How ICT Shapes Wages, Working Conditions, and Job Satisfaction

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Abstract

We study how the widespread diffusion of ICT affects wages, working conditions, and job satisfaction. We frame our empirical investigation with a model in which ICT can improve both wages and working conditions by increasing firms' output. Using French matched employer-employee data and an instrumental variable approach that is motivated by the model, we find that ICT diffusion in 2013–2019 has been beneficial to workers, who experienced both higher wages and better working conditions, particularly through greater flexibility, physical comfort, and safety. In contrast, ICT use has also increased psychological stress and work intensity. These effects vary across workers, firms, occupations and sectors, depending on their characteristics. Despite overall improvements in wages and working conditions, we estimate only modest positive effects of ICT use on job satisfaction. We discuss potential explanations for this finding.

Keywords: ICT diffusion; Wages; Working conditions; Job satisfaction

JEL codes: J3; J81; O33; I31; J28

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1 Introduction

Technology continuously reshapes work arrangements, wages, and well-being. Over recent decades, the main transformation has been digitalization, i.e., the pervasive diffusion and adoption of information and communication technologies (ICT) in the workplace. A large literature has studied its impact on productivity, job structures, and wages. To date, most research has focused on the material consequences of these transformations.[1] Far fewer studies have examined their impact on non-pecuniary aspects of work, such as autonomy, flexibility, work intensity, or subjective job satisfaction—and even fewer using causal inference. This paper adds to this literature by leveraging French matched employer-employee data to address these questions, while adopting a model-based approach to causal identification.

We study how the diffusion of ICT has affected wages, working conditions, and job satisfaction. We start by developing a simple model in which workers and firms bargain over surplus. The model predicts that by raising the firm's output, ICT should improve both wages and working conditions of workers employed by the firm. The model implies that the magnitude of the effects of ICT are heterogeneous, and depend on workers' valuation of working conditions, their outside options and their bargaining power. Since both wages and working conditions contribute to utility, we expect ICT to increase workers' job satisfaction through these indirect channels.

Estimating causal effects of ICT use on individual outcomes is challenging because the intensity of ICT use may correlate with unobservable individual characteristics that also affect wages and working conditions. In order to address this, we build on the model's prediction, where technology adoption at the firm drives outcomes of workers. In particular, we instrument ICT use at the individual level with establishment-level internet access intensity, i.e., the share of workers who have employer-provided internet connection. Internet availability strongly predicts ICT use, capturing an intention-to-treat, while workers' actual ICT usage reflects intensity of treatment take-up. We show that our instrument is "plausibly exogenous" in the sense of Conley et al. (2012). Our identification strategy is reinforced by the fact that only a handful of workers of each establishment are observed in

[1] In the late 1990s and early 2000s, digital transformation was shown to drive job polarization across the wage distribution, as programmable routine jobs (typically middle-class occupations) were progressively replaced by computers. See Autor et al. (2003), Autor et al. (2006), Goos and Manning (2007), Autor et al. (2008), Acemoglu and Autor (2011), Autor et al. (2014), Moreno-Galbis and Sopraseuth (2014), Goos et al. (2014), Harrigan et al. (2021). More recently, the Covid-19 pandemic accelerated the adoption of remote work technologies (see Hensvik et al., 2021, Dey et al., 2020, 2021, Barrero et al., 2021, Dingel, 2021), while the rise of artificial intelligence is now reshaping work practices across the economy.

the data; the unobserved characteristics of a few workers cannot have much influence over establishment-level decisions on internet connectivity. We control for detailed occupation fixed effects, and establishment and worker characteristics. We also study the robustness of our estimates to adding fixed effects for establishments, individuals, and for individuals' job spells within establishments.

We find that ICT use significantly improves hourly wages and working conditions. Our (weighted) 2SLS estimates imply that a 10 percentage point increase in ICT use out of total work-hours (the typical rise of this variable between 2013 and 2019, our reference period, is 14 percentage points) causes a 6.68% hourly wage increase and improves working conditions by 0.18 of its standard deviation. We measure working conditions using an aggregate index that includes learning opportunities, autonomy, support, stability, physical comfort and safety, psychological integrity, working hours, work–life balance, flexibility, and work intensity. We then study the impact of ICT on each dimension separately. Improvements in working conditions are mainly driven by better physical comfort and safety, as well as greater flexibility and adherence to standard working hours. In contrast, ICT use also increases stress and work intensity.

We document heterogeneous effects of ICT use on working conditions. First, we show that workers in both the private and public sectors experience improvements in both wages and working conditions when they use ICT more intensity. However, the underlying channels differ by sector. In both sectors ICT contributes to better physical comfort and safety. But in the public sector, ICT use is associated with greater adherence to standard working hours and an (undesirable) increase in work intensity, whereas in the private sector it leads to a rise in flexibility. These results can be understood through the different ways in which public and private sectors function.

We then find that workers in larger establishments and those with health and safety committees in their establishment benefit more from ICT use in terms of working conditions. This is consistent with these workers exercising greater bargaining power. Women experience greater gains in flexibility when using ICT more intensively, while men benefit more in physical comfort and safety. The effect of ICT use on improvement in flexibility is larger among managers, intermediate professions and employees, but smaller for manual workers. The effect of ICT use on increased stress and work intensity are strongest for office employees and other intermediate professions. These results may reflect variation in preferences across different dimensions of working conditions, but not occupations *per se*, for which we control for using 4-digit occupation fixed effects.

Finally, we evaluate ICT's impact on job satisfaction. Since both wages and working conditions contribute positively to utility, we expect ICT to raise job satisfaction. However, the estimated overall effect is small and not statistically significant. We find that ICT as such has almost no direct effect on job satisfaction—its influence operates entirely through wages and working conditions. The limited overall effect is explained by a mismatch between the dimensions that are improved the most by ICT (physical comfort, safety, standard hours, flexibility) and those that are most valued by workers in terms of job satisfaction (learning, autonomy, support, stability, psychological safety, work–life balance, and unconstrained work pace)—some of which are negatively affected by ICT (such as psychological safety and unconstrained work pace).

This paper makes three main contributions. First, we add to the literature on the effects of ICT diffusion, which mainly focused on employment shifts, and wage dynamics (e.g. Autor et al., 2003; Goos and Manning, 2007; Goos et al., 2009; Michaels et al., 2014; Arntz et al., 2016; Frey and Osborne, 2017). ICT has also been shown to improve communication among workers (Hart and Moore, 2005; Dessein and Santos, 2006; Cremer et al., 2007), reduce information asymmetries (Jensen and Meckling, 1992), and increase productivity (see Institute for Prospective Technological Studies, 2013 for a literature review). At the same time, ICT has been associated with greater autonomy, longer working hours, worse work-life balance, and increases in work intensity (Bloom et al., 2014, Martin and Omrani, 2015; Martin, 2017; Menon et al., 2020; Gihleb et al., 2020; Caselli et al., 2021), with negative consequences for health and well-being (see Blasco et al., 2024, Schwabe and Castellacci, 2020; Gunadi and Ryu, 2021; Bolli and Pusterla, 2022; Lordan and Stringer, 2022; Kortmann et al., 2022; Haepp, 2021; see Eurofound and ILO, 2017 or Martin and Hauret, 2022 for reviews of this literature). Our paper takes a broad perspective by considering jointly multiple dimensions of working conditions, which shows that ICT generally improves job quality, albeit unevenly.[2]

Second, we use matched employer–employee data to provide causal inference. To the best of our knowledge, the matched employer module of the French Working Conditions Survey has hitherto not been used to study the impact of ICT on working conditions. Framed by our model, these data permit us to develop an instrumental variable approach, which is an important and original contribution of our work.

Third, our results indicate that improvements in wages and working conditions do not

[2]Some papers take a perspective of multiple components of working conditions as we do here (e.g. Askenazy and Caroli, 2010; Green et al., 2013; Osterman, 2013; Antón et al., 2023; Duhautois et al., 2022), but in these papers there is no attempt to provide causal inference.

necessarily translate into higher job satisfaction, because workers value different aspects of job quality to varying degrees. This complexity underscores the need to move beyond wage-focused analyses when assessing the impact of technological change on workers' well-being. Previous studies on workers' preferences regarding job attributes do not consider ICT intensity, with the exception of Bolli and Pusterla (2022). Using Swiss data, Bolli and Pusterla (2022) estimate a positive association between digitization and job satisfaction, but do not attempt to provide causal inference on the mechanisms, as we do.

The rest of the paper is structured as follows. Section 2 outlines the theoretical framework. Section 3 details the data, while Section 4 explains the empirical strategy. Section 5 reports the estimated effects of ICT on wages, working conditions, and job satisfaction. Finally, Section 6 concludes.

2 Theoretical framework

We develop a simple model along the lines of Adams-Prassl et al. (2023) that allows us to understand the economic mechanisms that drive the determination of working conditions and wages. Both dimensions are simultaneously negotiated by firms and workers in a bargaining process. We then study how ICT may affect working conditions and wages.

We assume that workers have a strictly concave utility function given by $u(w, q) = \log w + \theta \log q$, with $\theta > 0$, where w is the wage and q for quality of working conditions. For simplicity, we assume that q is a scalar, but the framework can easily be extended to a vector of working conditions. For simplicity, we assume log-separability of wages and working conditions, since empirically we do not find robust relationship between an interaction of wages and working conditions on job satisfaction (see Table D.1 in Appendix D). These preferences trivially imply that for a given level of utility, the worker may accept a lower wage for better working conditions.

Firm profits are given by $\pi = y + \gamma(q) - w$, where y represents the output per worker, w is the wage paid to the worker, and $\gamma(q) = \alpha q - \frac{1}{2}q^2$, $\alpha \geq 0$, captures the net effect of working conditions on output: better working conditions may make the worker more productive at rate α, but they are costly to provide.

The worker and the firm enter a bargaining process over wages and working conditions.[3] Denote by $\overline{U}$ the worker's exogenous outside option and by $\beta \in (0, 1)$ the worker's bargaining power. We represent the Nash bargaining process between the firm and the worker as

[3]We are implicitly assuming a one job-one firm setup, so as to simplify the bargaining process.

maximizing the following objective with respect to w and q:

$$lnS(w,q) = \beta \cdot \log\left[\log w + \theta \log q - \overline{U}\right] + (1-\beta)\cdot \log\left[y + \alpha q - \frac{1}{2}q^2 - w\right],$$

where $\log w + \theta \log q - \overline{U}$ is the worker's surplus from the match and $y + \alpha q - \frac{1}{2}q^2 - w$ is the firm's surplus, and we normalize the firm's outside option to zero. Note that for the match to take place the surplus of each party must be positive, otherwise the match will not happen.

