, and the downstream sectors, which mainly adopts them.

Without surprise, the most massive source of the digital divide is, in both countries (but again with a stronger effect for France), related to the absence of (subjective) appropriate digital skills: digital use significantly increases job satisfaction for those who consider that they have the digital skills, whereas it decreases it for the others.

As for the other sources of individual heterogeneity, the patterns are different between the two countries. In the case of Japan, the digital divide by education level is the most important, while it is not significant in the French case. Except for highly educated workers, for whom digital use does not lead to higher satisfaction, having a higher level of education leads to a positive impact of digital

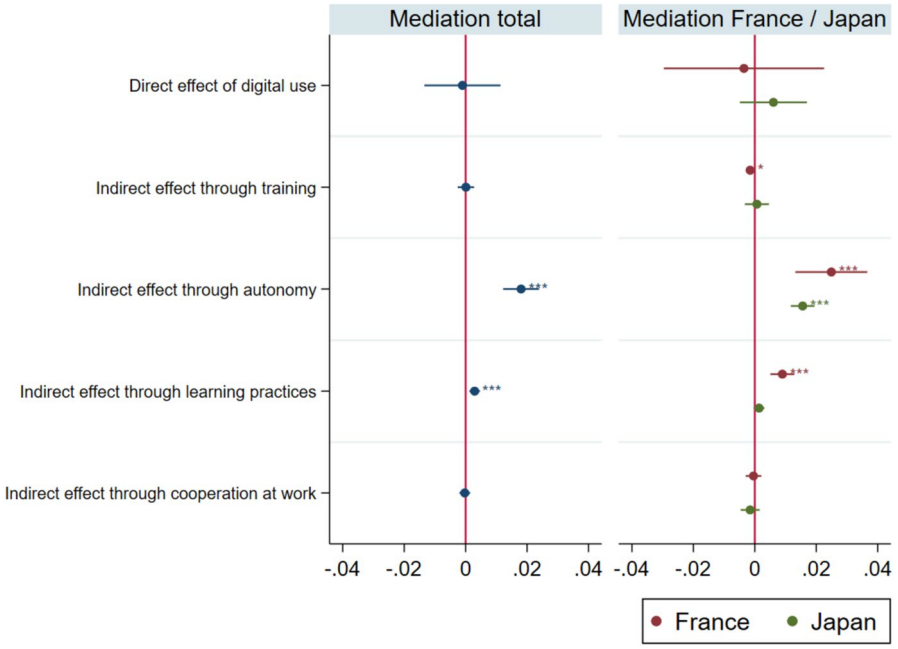

Fig. 3 Determinant of digital use in France and Japan (Relation 2.1 and Relation 2.2—Relation 3.1). *Source*: PIAAC data—2011. French (4,095) and Japanese (3,717) employees. Regression analysis (OLS) on the index of digital use. Marginal effects of the mediation analysis reported, with confidence intervals (95%). ***$p<0.001$, **$p<0.01$, *$p<0.05$, +$p<0.1$

use on job satisfaction. Similarly, digital use slightly increases job satisfaction for high-skilled French workers (defined by occupation) but not for Japanese workers. In terms of sectors, we observe clearly different patterns between France and Japan. While in France, working in Upstream sectors is associated with a positive relationship between digital use and job satisfaction, there is no difference in Japan. On the other hand, working in high digital-intensive sectors in Japan leads to a positive relationship and working in a low digital-intensive one leads to a negative relationship. In France, the digital intensity of the sectors appears to not influence the relation.

Finally, surprisingly, we do not find any significant effect of the type of contract (open-ended vs. short-term contract) on satisfaction in itself (Fig. 4, in Appendix) but also no effect in the case of interaction with digital use (Table 7). Previous work in the European context stressed that stability and career prospects are related to job satisfaction (Bustillo et al., 2011; Clark, 2015; Eurofound, 2017b). Nevertheless, the type of contract (open-ended vs. short-term contract) is not strongly linked to stability and career prospects. In other words, the perception of stability and prospects is not determined by the fact that the worker is on an open-ended contract. In the Japanese case, some previous works underlined the positive relationship between job satisfaction and regular jobs (Matsuki & Nakamura, 2018); however, the type of contract does not reflect the regular or non-regular employment statute of the worker

Table 7 Direct relations of digital use on job satisfaction by sub-categories of workers in France and Japan (Relation 2.1 and Relation 3.1). Source: PIAAC data—2011. Regression analyses (OLS) on the index of job satisfaction. Marginal effects reported

	M1_full b/se	M1_fr b/se	M1_jp b/se
Dep. Var. Index of satisfaction (interaction by under skill)			
Japan	−0.071***		
	(0.003)		
Index of digital use (ref. under-skilled in digital uses)	−0.022**	−0.048**	−0.013*
	(0.007)	(0.016)	(0.006)
Having the appropriate skill in digital use # Index of digital use	0.028***	0.050**	0.027***
	(0.007)	(0.016)	(0.006)
Dep. Var. Index of satisfaction (interaction by gender)			
Japan	−0.074***		
	(0.003)		
Index of digital use (ref. Male)	0.009	0.001	0.013
	(0.010)	(0.014)	(0.014)
Female # Index of digital use	−0.024	−0.009	−0.018
	(0.016)	(0.007)	(0.025)
Dep. Var. Index of satisfaction (interactions by education level)			
Japan	−0.072***		
	(0.003)		
Index of digital use (Ref: Lower secondary or less)	−0.053***	−0.027	−0.066**
	(0.010)	(0.032)	(0.024)
Upper secondary # Index of digital use	0.054***	0.025	0.076**
	(0.015)	(0.028)	(0.028)
Tertiary prof or bachelor degree # Index of digital use	0.062***	0.039	0.079**
	(0.014)	(0.036)	(0.027)
Tertiary master degree and more # Index of digital use	0.062	−0.006	0.111
	(0.065)	(0.051)	(0.100)
Dep. Var. Index of satisfaction (interaction by occupation)			
Japan	−0.073***		
	(0.003)		
Index of digital use (ref. Middle-skilled)	−0.002	−0.016	0.007
	(0.012)	(0.015)	(0.013)
High-skilled # Index of digital use	0.008	0.031 +	0.000
	(0.009)	(0.018)	(0.014)
Low-skilled # Index of digital use	−0.008	−0.007	−0.003
	(0.025)	(0.026)	(0.031)
Dep. Var. Index of satisfaction (interaction by sector—Calvino et al., 2018)			
Japan	−0.073***		
	(0.003)		
Index of digital use (ref. High digital-intensity sectors)	0.022 +	0.009	0.031*
	(0.012)	(0.011)	(0.013)

Table 7 (continued)

	M1_full b/se	M1_fr b/se	M1_jp b/se
Low digital-intensity sectors # Index of digital use	−0.028***	0.002	−0.041***
	(0.007)	(0.020)	(0.010)
Medium–high digital-intensity sectors # Index of digital use	−0.025	−0.022*	−0.025
	(0.015)	(0.009)	(0.020)
Medium–low digital-intensity sectors # Index of digital use	−0.014	−0.002	−0.021
	(0.016)	(0.027)	(0.029)
Dep. Var. Index of satisfaction (interaction by sector—Dosi et al., 2021)			
Japan	−0.074***		
	(0.003)		
Index of digital use (ref. Downstream sectors)	−0.001	−0.003	0.006
	(0.006)	(0.013)	(0.008)
Upstream sectors # Index of digital use	0.027**	0.044***	0.014
	(0.010)	(0.012)	(0.013)
Dep. Var. Index of satisfaction (interaction by type of contract)			
Japan	−0.073***		
	(0.003)		
Index of digital use (ref. fixed-term contract)	−0.002	−0.015	0.008
	(0.014)	(0.018)	(0.018)
Permanent contract # Index of digital use	0.002	0.013	−0.002
	(0.013)	(0.028)	(0.021)
Controls			
Gender, Firm size, Wage, Occupation level, Contract characteristics, Education level, Sector, Age, Family situation, Health Level			
Number of Obs	6386	3281	3105

Standard errors in parentheses: $+p<0.10$, $*p<0.05$, $**p<0.01$, $***p<0.001$

(Kambayashi & Kato, 2012). For these reasons, we can assume that our variable of the type of contract is not enough sufficient to measure job stability and career prospects and can explain the absence of relationships.

These results, which take into account within countries differences (among workers with different characteristics), relativize the similarity of patterns in Japan and France that were found previously. It should lead us to more systematically and jointly investigate the within and between-countries differences to better understand the indirect impact of digital use on job satisfaction that goes through work organization variables.