The first-order necessary condition (FONC) with respect to w is

$$\frac{\beta}{\Delta}\cdot\frac{1}{w} - (1-\beta)\frac{1}{\pi} = 0$$

and the first-order necessary condition with respect to q is

$$\beta \cdot \frac{\theta}{\Delta \cdot q} + (1-\beta)\cdot\frac{\alpha - q}{\pi} = 0,$$

where we denote by Δ the worker's surplus and π is the firm's surplus, since the outside option is zero. Solving for Δ in the FONC for w and substituting this into the FONC for q yields:

$$q^2 - \alpha q - \theta w = 0 \Longrightarrow w = \frac{q(q-\alpha)}{\theta}$$

Positive wages imply $q > \alpha$, since $\theta > 0$ and $q > 0$.

The FONC for w together with $w = q(q-\alpha)/\theta$ form a system of equations that implicitly determines (w^*, q^*), where $q^* > \alpha$. Comparative statics for this system (see derivations in Appendix B) are summarized in Table 1. Increases in firm surplus due to greater y or α improve both wages and working conditions, since the worker is able to apportion to herself part of this additional surplus through the bargaining process. Improvement in the worker's bargaining power or outside option trivially allow the worker to obtain both higher wages and better working conditions. When the worker's preference for working conditions is greater, the worker is more willing to give up wages for better working conditions, but the effect on q itself is ambiguous. On the one hand, the worker receives greater utility per q, which makes her require more q (the flip-side of the effect on wages); on the other hand, the firm needs less q to give the worker the same level of utility.

Table 1: Comparative Statics

Parameter	Effect on q^*	Effect on w^*
Output y	$\uparrow$	$\uparrow$
Firm return α	$\uparrow$	$\uparrow$
Bargaining power β	$\uparrow$	$\uparrow$
Outside option U	$\uparrow$	$\uparrow$
Worker value θ	ambiguous	$\downarrow$

The impact of ICT adoption at the firm. We now analyze the potential impact of ICT on the equilibrium wage and working conditions. Denote ICT by t. We assume that new technology improves the firm's output by $y(t)$ with $y'(t) > 0$, and/or reduces the cost of proposing one additional unit of quality, or, equivalently, increases the profit of proposing one additional unit of quality:

- Firm total profit: $\pi = y(t) + \gamma(q,t) - w$
- Firm benefit from quality: $\gamma(q,t) = \alpha q - \frac{1}{2}\frac{q^2}{t}$ or $\gamma(q,t) = \alpha(t)q - \frac{1}{2}q^2$ with $\alpha'(t) > 0$. In both cases, for a given increase in t, we have that $\partial\gamma(q,t)/\partial t > 0$, which implies that it is profitable for the firm to increase quality.

Using static comparative findings summarized in Table 1, we conclude that, through its impact on output $y(t)$ and/or on $\gamma(q,t)$, ICT adoption by the firm translates into better wages and working conditions. Because both dimensions contribute positively to the worker's utility, we conclude that ICT should positively contribute too to the worker's job satisfaction thanks to the indirect effect mediated by wages and working conditions.

Our framework also implies that these effects will be heterogeneous across workers, firms and occupations, depending on how workers value working conditions, their outside options and bargaining power, and on how ICT affects the firm's surplus (see, again, Appendix B). For example, the impact of ICT on working conditions increases with worker's bargaining power β and with the strength of preferences for working conditions θ. The effect of ICT on wages similarly increases with β, as well as with the initial level of q. The effect of ICT on both w and q decreases with the level of wages at which the worker is employed when the firm increases ICT availability.

3 Data

3.1 The Working Conditions Survey

We use data from the Working Conditions Survey (WCS), which is conducted jointly by the French Ministry of Labor's Directorate for Research, Studies and Statistics (DARES) and the French National Institute of Statistics and Economic Studies (INSEE). The WCS is an annual, nationally representative survey of approximately 25,000 workers in France. It provides rich information on work organization and working conditions across multiple dimensions, which we detail in Table 2, as well as wages and other demographics. We use the 2013 and 2019 waves of the WCS, which are the only ones that report ICT use.

Main variables definitions. In 2013 and 2019 the WCS included questions on workers' use of information and communication technologies (ICT). Workers reported the number of weekly minutes they spent using at least one of the following tools: desktop (fixed) computer, laptop (mobile) computer, professional email address, internet and intranet. We convert this variable into the proportion of daily working time during which the individual uses ICT.

Weekly hours of work are used to compute hourly wages. Wages are adjusted for consumer price index (CPI) inflation between survey years (reference year: 2005).

The WCS also collected numerous measures of non-pecuniary working conditions. Following the Eurofound convention (see Eurofound, 2015 and Eurofound and ILO, 2017), we define twelve dimensions of working conditions: learning, autonomy, support, stability, physical comfort, physical safety, psychological safety, standard working hours, not working on weekends, work-life balance, flexibility and unconstrained work pace; see Table 2 for a detailed definition of these dimensions. Higher values indicate learning more on the job, more autonomy, support and stability, better physical and psychological safety, working standard hours, not working in the weekend, more flexibility, better work-life balance and lower work pace. To facilitate comparisons with wages, we summarize these twelve indicators into a single Working Condition Index (WCI). The index is computed as the unweighted average of the twelve indicators. We then standardize the WCI to have a mean of 0 and a standard deviation of 1.

In 2019, the survey also asked employees to rate their overall job satisfaction on a scale from 0 ("not satisfied at all") to 10 ("totally satisfied"): "Over the course of your working life, please rate from 0 to 10 your level of agreement with the following statement: for the

Table 2: Definition of Non-Pecuniary Working Condition Indicators

Indicator	**Definition**
Learning	Mean of four variables: (i) indicator for learning new skills on the job; (ii) indicator for access to sufficient and appropriate training; (iii) discrete variable (0, 1/3, 2/3, 1) for improved career prospects; (iv) similarly defined discrete variable for opportunities for professional skill development.
Autonomy	Mean of (i) indicator for ability to choose methods to accomplish work objectives; (ii) indicator for no immediate dependence on colleagues; (iii) discrete variable (0, 1/3, 2/3, 1) for less adherence to orders; (iv) discrete variable (0 to 1) for extent work rhythm is influenced by external client demands.
Support	Mean of three indicators equal to 1 if the individual declares receiving support from (i) colleagues, (ii) their manager, and (iii) the opportunity to cooperate with others.
Stability	Mean of (i) indicator equal to 1 if the individual believes they have a low probability of job loss within six months; (ii) discrete variable (0, 1/6, ..., 1) where 0 = no contract and 1 = permanent contract/civil service; (iii) continuous normalized seniority variable (0 to 1).
Physical comfort	Mean of six indicators equal to 1 if the worker does not (i) work in painful positions, (ii) stand up for long periods, (iii) walk extensively, (iv) move heavy loads, (v) perform painful or tiring movements, or (vi) continuously repeat the same gestures/operations.
Physical safety	Mean of four indicators equal to 1 if the worker is not exposed to (i) vibrations, (ii) smoke, (iii) chemical products, or (iv) traffic accidents.
Psychological safety	Mean of five variables: (i) discrete variable (0 to 1) capturing whether the individual does things they disapprove of (0 = often, 1 = never); (ii) discrete variable for absence of pressure at work (0 = always, 1 = never); and three indicators for absence of tense interactions with (iii) clients, (iv) managers, and (v) colleagues.
Standard hours	Mean of three discrete variables (0, 1/2, 1) summarizing whether the individual does not work (i) evenings, (ii) nights, or (iii) early mornings.
Not working weekend	Mean of two discrete variables (0, 1/2, 1) summarizing whether the individual does not work on (i) Saturdays and (ii) Sundays.
Flexibility	Mean of four variables: (i) indicator for ability to take a break at will; and three discrete variables (0 to 1) capturing whether (ii) working time is not monitored, (iii) the individual can organize their work time freely, and (iv) can easily take 1–2 hours off during the day.
Work–life balance	Mean of four discrete variables (0, 1/3, 2/3, 1), where 1 corresponds to (i) no overtime, (ii) no work brought home, (iii) no thinking about work outside hours, and (iv) work hours compatible with family/social activities.
Unconstrained work pace	Mean of four variables: (i) indicator for having enough time to do the job; and three discrete variables (0 to 1) capturing whether the individual (ii) does not have to work at high speed, (iii) does not have strict deadlines, and (iv) does not manage an excessive workload.

most part, I am satisfied with my professional life."

Sample and summary statistics. Our pooled sample for 2013 and 2019 contains approximately 50,300 observations. We exclude workers from the agricultural sector and those living outside mainland France. The sample is broadly representative of the French workforce. Table 3 shows that, for example, women account for 56% of the sample, 63% of workers holds at least a diploma equivalent to the French baccalauréat (end of high school), and 81% work full-time.

Table 3: Summary Statistics Across Samples (2013 and 2019)

	Pooled sample		Panel sample		Merged sample	
	Mean	SD	Mean	SD	Mean	SD
Male	0.44	0.5	0.43	0.5	0.43	0.49
Age	43.91	10.62	44.6	9.38	43.79	10.44
No Diploma	0.06	0.24	0.05	0.22	0.06	0.24
CEP, Brevet	0.07	0.025	0.05	0.22	0.06	0.23
CAP, BEP	0.25	0.43	0.25	0.043	0.25	0.43
Baccalaureate	0.18	0.38	0.18	0.39	0.18	0.38
BAC+2	0.15	0.36	0.17	0.37	0.15	0.36
BAC+3 or BAC+4	0.16	0.36	0.17	0.37	0.16	0.37
BAC+4 or more	0.14	0.34	0.14	0.34	0.14	0.34
In couple	0.77	0.42	0.79	0.41	0.77	0.42
Has children	0.6	0.49	0.66	0.47	0.61	0.49
Immigrant	0.09	0.29	0.07	0.25	0.08	0.27
Full-time worker	0.81	0.39	0.81	0.39	0.83	0.38
ICT	0.44	0.39	0.46	0.38	0.45	0.39
Hourly wages	10.73	12.63	10.95	13.25	10.91	9.33
Working conditions (unstand.)	0.69	0.13	0.64	0.12	0.63	0.12
No. of observations	50,313		25,078		21,575	

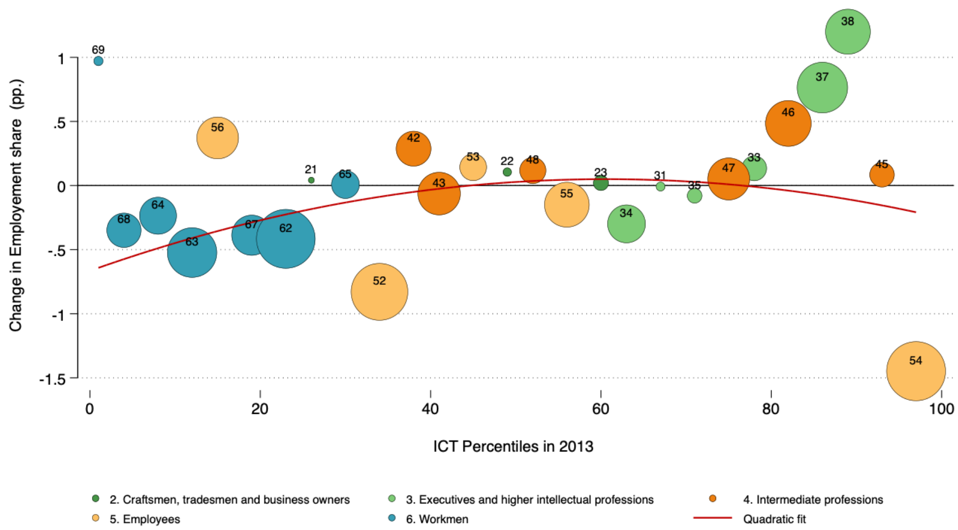
Notes: Working conditions survey, 2013, 2019, including public and non-farm private sectors.

Both the incidence and intensity of ICT use increased markedly between 2013 and 2019. The share of workers using ICT at all rose from 73.4% in 2013 to 100% in 2019. Among ICT users, the average share of working time spent using ICT increased from 39% in 2013 to 53% in 2019 (see Table A.1).

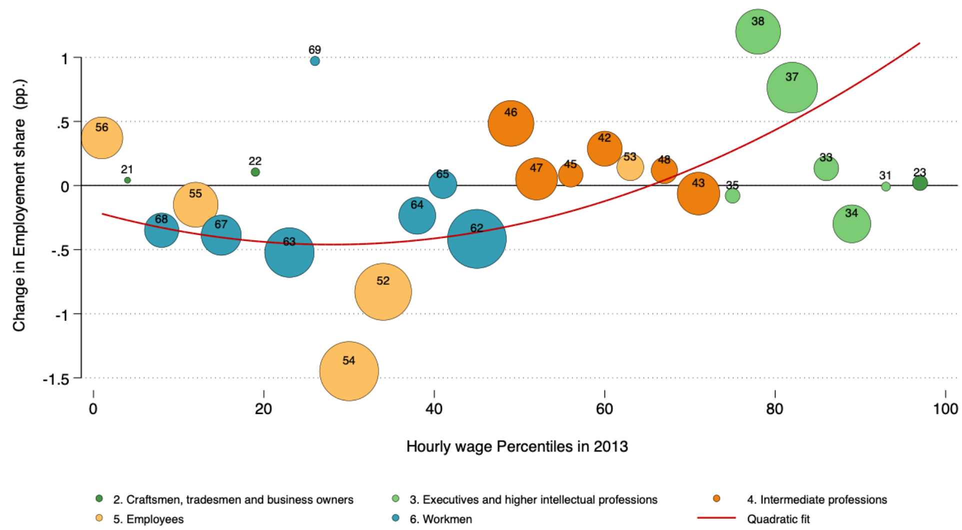
Appendix Tables A.1 and A.2 present summary statistics and correlation matrices for the twelve non-pecuniary working conditions. Between 2013 and 2019, working conditions improved modestly, due to improvements in learning and development, support, stability, physical comfort, physical risk, standard working hours, and unconstrained work pace. The correlations among these indicators are relatively low (mostly 0.1–0.2).

Figure 1 shows the increase in employment shares by occupation according to their ICT intensity. Occupations with rising employment shares tend to be those that use ICT more intensively, with the major exception of administrative staff in private companies (category 54), whose employment share declined substantially—likely because many of the routine tasks they traditionally performed have been automated. As in many European countries, this shift reflects occupational upgrading (e.g., Reshef and Toubal, 2024; Eurofound, 2015 report; Arntz et al., 2022): growth in ICT-intensive occupations has been associated with increases in both higher-paying jobs and occupations offering better working conditions.

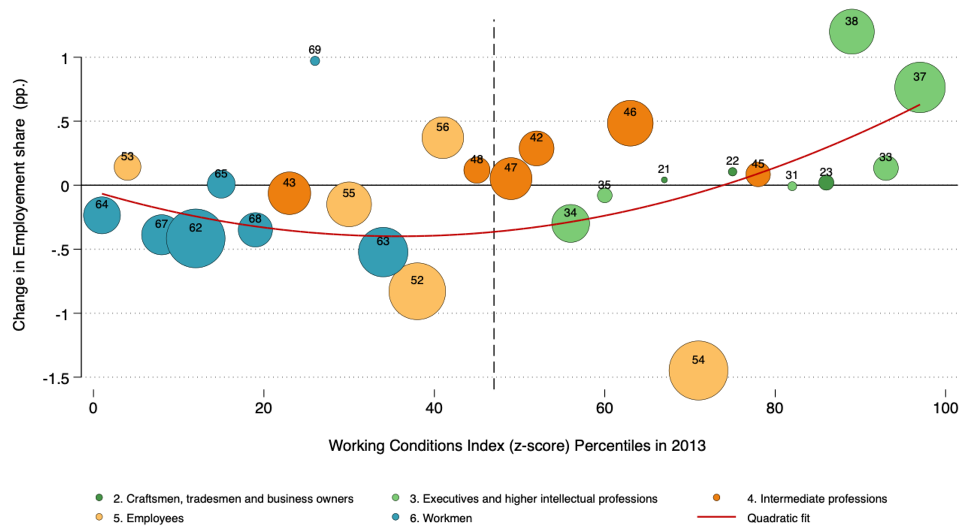
Figure 1: Trends in Employment Shares by ICT, Wage and Working Conditions



(a) ICT percentiles



(b) Wage percentiles



(c) Working conditions percentiles

Notes: French Working Conditions Survey (WCS). These figures show changes in employment shares, in percentage points, from 2013 to 2019, by occupation on the Y-axis. Occupations are ranked from left to right based on their percentile of ICT use (or wages or working conditions) in 2013 on the X-axis. Weights are applied to ensure a representative sample. ICT use is defined as the proportion of daily work hours during which an individual uses ICT. Working conditions are measured using an aggregate indicator, which is constructed from 12 sub-indicators: learning, autonomy, support, stability, physical comfort, physical risk, psychological integrity, standard working hours, no weekend work, flexibility, and unconstrained work pace. The size of each observation represents the initial employment share in 2013. Each observation is identified by its French occupation code (*Professions et catégories socioprofessionnelles*, PCS). The sample includes both the public and non-farm private sectors.

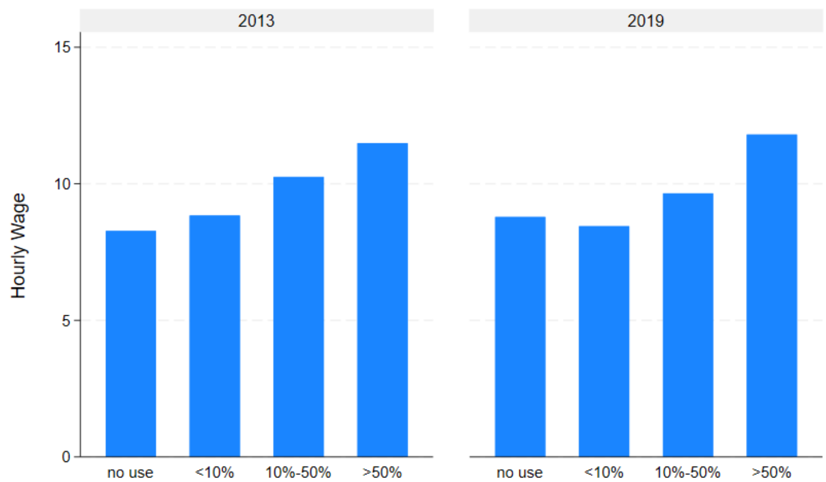
Panel structure. A key feature of the WCS is its panel dimension: about half of the workers surveyed in 2013 were also surveyed in 2019, yielding approximately 25,000 panel observations. Table 3 compares the characteristics of the full employee sample and the balanced panel sample. Workers in the panel sample are slightly older, as one could expect, but otherwise its characteristics are very similar to the full sample. Although most of our analyses will be based on the matched employer-employee sample, it is reassuring, in terms of representativeness, to see that the composition of these samples are similar.

Machted employer-employee data. Since 2013 the WCS has included a matched employer-employee component, linking employer survey responses with employee data. This matched sample contains 21,575 observations (43% of the pooled employee dataset), covering about 13,788 establishments (observed either in 2013 or in 2019). On average, there are 3.4 employees per establishment (Appendix Table A.3 shows the distribution of employees per establishment). Most employers responded to the survey in only one wave. Only 1,926 establishments appear in both 2013 and 2019. Table 3 shows that the matched sample contains a slightly higher share of full-time workers and fewer immigrants than the full employee sample, but the samples remain highly comparable overall.

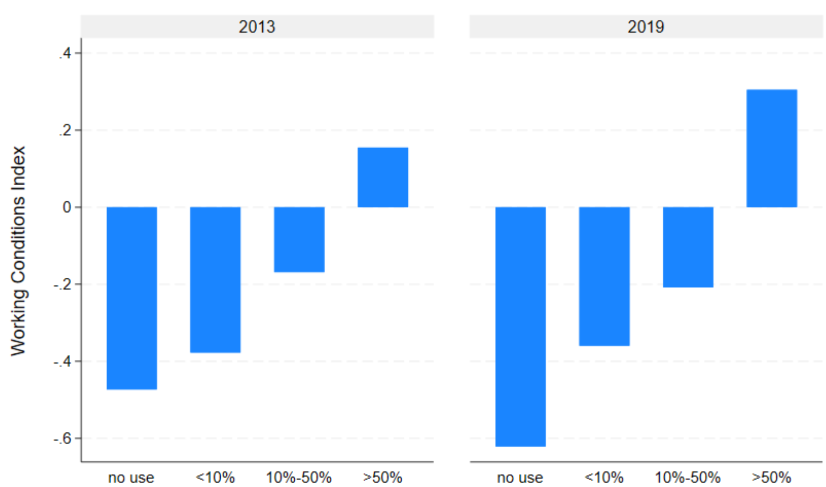
The employer survey collects information on establishment characteristics, workforce management, work organization, and employee representation. Importantly, in both 2013 and 2019, employers were asked about the share of workers using the internet at the workplace, with response categories: "not using it", "less than 10%", "10-50%", "50% and more" and "I do not know". This measure of ICT adoption at the establishment level reflects the employer's view of the entire workforce and is therefore not affected by partial employee coverage in the survey.