4.5 Limitations and robustness of the analysis

Our results face several limitations, which have to be stressed. First, as presented above the cross-sectional dimension of our data is a limit that does not allow one to identify causal relationships. We establish only correlation and association, even if our statistical techniques allow us to clarify the relations and the many variables used to avoid several confounding issues. Nevertheless, some aspects can be viewed as more robust than others. The theoretical framework presented in Sect. 2 as well as the literature can help to first assess the robustness of some results. The reverse causality issue is present mainly in the relationship between work-organization practices and digital use (Relation 2.2). The findings from the literature remain inconclusive since some works support that work organization can determine technology production and adoption, while others support rather the primacy of technology adoption as a shock at the workplace that implies adapting work organisation. Finally, some other works argue that technology adoption and work organization are codetermined. Beyond the structure of the data, the conceptual framework is itself a limitation. On the contrary, the other relationships are more clear-cut. Because Relation 1.1 is focused on the structural (socio-economic and contextual) determinants of digital use, it is difficult to support reverse causality. Similarly, it seems also difficult to argue that job satisfaction could determine digital use or work organization practices, or if it plays a role it would be a very limited one. For these reasons, we can first assert the conceptual framework that allows us to provide insights into the technology-working conditions relationships.

Nevertheless, to assess the robustness of our results, we also conducted a set of statistical tests. The variables used are index-transformation of the initial ordinal variable, and even though it appears more relevant to keep most of the variance some studies prefer to use dummified variables. The main reason is that the interpretation can be clearer mainly in terms of the presentation of the results. A good assessment is to find relatively similar results regardless of the data processing used. Divergent results would support the fact that the distribution of the initial variable can be very particular. Without surprise, the results with dummy variables (for digital use, job satisfaction and work organization) give very similar results, but these results slightly vary in terms of significance according to the threshold used for processing ordinal variables to binary variables. This latter aspect supports our argument of index processing to keep all the variance and avoid the arbitrary threshold for dummification.

To deal with the codetermination issue, we have tried to instrument the digital use variable. To do so, the abundance of variables in PIAAC data is a real advantage, but unfortunately, no good instrument was found. A good instrument must be relevant, have good predictive power, be precise, exogenous (from other confounding

variables but also the instrumented variable), and independent (from the outcome variables). We try two strategies of instrumentation, one with the measured skill in literacy and numeracy in PIAAC and one with several (relatively) exogeneous and time-invariant socio-economic variables (age, education level, occupation at detailed level—ISCO 2-digits). For the first strategies the predictive power was not sufficiently good but even more problematic, the instruments are not independent of the outcome variables (work organization practices as well as job satisfaction). The second instrumentation strategy is more satisfactory, even though it does not consist of true instruments. Age, education level, and detailed occupation account for around 54% of the variance of the digital use index and only 2% of the satisfaction index. The results from this instrumental variables strategy are very similar to our baseline results and thus support the robustness of the analysis (detailed in Table 9 in Appendix).

5 Discussion and concluding remarks

In this paper, we have analyzed the diverse impacts of digital use in the early 2010s on some aspects of job quality by comparing work organization and job satisfaction in Japan and France.

A major difficulty in this investigation is that there is no unified model linking digital use and job quality. The challenge is to study several simultaneous relations, at different levels of analysis, and with direct and indirect effects (mediation factors). To be able to test the relationships between digital use and job satisfaction we introduce a simplified mediation model that synthesizes the different relations of interest.

Based on the PIAAC 2013 Survey, our results can be summarized as follows. First, surprisingly, despite differences in work organization and job satisfaction between France and Japan, we did not find overall substantial differences between the two countries regarding the impact of digital use on work organization practices and job satisfaction.

Second, in more detail, there are differences between French and Japanese workers in the mechanisms at work but the overall outcome is similar. In general, we find no direct effect of digital use on job satisfaction. However, digital use is associated with work organization forms (mainly autonomy and flexibility; learning), through which it has positive indirect effects on job satisfaction.

Third, the absence of direct effects of digital use on job satisfaction can be decomposed into a negative effect of digital use (techno-strain) compensated by a positive effect for those who have the right digital skills. This mechanism is a source of inequalities within each country. To put it differently, the most massive source of the digital divide is, in both countries, related to the absence of digital skills.

Moreover, our fourth major result suggests there are also other sources of individual heterogeneity, for which the patterns are different between the two countries.