The share of establishments with minimal ICT use declined from 2013 to 2019: the share with fewer than 10% of employees using ICT fell from 14% to 11%. The share with 10–50% of employees using ICT also decreased. Conversely, the share with over 50% of employees using ICT rose from 57% to 62% (Appendix Figure A.1). Additionally, Figure 2 shows that establishments with higher ICT use were associated with higher wages and better working conditions for employees.

Figure 2: Average wages and working conditions by establishment ICT intensity



(a) Hourly wage



(b) Working conditions index

Notes: The figure reports average wages and working conditions by ICT-intensity of establishments: establishments where the share of employees using ICT is 0%, below 10% (but more than zero), 10–50% and above 50%.

4 Empirical strategy

We now turn to studying the empirical relationship between ICT, wages and working conditions. Given that ICT adoption may correlate with unobservables affecting wages and working conditions, this could bias our estimates, even if we control for several observable worker characteristics. To mitigate this endogeneity, we exploit the employer–employee nature of our data. Specifically, we instrument individual ICT use with establishment-level variation in workers' access to the internet. We then use the instrumented values of ICT use to estimate its impact on wages and working conditions. Our identifying assumption is that a firm's ICT adoption rate captures an exogenous "intention to treat", while the intensity of ICT use at the individual level reflects actual treatment take-up. Under this assumption, establishment-level variation in ICT adoption affects individual outcomes only through its impact on individual ICT use, allowing us to recover the causal effect of ICT adoption on wages and working conditions.

4.1 ICT, Wages and Working Conditions

We begin by estimating the relationship between ICT use, wages and working conditions using the following specification:

$$Y_{ijet} = \beta_Y + \pi_Y ICT_{it} + X_{it}\delta_Y + X_{et}\rho_Y + \alpha_t + \alpha_{r(i,t)} + \alpha_j + \alpha_e + \alpha_i + \varepsilon_{ijet}, \qquad (1)$$

where Y_{ijet} denotes either the log hourly wage or the working condition index (or its components) of worker i in occupation j, working in establishment e in year t. ICT_{it} denotes the share of workday hours during which individual i uses ICT in year t. X_{it} includes individual socio-demographic controls (gender, age, education, marital status, number of children, immigration status and whether individual is a full-time worker). X_{et} comprises establishment-level control variables (establishment workforce size, presence of a staff representative, presence of a staff union, and existence of a health and safety committee). We consider different model specifications with varying fixed effects, including year (α_t), occupation (α_j), establishment (α_e), individual (α_i), and region of residence $\alpha_{r(i,t)}$), where $r(i,t)$ denotes the region where individual i resided in year t.

All specifications are estimated on the merged employer-employee sample. We consider only individuals for whom both information on wages and working conditions have been specified. We use weighted least squares (WLS) regressions with sampling weights to ensure that the sample is representative of the whole labor force population.[4] We report robust standard errors clustered at the individual level, since some individuals appear more than once in our sample.

4.2 IV strategy

We instrument our explanatory variable ICT_{iejt} by the propensity of establishments to offer internet connection to their workers. Formally, we measure this propensity using two dummy variables defined at the establishment level: the first equals one when the percent of employees in the establishment that use the internet is between 10% and 50% and zero otherwise ($\chi_{10-50,et}$); the second equals one if more than 50% of the employees of the establishment that use the internet and zero otherwise ($\chi_{>50,et}$). This choice corresponds to the way the data at the establishment level are collected (see Section 3). The second and first stage regressions are, respectively,

$$Y_{ijet} = \beta_Y + \pi_Y ICT_{it} + X_{it}\delta_Y + X_{et}\rho_Y + \alpha_t + \alpha_{r(i,t)} + \alpha_j + \varepsilon_{ijet} \tag{2}$$

$$ICT_{ijet} = \beta_{ICT} + \lambda_1\chi_{10-50,et} + \lambda_2\chi_{>50,et} + X_{it}\delta_{ICT} + X_{et}\rho_{ICT} + \tau_t + \tau_{r(i,t)} + \tau_j + u_{ijet} \tag{3}$$

The identification assumption is that the establishment's intention to treat affects the outcome Y_{ijet} only through the individual take-up. This is a reasonable assumption because the establishment information pertains to the availability of internet it offers to all of its employees, while only a handful of them, and typically only one (see Appendix A.3), are sampled in our data. The exclusion restriction is reinforced by controlling for both individual and establishment control variables. We implement this strategy using weighted two stage least squares (W2SLS), with the same sampling weights as above. Since the instrument varies by establishment, and some establishments have more than one employee in the WCS, we report robust standard errors clustered at the establishment level.

This IV approach is an original contribution to the existing literature, which mainly focuses on correlations between ICT use, wages and working conditions. While improving causal inference, we must interpret the results with caution, since it is not unlikely that the W2SLS estimator identifies a local average treatment effect (LATE), rather than the average treatment effect (ATE). This would arise if, for example, individuals who know that they would see greater gains in their wages and working conditions respond more intensively to the intention to treat, causing the LATE to be greater than the ATE.

[4] See Appendix E for details on sampling weights.

We address concerns that our instrument is not perfectly exogenous, in the sense that it may have a direct effect on wages and working conditions that does not go through ICT. To do this, we apply the "plausibly exogenous" methodology developed by Conley et al. (2012). In particular, we implement the "Local-to-Zero" methodology, which constructs standard errors or bounds on the estimates that take into account uncertainty about the exogeneity of the instrument.

We briefly describe the idea underlying this method here and refer the reader to Appendix F for more details on this procedure. If the instrument (internet availability at the establishment) is perfectly exogenous, then it would have a coefficient of zero if added to the structural ("second stage") equation. Uncertainty about this hypothesis is captured by variation of this coefficient around zero (given a distribution for this coefficient, say, normal or uniform, with mean zero). If the coefficient to ICT remains statistically significant (or the bounds do not include zero) after taking into account this uncertainty, then this indicates that even if the instrument is not strictly exogenous, it is strong enough to justify small violations of the exclusion restriction, and is thus useful for inference.

4.3 Wages, Working Conditions and Job Satisfaction

As highlighted by our theoretical framework, if ICT use increases wages and improves overall working conditions, it should also affect workers' job satisfaction. We therefore seek to estimate how ICT diffusion influences job satisfaction both directly and indirectly through these two channels.

We observe workers' job satisfaction in 2019, which allows us to estimate the following specifications:

$$JS_{ije} = \omega_{LS}^{total}\text{ICT}_i + X_i\delta_{LS} + X_e\rho_{LS} + \alpha_{r(i)} + \alpha_j + \epsilon_{ije} \tag{4}$$

$$JS_{ije} = \omega_{LS}^{direct}\text{ICT}_i + \mu_{LS}\log(wage)_i + \nu_{LS}WC_i + X_i\delta_{LS} + X_e\rho_{LS} + \alpha_{r(i)} + \alpha_j + \epsilon_{ije} \tag{5}$$

In equation (4) ω_{LS}^{total} captures the total effect of ICT on job satisfaction. In equation (5) ω_{LS}^{direct} captures the direct effect of ICT on job satisfaction, conditional on wages ($\log(wage)_i$) and non-pecuniary working conditions (WC_i), thereby controlling for the indirect channels through which ICT may operate.

5 Results

We begin by reporting estimates of the effect of ICT use on wages and working conditions using both weighted (by sampling weights) least squares (WLS) and weighted two-stage least squares (W2SLS). We then examine the relationship between ICT use and job satisfaction, and assess the extent to which this relationship is mediated through wages and non-pecuniary working conditions.

5.1 ICT, Wages and Working Conditions

Our model predicts that if ICT adoption increases firms' output, greater ICT use should translate into higher wages and improved working conditions. Table 4 reports WLS estimates for our merged employer–employee sample in 2013 and 2019, covering both the public and private sectors. We report in Column 1 results that include individual socio-demographic controls along with year and region fixed effects. In Column 2 we add 4-digit occupation fixed effects, restricting identification to within-occupation heterogeneity. In Column 3 we add to Column 2 establishment-level controls. In Column 4 we remove all establishment controls and instead introduce establishment fixed effects. In Column 5 we include worker fixed effects, restricting identification to within-worker variation over time. Finally, in Column 6 we introduce worker-by-establishment fixed effects, relying on within-worker and establishment variation.

Panel A shows a positive association between the intensity of ICT use and wages across all specifications. For example, in Column 3 a 10 percentage point increase in the share of the workday spent using ICT is associated with a 0.71% wage increase. This relationship weakens considerably and becomes statistically insignificant once we account for within-establishment variation (Column 4), suggesting that much of the observed association between individual ICT intensity and wages is driven by establishment-level characteristics. When exploiting within-individual variation over time (Column 5), we find that a 10 percentage point increase in the share of the workday spent using ICT (the typical rise of this variable between 2013 and 2019, our reference period, is 15 percent points) is associated with a statistically significant 1.08% wage increase.

Panel B of Table 4 shows a positive association between the intensity of ICT use and working conditions across all specifications. The relationship is statistically significant in all but the most stringent specification in Column 6, with worker-establishment fixed effects. Comparing Columns 1 and 2, the coefficient to ICT use declines markedly when occupation fixed effects are added, indicating that a substantial portion of the variation in working conditions reflects occupational sorting. Nevertheless, the relationship between ICT use and non-pecuniary working conditions remains both positive and statistically significant. In Column 3, with both occupation fixed effects and establishment controls, we find that a 10 percentage point increase in the share of the workday spent using ICT is associated with a 0.028 SD improvement in working conditions. This relationship is somewhat weaker, albeit statistically significant, when we add establishment fixed effects and individual fixed effects in Columns 4 and 5, respectively. In Column 5, we find that a 10 percentage point increase in ICT use is associated with a 0.023 SD increase in working conditions. As with wages, the relationship between ICT use and working conditions weakens considerably, both in magnitude and precision, when we add worker-establishment fixed effects in Column 6.

Table 4: ICT, Wages and Working Conditions

	Panel A: Log Hourly Wage					
	(1)	(2)	(3)	(4)	(5)	(6)
ICT	0.088***	0.077***	0.071***	0.038	0.108***	0.067
	(0.023)	(0.019)	(0.019)	(0.025)	(0.034)	(0.051)
	Panel B: Working Conditions Index (z-score)					
	(1)	(2)	(3)	(4)	(5)	(6)
ICT	0.754***	0.276***	0.277***	0.198***	0.227***	0.113
	(0.108)	(0.057)	(0.057)	(0.072)	(0.074)	(0.095)
Obs.	18,163	18,024	18,024	8,776	4,340	2,370
Individual Controls	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓
Region Fixed Effects	✓	✓	✓	✓	✓	✓
Occupation FE 4-digits		✓	✓	✓	✓	✓
Establishment Controls			✓			
Establishment FE				✓		
Worker Fixed Effects					✓	✓
Establishment*Worker FE						✓

Notes: Working condition survey merged sample for 2013 and 2019 including public and private sectors. Weighted least square regressions with sampling weights defined to ensure a representative sample. Robust standard errors are clustered at the individual level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5.2 Components of working conditions.