In the case of Japan, another digital divide appears by education level and it is only slightly correlated with the existence of digital skills. In the case of France, the other sources of the digital divide are related to the differences across sectors and also, in a less important way, across occupations.

It means that the similar patterns between Japan and France that have been found in our initial model are relativized when one looks at within countries differences (among workers with different characteristics). It should lead us to more systematically and jointly investigate the within and between countries' institutional differences regarding the impact of digital use on job quality.

It is also worth mentioning some of the limitations of our paper, which can be a starting point for further investigation. Here, we limit ourselves to two major ones. First, while the comparison between Japan and France is of interest because of the differences between the two countries, it is difficult to assume that it allows us to describe a general pattern that could be observed as well in other countries. It is thus necessary to extend the international comparison to have a better understanding of the impact of digital use on job quality. Second, as the data used in this paper covers the early 2010s, our contribution can be considered as rather a historical investigation of the impact of the first wave of the introduction of digital technologies in the workplace. It means that other investigations are required to analyze this relationship in the most recent period. In particular, it would be interesting to analyze whether the converging differences that we have found between Japan and France have changed over the most recent period, especially in the context of the spread of telework.

Finally, our historical analysis echoes the strong digitalization of work after the COVID-19 pandemic. There is interest in comparing the digitalization trends of the 2010s with those of the 2020s. The pandemic led to extensive use of telework and work-from-home arrangements, resulting in a wealth of research. Current literature presents conflicting views on the impact of telework on job quality (Mofakhami et al., 2024). Some studies suggest that telework enhances job control, autonomy, and satisfaction. In contrast, others indicate potential drawbacks such as increased non-standard working hours, intensity, and feelings of isolation, which could negatively affect workers' health and well-being. Our overall framework, which claims the importance of integrating digital use and work organization to understand job quality, thus appears relevant for understanding the ongoing digitalization of the work process.

Appendix

See Fig. 4 and Tables 8 and 9

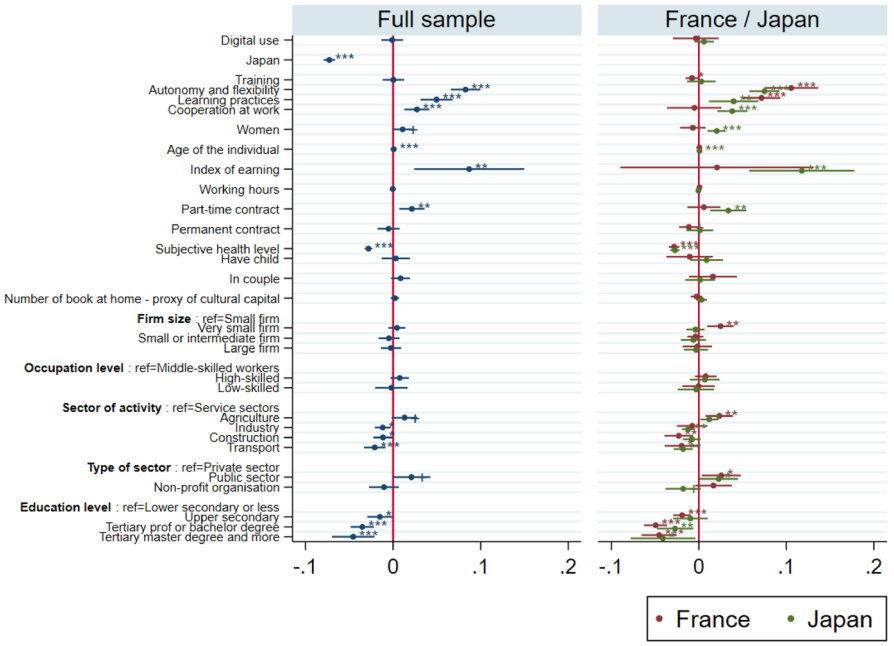

Fig. 4 Direct relations of digital use and work organizations practices on job satisfaction in France and Japan (Relation 2.1 and Relation 3.1)—full regression. *Source*: PIAAC data—2011. French (4,095) and Japanese (3,717) employees. Regression analysis (OLS) on the index of digital use. Marginal effects reported, with confidence intervals (95%). ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, +$p < 0.1$