Table 5 examines the relationship between ICT use intensity and the various components of working conditions. The regressions control for individual and establishment characteristics and include year, region, and occupation fixed effects (like in Column 3 of Table 4). The results suggest that the overall positive impact of ICT on working conditions is driven by a combination of sometimes contrasting effects. Consistent with previous literature, ICT use is positively associated with improved physical comfort and safety. This makes sense, since working more time in front of a computer reduces physical risk. ICT use is also associated with more favorable time-use conditions, including standard working hours, reduced weekend work, and greater flexibility. At the same time, ICT use is associated with lower psychological safety and a faster, more demanding work pace (Bloom et al., 2014, Martin and Omrani, 2015; Martin, 2017; Menon et al., 2020; Gihleb et al., 2020; Caselli et al., 2021).

Table 5: ICT and Components of Working Conditions

	Learning & Development	Autonomy	Support	Stability	Physical comfort	Physical safety
	(1)	(2)	(3)	(4)	(5)	(6)
ICT	0.072	0.055	-0.037	0.017	0.499***	0.376***
	(0.061)	(0.068)	(0.051)	(0.057)	(0.049)	(0.051)
	Psycho safety	Standard workhours	Not working weekend	Flexibility	Work-life balance	Uncons. work pace
	(7)	(8)	(9)	(10)	(11)	(12)
ICT	-0.127*	0.130**	0.242***	0.147**	-0.048	-0.132**
	(0.076)	(0.059)	(0.046)	(0.062)	(0.066)	(0.064)
Obs.	18,024	18,024	18,024	18,024	18,024	18,024
Individual Controls	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓
Region Fixed Effects	✓	✓	✓	✓	✓	✓
Occupation FE 4-digits	✓	✓	✓	✓	✓	✓
Establishment Controls	✓	✓	✓	✓	✓	✓

Notes: Working condition survey merged sample for 2013 and 2019 including public and private sectors. Weighted least square regressions with sampling weights defined to ensure a representative sample. All non-pecuniary working conditions have been standardized. Robust standard errors are clustered at the individual level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5.3 W2SLS results

We exploit the matched employer-employee dimension of our data and instrument individual ICT use ICT_{iejt} by the propensity of establishments to offer internet connection to their workers. Table 6 provides evidence that greater ICT use causally increases both hourly wages and aggregated working conditions.

In Panel A we report strong first stage results, with K-P F-statistics above 15. The point estimates on ICT use in Panels B and C are positive, statistically significant, and substantially larger than those reported in Table 4. We interpret this results as a local average treatment effect (LATE): the intention to treat at the establishment induces greater treatment take up for individuals who know that they will gain more from treatment. According to Columns (6) and (9), a 10 percentage point increase in ICT use raises wages by 6.68% and improves working conditions by 0.18 standard deviations.

In order to assess the importance of potential violations of the exclusion restriction, we apply the Local-to-Zero (LTZ) method of Conley et al. (2012). As explained above in Section 4.2 (and in greater detail in Appendix F), this takes into account uncertainty about the exogeneity of establishment-level instrument. Specifically, we estimate versions of equation 2 that include the establishment-level instruments and we store the variance of the coefficients to the instruments, γ, here denoted Var_{γ}. We then use the LTZ method to construct confidence intervals for the W2SLS coefficients to ICT using different multiples of Var_{γ}—1, 2, 5, and 10—and two distributions for γ—normal and uniform. The results in Appendix Tables F.1 and F.2 imply that the uncertainty about the exogeneity of the instruments needs to be very high in order to render the W2SLS estimates not statistically significant—here captured by more than ten times Var_{γ}. This indicates that even if the instrument is not strictly exogenous, it is strong enough to justify small violations of the exclusion restriction, and is thus useful for inference.

We also apply our IV strategy to the different components of working conditions. The results are reported in Table 7. Consistent with the findings reported in Table 5, greater ICT intensity is associated with enhanced learning and development on the job, improved physical comfort and safety, and more desirable time-use conditions, including standard working hours and greater flexibility. At the same time, ICT use is linked to reduced stability. The coefficient to unconstrained work pace turns positive but loses precision and becomes statistically insignificant.

Table 6: ICT, Wages, and Working Conditions—W2SLS

	Panel A: ICT, first stage		
	(1)	(2)	(3)
0.1 < Internet < 0.5	0.115***	0.036**	0.033**
	(0.035)	(0.014)	(0.014)
0.5 < Internet	0.211***	0.074***	0.074***
	(0.022)	(0.014)	(0.014)
K-P F-stat	46.99	15.45	15.78
	Panel B: Log Hourly Wage		
	(4)	(5)	(6)
ICT	0.649***	0.725**	0.668**
	(0.151)	(0.331)	(0.326)
	Panel C: Working Conditions Index		
	(7)	(8)	(9)
ICT	1.350***	1.778***	1.767***
	(0.396)	(0.680)	(0.672)
Observations	18,163	18,024	18,024
Individual Controls	✓	✓	✓
Year Fixed Effects	✓	✓	✓
Region Fixed Effects	✓	✓	✓
Occupation FE (4-digits)		✓	✓
Establishment Controls			✓

Notes: Working condition survey merged sample for 2013 and 2019 including public and private sectors. Weighted two-stage least square regressions with sampling weights defined to ensure a representative sample. Robust standard errors are clustered at the establishment level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 7: ICT and Components of Working Conditions—W2SLS

	Learning & Development	Autonomy	Support	Stability	Physical comfort	Physical safety
	(1)	(2)	(3)	(4)	(5)	(6)
ICT	3.810***	0.907	0.054	-1.547**	1.607***	1.633**
	(0.928)	(0.882)	(0.797)	(0.785)	(0.574)	(0.727)
K-P F-stat	15.78	15.78	15.78	15.78	15.78	15.78
	Psycho safety	Standard workhours	Not working weekend	Flexibility	Work-life balance	Uncons. work pace
	(7)	(8)	(9)	(10)	(11)	(12)
ICT	-1.158	1.431**	-0.108	1.413**	0.302	0.727
	(0.808)	(0.685)	(0.589)	(0.709)	(0.700)	(0.684)
K-P F-stat	15.78	15.78	15.78	15.78	15.78	15.78
Observations	18,024	18,024	18,024	18,024	18,024	18,024
Individual Controls	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓
Region Fixed Effects	✓	✓	✓	✓	✓	✓
Occupation FE 4-digits	✓	✓	✓	✓	✓	✓
Establishment Controls	✓	✓	✓	✓	✓	✓

Notes: Working condition survey merged sample for 2013 and 2019 including public and private sectors. Weighted two-stage least square regressions with sampling weights defined to ensure a representative sample. All non-pecuniary working conditions have been standardized. Robust standard errors are clustered at the establishment level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5.4 Heterogeneity analysis

In this section we test several dimensions of heterogeneity of the effect of ICT on wages and on working conditions. Overall, the results do indicate heterogeneous effects of ICT on wages and on working conditions across sectors, gender, worker groups, firms, and occupations.

Sectors. Sectoral analyses show that ICT adoption improves wages and overall working conditions in both the public and private sectors, although the underlying channels differ. In both sectors, ICT contributes to greater physical comfort and safety. In the public sector, ICT use is associated with stricter adherence to standard working hours but also higher work intensity, whereas in the private sector it is linked to a stronger rise in flexibility (see Appendix Table G.1).[5] This may reflect heterogeneity of preferences of workers across these two sectors.

Workers. We find stronger effects of ICT use on wages for part-time workers, while improvements in working conditions are stronger for full-time workers (versus part-time) and for women (versus men). At the component level, ICT enhances physical comfort and safety across both groups. However, flexibility mostly increases among full-time workers and women, whereas part-time workers experience higher stress levels. Women also face a rise in work intensity (see Appendix Tables G.2 and G.3).

These differences could reflect employer practices, job roles, or bargaining power. Actually, the higher stress levels reported by part-time workers may be driven from more monitoring, more task fragmentation, more pressure to respond instantly, for this vulnerable workers. In contrast, for women, we may imagine that the overall improvement in working conditions may have come at the expense of more work intensity.

Firms. We find larger effects of ICT use in larger firms on both wages and working conditions. In these firms, ICT actually upgrades work, instead of just speeding it up. The presence of worker representation—in particular Health and Safety Committees—amplifies positive effects on comfort, safety, standard hours, weekend-free work, and flexibility. In their absence, ICT effects are weaker and may reduce psychological safety while increasing

[5] Appendix C presents an alternative specification of the theoretical model from Section 2, specifically adapted for the public sector, where wages are exogenously set rather than determined by a bargaining model. In this version of the model digitalization affects only working conditions because pay scales are fixed by a negotiation process. However, our empirical findings reveal that wages in the public sector also increase with ICT use intensity. We deduce from this that the public sector does adapt its wage structures (or "wage grids") to reflect the productivity improvements driven by ICT.

work intensity (see Appendix Tables G.4, G.5, G.6 and G.7). This suggests that worker representation shapes how ICT is implemented: when staff representatives are present and workers' bargaining power is stronger, the introduction of ICT is more worker-friendly (Acemoglu and Johnson, 2023). In contrast, when workers have weaker bargaining power, ICT diffusion exhibits work intensification and more monitoring.

Occupations. We classify occupations into four broad groups: Managers (including upper level engineers and other "liberal professions"), Intermediate professions (e.g., middle management, technicians), Employees (mostly white collar), and Workmen (mostly blue collar). We find that intermediate professions and employees benefit the most from increases in ICT use, showing positive associations with both wages and working conditions. However, these groups also bear the brunt of negative effects on psychological safety and work intensity. Executives experience some positive effects—especially on work-life balance—but also face drawbacks, with ICT use negatively associated with learning opportunities and job stability (see Appendix Table G.8).

Taken together, these findings indicate that while the benefits of ICT adoption are broadly positive, they are mediated by sectoral, worker, firm, and occupational characteristics—probably reflecting differences in workers' preferences, outside options, bargaining power, and how ICT affects firms' surplus. For some groups, improvements in physical and temporal working conditions come with trade-offs such as increased work pace or reduced psychological safety.

5.5 Wages, Working Conditions and Job Satisfaction

Table 8 presents the effects of ICT use on job satisfaction. We report estimates of equation 4 in the "Total Effect" panel and of equation 5 in the "Direct Effect" panel. Recall that in both specifications—over and above ICT, wages, and working conditions, depending on the specification—we control for individual worker's demographics, establishment controls, and region and occupation fixed effects. In order to facilitate the presentation, we standardize the variables of interest: job satisfaction, ICT use, log wages and the working conditions index.

Table 8: The Relationship between Satisfaction, Wages and Working Conditions (W2SLS) (2019)

	Job Satisfaction (z-score)			
	(1)	(2)	(3)	(4)
Total Effect:				
ICT (z-score)	0.126	0.262	0.307	0.307
	(0.152)	(0.348)	(0.349)	(0.349)
Direct Effect:				
ICT (ω_{ict}) (z-score)	-0.179	-0.067	-0.024	-0.255
	(0.179)	(0.344)	(0.346)	(0.364)
Log Hourly Wages (z-score)	0.106***	0.086***	0.089***	0.052**
	(0.022)	(0.024)	(0.024)	(0.025)
Working Conditions Index (z-score)	0.391***	0.427***	0.421***	
	(0.054)	(0.038)	(0.038)	
Autonomy				0.039**
				(0.016)
Learning & development				0.360***
				(0.019)
Support				0.056***
				(0.017)
Stability				0.086***
				(0.019)
Physical comfort				0.103
				(0.069)
Physical safety				0.012
				(0.030)
Psychological safety				0.049***
				(0.015)
Standard work hours				-0.030
				(0.020)
Not working weekends				-0.016
				(0.029)
Flexibility				0.037*
				(0.019)
Work-life balance				0.030*
				(0.017)
Unconstrained work pace				0.094***
				(0.025)
Observations	8,504	8,411	8,411	8,411
Individual Controls	✓	✓	✓	✓
Region Fixed Effects	✓	✓	✓	✓
Occupation FE (4-digits)		✓	✓	✓
Establishment Controls			✓	✓

Notes: Estimates based on the 2019 working condition survey, merged sample. Weighted two-stage least squares regressions with sampling weights ensuring representativeness. Robust standard errors are clustered at the establishment level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

The results indicate an imprecise, but positive total effect: a 1-standard deviation increase in ICT use is associated with a 0.30 standard deviation increase in job satisfaction (Column 3), although this effect is not statistically significant. The positive, total effect is entirely mediated by the indirect effects of ICT through higher wages and improved working conditions, illustrated by Table 8. Specifically, a 1-standard deviation increase in the log hourly wage raises job satisfaction by 0.09 of a standard deviation, while a 1-standard deviation increase in working conditions increases it by 0.42 of a standard deviation. In contrast, unsurprisingly, the direct effect of using ICT as such on job satisfaction—after accounting for wages and working conditions—is not statistically significant. The observed 0.30 standard deviation increase in job satisfaction associated with ICT use is due to its indirect effects on wages and working conditions.

Given the strong effects of ICT on wages and working conditions, one might have expected a larger total effect of ICT on job satisfaction. The reason it does not is that the dimension of working conditions that are most strongly affected by ICT use are not strongly associated with job satisfaction. Column 4 in Table 8 shows that the positive contribution of working conditions to job satisfaction is driven primarily by dimensions such as learning, autonomy, support, stability, psychological safety, work–life balance, and unconstrained work pace. As Table 5 indicates, most of these dimensions are not strongly associated with more ICT use; if anything, ICT exerted negative effects on psychological safety and unconstrained work pace. Consequently, the relatively modest overall effect of ICT on job satisfaction can be attributed to a mismatch between the dimensions that ICT most improves and the dimensions that workers value most—some of which ICT negatively affects.

6 Conclusion

This paper shows that the intensification of ICT from 2013 to 2019 increased both wages and working conditions—but had modest effects on job satisfaction. We leverage matched worker-employer administrative data in order to provide causal inference on these relationships. We estimate that a 10 percentage increase in ICT use raises wages by 6.68% and improves overall working conditions by 0.18 standard deviations. Improvements in working conditions are primarily driven by enhanced flexibility, physical comfort, and safety. However, ICT adoption entails a trade-off, as it also leads to increased psychological stress and greater work intensity. These effects are heterogeneous across various groups, probably reflecting differences in workers' preferences, outside options, and bargaining power.

Despite general improvements in wages and working conditions, the overall increase in job satisfaction associated with ICT use is modest and statistically insignificant. This limited gain is explained by a "mismatch" between the dimensions of working conditions that workers value most (e.g., autonomy, learning, support, stability, psychological safety and manageable work pace), which are often negatively affected by ICT, and those that ICT use improves the most (e.g., flexibility, standard hours, physical comfort and safety).

Our findings underscore the importance of moving beyond analyses focused solely on wages when assessing the welfare impact of technological change. Investigating the organizational structures and variation in preferences that underlie the mismatch that limits overall job satisfaction is a fruitful avenue for future research.

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A Additional descriptive statistics

Table A.1: Descriptive Statistics, Merged Sample

	Both 2013 and 2019			Avg.	
Variable	Obs.	Avg.	S.D.	2013	2019
ICT	21,575	0.45	0.37	0.39	0.53
Log Hourly Wage	20,829	2.98	0.43	2.96	3.00
WCI (unstandardized)	18,974	0.63	0.12	0.63	0.64
Learning (unstandardized)	20,329	0.60	0.24	0.59	0.61
Autonomy (unstandardized)	21,184	0.56	0.21	0.56	0.56
Support (unstandardized)	21,448	0.81	0.25	0.81	0.82
Stability (unstandardized)	20,995	0.68	0.18	0.66	0.70
Physical comfort (unstandardized)	21,516	0.59	0.34	0.58	0.60
Physical risk (unstandardized)	21,522	0.74	0.29	0.73	0.74
Psychological safety (unstandardized)	20,582	0.57	0.21	0.57	0.57
Standard working hours (unstandardized)	21,571	0.77	0.31	0.77	0.78
Not working weekend (unstandardized)	21,570	0.68	0.38	0.68	0.68
Flexibility (unstandardized)	20,404	0.62	0.21	0.62	0.62
Work-life balance (unstandardized)	20,577	0.40	0.14	0.40	0.40
Uncons. work pace (unstandardized)	20,431	0.55	0.23	0.55	0.56
$1[0.1 \leq \text{Internet} \leq 0.5]$	15,955	0.28	0.45	0.30	0.26
$1[\text{Internet} > 0.5]$	15,955	0.58	0.49	0.57	0.62

Table A.2: Correlation Matrix, Merged Sample

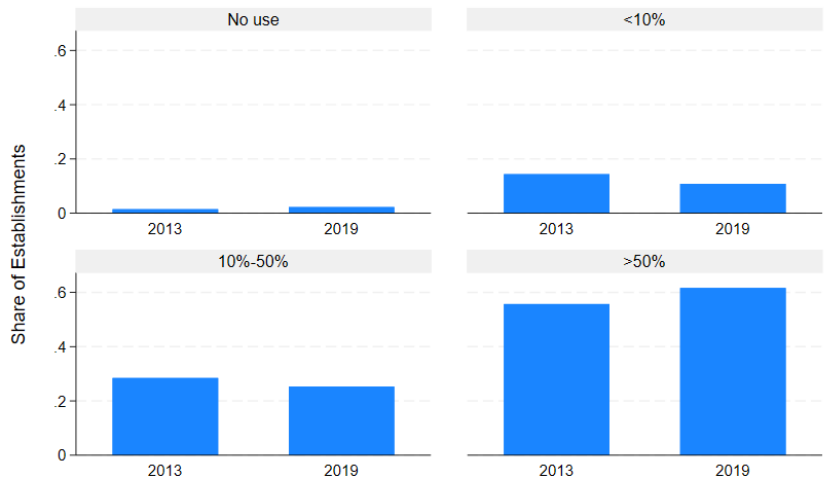
Variable	Learning (1)	Autonomy (2)	Support (3)	Stability (4)	Physical Comfort (5)	Physical Risk (6)
Learning	1					
Autonomy	0.016	1				
Support	0.290	-0.130	1			
Stability	0.162	0.074	0.023	1		
Physical Comfort	0.240	0.238	0.097	0.109	1	
Physical Risk	0.115	0.096	0.069	0.088	0.456	1
Psychological Safety	0.157	0.149	0.127	0.048	0.141	0.065
Standard Working Hours	0.023	0.194	0.005	0.031	0.348	0.230
Not Working Weekend	0.014	0.181	0.023	-0.008	0.373	0.117
Flexibility	0.167	0.188	0.124	0.080	0.332	0.081
Work-Life Balance	0.194	0.070	0.123	0.098	0.222	0.106
Unconstrained Work Pace	0.186	0.247	0.133	0.098	0.257	0.126

	Psycho safety (7)	Standard work hours (8)	Not working weekend (9)	Flexibility (10)	Work life balance (11)
Psychological Safety	1				
Standard Working Hours	0.099	1			
Not Working Weekend	0.156	0.587	1		
Flexibility	0.138	0.260	0.280	1	
Work-Life Balance	0.154	0.210	0.190	0.224	1
Unconstrained Work Pace	0.279	0.131	0.139	0.204	0.224

Table A.3: Distribution of Employees per Establishment (Merged Sample, 2013 and 2019)

Number of employees in establishment	Number of observations	Percent of observations	Number of establishments
1 employee	11,810	54.74	11,106
2 employees	3,499	16.22	1,623
3 employees	1,435	6.65	440
4 employees	1,041	4.83	233
5 employees	573	2.66	102
6 employees	475	2.20	70
7 employees	447	2.07	59
8 employees	216	1.00	24
9 employees	296	1.37	30
10 employees	223	1.03	19
11 employees	185	0.86	15
12 employees	152	0.70	12
13 employees	92	0.43	6
14 employees	107	0.50	7
15 employees	115	0.53	7
16 employees	53	0.25	3
17 employees	60	0.28	3
18 employees	47	0.22	2
19 employees	151	0.70	7
20 employees	46	0.21	2
21 employees	50	0.23	2
22 employees	76	0.35	3
23 employees	51	0.24	2
24 employees	50	0.23	2
25 employees	54	0.25	2
26 employees	60	0.28	2
29 employees	32	0.15	1
32 employees	38	0.18	1
35 employees	38	0.18	1
36 employees	45	0.21	1
50+ employees	58	0.27	1
Total	21,575	100	13,788

Figure A.1: Distribution of establishments by ICT intensity



Notes: The figure reports the distribution of establishments over ICT-intensity categories: establishments where the share of employees using ICT is 0%, below 10% (but more than zero), 10–50% and above 50%. The percentages across these four categories are reported in 2013 and in 2019.