Table 8 List of the created variables

Created variables	Variables used in PIAAC	Methods	Type of the variable
Index of ICT use	Frequency use of internet at work—email (g_q05a) Frequency use of internet at work—better understand issues related to work (g_q05c) Frequency use at work—spreadsheet software (g_q05e) Frequency use at work—word processor (g_q05f)	(1) All the ordinal variables are standardized from 0 (lowest category) to 1 (highest category) (2) Correlations (PCA, Pearson correlation, alpha's Cronbach) are validated (3) Index is created by a mean of all the standardized variables	Continuous variable (0 to 1)
Index of satisfaction	Satisfaction level with the current job (d_q14)	(1) The ordinal variable is standardized from 0 (lowest category) to 1 (highest category)	Continuous variable (0 to 1)
Autonomy and flexibility index	Control over the pace of work (d_q11a) Control over work methods (d_q11b) Control over the speed of work (d_q11c) Control over working hours (d_q11d)	(1) All the ordinal variables are standardized from 0 (lowest category) to 1 (highest category) (2) Correlations (PCA, Pearson correlation, alpha's Cronbach) are validated (3) Index is created by a mean of all the standardized variables	Continuous variable (0 to 1)
Planning your own activities (score)	Planning your own activities (f_q03a)	(1) The ordinal variable is standardized from 0 (lowest category) to 1 (highest category)	Continuous variable (0 to 1)
Learning index (score)	Learning from co-workers (d_q13b) Learning-by-doing (d_q13c)	(1) All the ordinal variables are standardized from 0 (lowest category) to 1 (highest category) (2) Correlations (PCA, Pearson correlation, alpha's Cronbach) are validated (3) Index is created by a mean of all the standardized variables	Continuous variable (0 to 1)
Cooperation index (score)	Sharing information with co-workers (f_q02a). Time cooperating with co-workers (f_q01b)	(1) All the ordinal variables are standardized from 0 (lowest category) to 1 (highest category) (2) Correlations (PCA, Pearson correlation, alpha's Cronbach) are validated (3) Index is created by a mean of all the standardized variables	Continuous variable (0 to 1)
Participated in formal or non-formal training (dummy)	Participated in formal or non-formal training (fnfaet12)	(1) A dummy variable is created for employees who benefited a training	Dummy variable

Table 8 (continued)

Created variables	Variables used in PIAAC	Methods	Type of the variable
Hourly net wage index	Hourly net wage with bonuses—parity purchase power (in $) (earnmthbonusppp)	(1) The hourly net wage is converted in logarithm to normalize the distribution (2) A standardized index is created with 1 as the highest value and 0 as the lowest one	Continuous variable (0 to 1)

Table 9 Instrumental variables regression comparison. Source: PIAAC data—2011. Regression analysis (OLS and GMM) on the index of job satisfaction. Marginal effects reported

	M1_full	M1_full_IV	M1_fr	M1_fr_IV	M1_jp	M1_jp_IV
	b/se	b/se	b/se	b/se	b/se	b/se
Dep. var. index of satisfaction						
Japan (ref. France)	−0.073***	−0.072***				
	(0.003)	(0.005)				
Index of digital use	−0.007	−0.027	−0.001	−0.024	−0.003	−0.015
	(0.005)	(0.019)	(0.012)	(0.024)	(0.004)	(0.024)
Training (ref. No training)	0.000	0.002	−0.008*	−0.006	0.003	0.004
	(0.006)	(0.005)	(0.004)	(0.007)	(0.008)	(0.007)
Autonomy and flexibility (index)	0.083***	0.094***	0.106***	0.114***	0.075***	0.085***
	(0.009)	(0.013)	(0.016)	(0.015)	(0.009)	(0.017)
Learning practices (index)	0.050***	0.052***	0.072***	0.074***	0.040**	0.041***
	(0.009)	(0.009)	(0.011)	(0.012)	(0.014)	(0.012)
Cooperation at work (index)	0.027***	0.025**	−0.005	−0.004	0.038***	0.034**
	(0.007)	(0.009)	(0.016)	(0.013)	(0.009)	(0.012)
Controls						
Gender, Firm size, Wage, Occupation level, Contracts characteristics, Education level, Sector, Age, Family situation, Health level						
Number of Obs	6386	6386	3281	3281	3105	3105

Standard errors in parenthses: + p < 0.10, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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Declarations

Conflict of interest The authors do not have any conflict of interest in relation with the submission of this paper.

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