B Explicit comparative statics derivations for the theoretical framework

Choose w and q to maximize

$$lnS(w,q) = \beta \cdot \log\left[\log w + \theta \log q - \overline{U}\right] + (1-\beta) \cdot \log\left[y + \alpha q - \frac{1}{2}q^2 - w\right],$$

The first-order necessary condition with respect to w is

$$\frac{\beta}{\Delta} \cdot \frac{1}{w} - (1-\beta)\frac{1}{\pi} = 0$$

and the first-order necessary condition with respect to q is

$$\beta \cdot \frac{\theta}{\Delta \cdot q} + (1-\beta) \cdot \frac{\alpha - q}{\pi} = 0,$$

where we denote by Δ the worker's surplus and π is the firm's surplus, since the outside option is zero. Solving for Δ in the FONC for w and substituting this into the FONC for q yields:

$$q^2 - \alpha q - \theta w = 0 \Longrightarrow w = \frac{q(q-\alpha)}{\theta}$$

Positive wages imply $q > \alpha$, since $\theta > 0$ and $q > 0$.

Using $q(q-\alpha)/\theta = w$ in the FONC w.r.t. q gives the following system:

$$E_1(q,w) = q^2 - \alpha q - \theta w = 0$$
$$E_2(q,w) = \log w + \theta \log q - U - \frac{\beta}{1-\beta} \cdot \frac{1}{w}(y + \alpha q - \tfrac{1}{2}q^2 - w) = 0.$$

Let $\pi = y + \alpha q - \frac{1}{2}q^2 - w$. The Jacobian matrix is:

$$J = \begin{bmatrix} 2q-\alpha & -\theta \\ \frac{\theta}{q} + \frac{\beta}{1-\beta} \cdot \frac{q-\alpha}{w} & \frac{1}{w} + \frac{\beta}{1-\beta}\left(\frac{\pi}{w^2} + \frac{1}{w}\right) \end{bmatrix}$$

and the determinant of J is:

$$\det(J) = (2q-\alpha) \cdot \left(\frac{1}{w} + \frac{\beta}{1-\beta}\left(\frac{\pi}{w^2} + \frac{1}{w}\right)\right) + \theta \cdot \left(\frac{\theta}{q} + \frac{\beta}{1-\beta} \cdot \frac{q-\alpha}{w}\right) > 0,$$

since $q > \alpha$ and $\pi \geq 0$ in any equilibrium.

Cramer's Rule Characterization We write the system as:

$$J\begin{bmatrix} dq \\ dw \end{bmatrix} = \begin{bmatrix} R_1 \\ R_2 \end{bmatrix},$$

where:

$$R_1 = -dE_1 = q\,d\alpha + w\,d\theta$$

$$R_2 = -dE_2 = dU + \frac{q}{w}\cdot\frac{\beta}{1-\beta}\,d\alpha - \log q\,d\theta + \frac{\pi}{w(1-\beta)^2}\,d\beta + \frac{\beta}{w(1-\beta)}dy$$

Then by Cramer's Rule:

$$dq = \frac{\det(J_q)}{\det(J)}, \quad dw = \frac{\det(J_w)}{\det(J)}$$

$$J_q = \begin{bmatrix} R_1 & -\theta \\ R_2 & \frac{1}{w} + \frac{\beta}{1-\beta}\left(\frac{\pi}{w^2} + \frac{1}{w}\right) \end{bmatrix}, \quad J_w = \begin{bmatrix} 2q-\alpha & R_1 \\ \frac{\theta}{q} + \frac{\beta}{1-\beta}\cdot\frac{q-\alpha}{w} & R_2 \end{bmatrix}$$

and therefore:

$$\det(J_q) = R_1\cdot\left(\frac{1}{w} + \frac{\beta}{1-\beta}\left(\frac{\pi}{w^2} + \frac{1}{w}\right)\right) + \theta\cdot R_2$$

$$\det(J_w) = (2q-\alpha)\cdot R_2 - R_1\cdot\left(\frac{\theta}{q} + \frac{\beta}{1-\beta}\cdot\frac{q-\alpha}{w}\right)$$

Comparative statics w.r.t. y:

$$R_1 = 0$$

$$R_2 = \frac{\beta}{w(1-\beta)}dy > 0$$

$$\Rightarrow \frac{dq}{dy} > 0, \quad \frac{dw}{dy} > 0$$

Comparative statics w.r.t. α:

$$R_1 = q\,d\alpha > 0$$

$$R_2 = \frac{q\beta}{w(1-\beta)}d\alpha > 0$$

$$\Rightarrow \frac{dq}{d\alpha} > 0, \quad \frac{dw}{d\alpha} > 0$$

Comparative statics w.r.t. θ:

$$R_1 = w\,d\theta > 0$$
$$R_2 = -\log q\,d\theta < 0$$

$$\Rightarrow \frac{dq}{d\theta} \text{ is ambiguous }, \quad \frac{dw}{d\theta} < 0$$

Comparative statics w.r.t. U:

$$R_1 = 0$$
$$R_2 = dU$$

$$\Rightarrow \frac{dq}{dU} > 0, \quad \frac{dw}{dU} > 0$$

Comparative statics w.r.t. β:

$$R_1 = 0$$
$$R_2 = \frac{\pi}{w(1-\beta)^2} d\beta > 0$$

$$\Rightarrow \frac{dq}{d\beta} > 0, \quad \frac{dw}{d\beta} > 0$$

C Theoretical framework: public sector

Because in the public sector wages are essentially fixed by "public servants grills", we assume that, in the public sector, bargaining concerns only quality. In contrast in the private sector, workers and firms bargain over both wages and working conditions.

We retake the same framework as in Section 2 but assuming that bargaining only concerns quality, since wages are exogenously determined. The first order necessary conditions with respect to q, given the exogenous determined w equals:

$$\frac{\partial \log S}{\partial q} = \beta \cdot \frac{\theta/q}{(\log w + \theta \log q - U)} + (1-\beta) \cdot \frac{\alpha - q}{y + \alpha q - \frac{1}{2}q^2 - w} = 0$$

We have then one equation and one unknown q. The equation cannot be solved for q in closed form due to the combination of: polynomial terms in q, logarithmic terms in q and their multiplication together (transcendental nature). It is necessarily to solve it numerically. However, given that we know that the match only takes place if each party obtains a positive surplus, we can compute the range of values that the bargained q^* must adopt to ensure the positivity of the surpluses:

1. To ensure a positive worker's surplus, we need $q > \left(\frac{e^{\overline{U}}}{w}\right)^{1/\theta}$
2. To ensure the positivity of the firm's profit we need $y + \alpha q - \frac{1}{2}q^2 - w > 0$. This requires $q < 2\alpha$ if $w = y$ or $q < \alpha + \sqrt{\alpha^2 + 2(y-w)}$ if $w < y$. Note that for $w < y$ quality adopts a value above 2α, *i.e.* $\alpha + \sqrt{\alpha^2 + 2(y-w)} > 2\alpha$.

All in all, to ensure a positive surplus for both parties, the endogenously determined q should be defined within the range: $\left(\frac{e^{\overline{U}}}{w}\right)^{1/\theta} < q < \alpha + \sqrt{\alpha^2 + 2(y-w)}$.

From the explicit static comparative derivations presented in Appendix C.1 we conclude:

Table C.1: Summary of static comparative analysis in the public sector

Parameter	Economic Interpretation	Effect on q when parameter increases
β	Worker's bargaining power	$\uparrow$
θ	Worker's preference for quality	$\downarrow$
α	Firm's benefit from quality	$\uparrow$
y	Output produced by the worker	$\uparrow$
U	Worker's outside option	$\uparrow$

Note: Arrows indicate the direction of change in the negotiated job quality q following an increase in the corresponding parameter, holding all else constant.

C.1 Comparative statics derivations

$$\beta \cdot \frac{\theta}{\log w + \theta \log q - U} = -(1-\beta) \cdot \frac{q(\alpha - q)}{y + \alpha q - \frac{1}{2}q^2 - w}$$

- **Bargaining power β:** As β increases:
  - The LHS becomes larger
  - The RHS becomes smaller in magnitude
  - To compensate, the value of q must increase to bring the equation back into balance

$$\boxed{\text{Therefore, all else constant, } \frac{\partial q}{\partial \beta} > 0}$$

- **Preference for quality, θ:** One might expect that if workers value job quality more (i.e., higher θ), they would bargain for a higher level of quality q. However, this intuition does not fully align with the structure of the model. The left-hand side (LHS) of the equation represents the marginal utility gain to the worker from increased quality:

  $$\text{LHS} = \beta \cdot \frac{\theta}{\log w + \theta \log q - U}$$

  As θ increases:

  - The numerator increases linearly in θ,
  - The denominator also increases because of the term $\theta \log q$, and this increase may be faster, particularly for moderate or high values of q.

  Hence, the entire LHS may *decrease* with higher θ, especially if the worker becomes more sensitive to perceived costs of quality. Although a higher θ indicates stronger preference for quality, it also implies that the marginal utility cost of achieving higher quality rises faster (because of the log functional form). Therefore, workers may not push for higher q even if they care more about quality,

  $$\boxed{\text{All else constant, increasing } \theta \text{ leads to a decrease in the negotiated quality } q.}$$

- **Firm benefit α:** The parameter α captures the firm's marginal benefit from increasing job quality q. It appears only on the right-hand side (RHS) of the equation, which represents the firm's marginal cost of agreeing to a higher quality level. To determine whether the RHS is increasing or decreasing in α we need to derive the RHS with respect to α:

  We define

  $$F(\alpha) \;=\; \frac{q\alpha - q^2}{y + \alpha q - \frac{1}{2}q^2 - w}, \qquad q > 0,\; y > 0,\; w > 0,\; \alpha > 0.$$

Let

$$N(\alpha) = q\alpha - q^2, \qquad D(\alpha) = y + q\alpha - \tfrac{1}{2}q^2 - w.$$

Then

$$F(\alpha) = \frac{N(\alpha)}{D(\alpha)}.$$

Where

$$F'(\alpha) = \frac{q\big(y + \frac{1}{2}q^2 - w\big)}{D(\alpha)^2}.$$

Since $q > 0$ and $D(\alpha)^2 > 0$ whenever $D(\alpha) \neq 0$, the sign of $F'(\alpha)$ is determined solely by

$$y + \tfrac{1}{2}q^2 - w.$$

Step 4. Conclusion

- If $y + \frac{1}{2}q^2 - w > 0$, then $F'(\alpha) > 0$, so F is strictly increasing in α.
- If $y + \frac{1}{2}q^2 - w < 0$, then $F'(\alpha) < 0$, so F is strictly decreasing in α. However, for $w \leq y$ this scenario never applies
- If $y + \frac{1}{2}q^2 - w = 0$, then $F'(\alpha) \equiv 0$, so $F(\alpha)$ is constant (equal to 1) on its domain. In this case, changes in α should have no impact on the RHS that remains unchanged.

Since $w\varepsilon[U, y)$, the first scenario is the most likely one. This means that following an increase in α, the RHS becomes more negative (larger in absolute values). To reinstall the equilibrium q will have to increase.

- **Output y:** It appears only in the denominator of the right-hand side (RHS) of the equation, which reflects the firm's surplus and hence its marginal willingness to concede to higher job quality.
  - Denominator effect: As y increases, the firm's net surplus $y + \alpha q - \frac{1}{2}q^2 - w$ increases.
  - This increase makes the magnitude of the RHS smaller (i.e., less negative), reflecting a lower marginal cost for the firm to agree to a higher q.

To restore the balance in the Nash condition the LHS must also decrease in magnitude. Since the LHS depends inversely on $\theta \log q$, this requires an increase in q.

> All else constant, increasing y leads to an increase in the negotiated quality q.

Higher worker output increases the firm's surplus, making it more willing to agree to better job quality during bargaining.

- **Outside option U:** The variable U represents the worker's outside option, i.e., the utility the worker receives if bargaining fails. It appears only in the denominator of the left-hand side (LHS), which reflects the worker's marginal utility gain from quality.

  As U increases, the denominator $\log w + \theta \log q - U$ decreases. This causes the LHS to increase, reflecting a higher marginal gain for the worker at a given level of q.

  Because the RHS remains unaffected by the change in U we expect q to increase so as to restore the the value of the LHS. Note though that the increase in q will also affect the RHS. We can though show that as far as $\alpha > 0$ and $0 < w < y$, for any $q < q_+ = \frac{\sqrt{2(y-w)\left(\alpha^2+2(y-w)\right)}-2(y-w)}{\alpha} > 0$, the RHS is strictly increasing in q (see proof below).

> All else constant, increasing the outside option U leads to an increase in the negotiated quality q.

A higher outside option strengthens the worker's bargaining position, enabling them to negotiate for better job quality.

Proof

We study

$$F(q) = \frac{q\alpha - q^2}{y + \alpha q - \frac{1}{2}q^2 - w}, \qquad \alpha > 0,\ 0 < w < y,\ q > 0.$$

Let

$$N(q) = q\alpha - q^2, \qquad D(q) = y + \alpha q - \tfrac{1}{2}q^2 - w.$$

Then

$$F'(q) = \frac{N'(q)D(q) - N(q)D'(q)}{D(q)^2}.$$

Since $N'(q) = \alpha - 2q$ and $D'(q) = \alpha - q$, one finds after simplification

$$F'(q) = \frac{\mathcal{S}(q)}{D(q)^2}, \qquad \mathcal{S}(q) = -\tfrac{\alpha}{2}q^2 + 2(w-y)q + \alpha(y-w).$$

Because $D(q)^2 > 0$ on the domain, the sign of $F'(q)$ is the same as that of $\mathcal{S}(q)$.

- At $q = 0$: $\mathcal{S}(0) = \alpha(y-w) > 0$.
- As $q \to \infty$: $\mathcal{S}(q) \sim -\frac{\alpha}{2}q^2 \to -\infty$.

Thus $\mathcal{S}(q)$ is positive for small q, eventually negative for large q, and has a unique positive root.

The root of $\mathcal{S}(q) = 0$ is

$$q_+ = \frac{\sqrt{2(y-w)\big(\alpha^2 + 2(y-w)\big)} - 2(y-w)}{\alpha} \; > \; 0.$$

Therefore,

$$F'(q) > 0 \quad \text{for } 0 < q < q_+, \qquad F'(q) < 0 \quad \text{for } q > q_+.$$

The denominator vanishes when

$$D(q) = 0 \iff q = q_D = \alpha + \sqrt{\alpha^2 + 2(y-w)}.$$

One checks algebraically that

$$q_D > q_+,$$

so the pole lies to the right of the turning point and does not interfere with the increasing interval.

All in all, for $\alpha > 0$ and $0 < w < y$,

$$\boxed{F(q) \text{ is strictly increasing on } (0, q_+), \text{ strictly decreasing on } (q_+, \infty), \text{ with a vertical asymptote at } q = q_D}$$

D The separability of the utility function

Table D.1: The Relationship Between Wages, Working Conditions and Job satisfaction (W2SLS) (2019).

	Job Satisfaction (z-score)	
	(1)	(2)
ICT (z-score)	-0.024	-0.017
	(0.346)	(0.345)
Log wage (z-score)	0.089***	0.086***
	(0.024)	(0.024)
Working conditions index (z-score)	0.421***	0.418***
	(0.038)	(0.038)
Log wage * Working conditions index		-0.020
		(0.017)
Observations	8,411	8,411
Individual controls	Yes	Yes
Region Fixed Effects	Yes	Yes
Occupation FE 4-digits	Yes	Yes
Establishment controls	Yes	Yes

Notes: Working condition survey merged sample for 2013 and 2019 including public and private sector. Weighted least square regressions with sampling weights defined to ensure a representative sample. All non-pecuniary working conditions have been standardized. Robust standard errors are clustered at the establishment level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

E The weighting strategy

The weighting process was conducted using the "*ipfweights*" command of Stata, which adjusts survey weights iterative through proportional fitting (IPF) to align the sample with known population margins. Separate weights were generated for both the unbalanced and balanced panels, as well as for the public, private, and combined sectors.

For the unbalanced panel, weights were calculated so that the sample in each year reflects the population of that same year. In contrast, for the balanced panel, weights were designed to ensure that the sample for both 2013 and 2019 remains representative of the population in 2013. Seven key demographic and labor market variables were used for this weighting process: gender, age category (five-year intervals from 15 to over 70), education level (five groups), a 2-digit occupational classification (27 categories), region (13 regions, with the 2013 data adjusted to reflect the 2015 regional reform for consistency with 2019), sector of employment (public/private), and employment contract type (full-time/part-time).

It is important to note that for certain variables, such as full-time/part-time status or region, we only have information at the aggregate level (i.e., public and private sector together). Additionally, the percentage of individuals employed in the public versus private sector was only used for the combined weights, as this distinction holds no relevance when sector-specific weights are being generated. The population margins for these variables were sourced from Social Security data for the respective years.

The iterative procedure in "*ipfweights*" was executed with 120 iterations to minimize the difference between sample and population margins within a specified tolerance threshold. This ensured accurate and reliable weights for the analysis.

F Implementing the Conley et al. (2012) LTZ method

In this appendix we briefly explain how we implement the "Local-to-Zero" (LTZ) method of Conley et al. (2012). The method takes into account uncertainty about the validity of the instrument variable in 2SLS.

Suppose that the structural ("second stage") equation we wish to estimate is

$$y = \beta x + \gamma z + \varepsilon,$$

where x is endogenous and z is a variable that we wish to use as an instrument for x. If z is a valid instrument, then it should not affect y other than through x; in this case $\gamma = 0$. Let the "first stage" equation be

$$x = \pi z + v.$$

The 2SLS estimator is consistent when $\gamma = 0$. The LTZ method allows computing standard errors for the usual 2SLS estimator of β under the assumption that γ has a distribution around a mean of zero, and that γ is independent. If the distribution of γ is normal,

$$\gamma \sim N(\mu_\gamma, \Omega_\gamma),$$

then the distribution of the 2SLS estimator of β is, approximately,

$$\hat{\beta} \sim N(\beta + A\mu_\gamma, V_{2SLS} + A\Omega_\gamma A'),$$

where A summarizes the relationship between x and z. In the case where both x and z are scalars, A is the inverse of the OLS estimator of π above. Under the assumption that $\mu_\gamma = 0$, the estimator $\hat{\beta}$ is centered around β, but with a larger variance than the usual 2SLS variance. The additional variance increases with Ω_γ and decreases with the strength of the instruments, here captured by a smaller A. Given an estimate of Ω_γ and of A, we can compute standard errors that are adjusted for the uncertainty about γ. If the distribution of γ is not normal, then one can approximate this variance and corresponding standard errors by simulation. If the coefficient remains statistically significant (or the bounds do not include zero), then this indicates that even if the instrument is not strictly exogenous, it is strong enough to justify small violations of the exclusion restriction, and is thus useful for inference.

We use the Stata command -plausexog- to implement the LTZ method. In order to do so, we need estimates of Ω_γ (estimates of A come from data). We proceed as follows. We estimate a version of the structural equation (2) with the two instrument variables (1[0.1 $\leq$ Internet $\leq$ 0.5] and 1[Internet $>$ 0.5]) included. We store the respective variances of the coefficients to these two instruments, denoted Var_γ (here γ is a 2×1 vector). We parametrize the -plausexog- command with multiples of 1, 2, 5 and 10 of Var_γ. Table F.1 reports the LTZ standard errors.

We also apply the LTZ method under the assumption that γ is distributed uniform on $[-a, a]$. We calculate a so that the implied variance of the uniform distribution, $(1/12)[a - (-a)]^2 = (1/3)a^2$ equals the same multiples of Var_γ used above. Table F.2 reports the implied bounds on the coefficients to ICT in the structural equation across values of γ.

Table F.1: Local-to-Zero standard error estimates—Normal distribution

	(1)	(2)	(3)	(4)
	$1 \times Var_\gamma$	$2 \times Var_\gamma$	$5 \times Var_\gamma$	$10 \times Var_\gamma$
Log Wages				
ICT	0.746***	0.746***	0.746**	0.746*
	(0.177)	(0.219)	(0.312)	(0.424)
Working conditions				
ICT	1.749***	1.749***	1.749***	1.749**
	(0.330)	(0.398)	(0.556)	(0.749)

Notes: All specifications include individual controls, year, region and occupation fixed effects as well as establishment controls. Sampling weights are applied. The number of observations is 18,024. Standard errors in parentheses are computed using the -plausexog- Stata command under the assumption of a normal distribution, and are clustered at the establishment level. $n \times Var_\gamma$ implies that we parametrize the variance of γ to n times the estimated variance the coefficients to the instruments in a regression of the structural equation that is augmented with the instruments.

Table F.2: Local-to-Zero coefficient bounds—Uniform distribution

	(1)	(2)	(3)	(4)
	$1 \times Var_\gamma$	$2 \times Var_\gamma$	$5 \times Var_\gamma$	$10 \times Var_\gamma$
Log Wages				
Lower Bound	1.083	1.160	1.335	1.517
Upper Bound	0.419	0.333	0.167	-0.013
Working conditions				
Lower Bound	2.419	2.507	2.787	3.164
Upper Bound	1.098	0.991	0.693	0.333

Notes: All specifications include individual controls, year, region and occupation fixed effects as well as establishment controls. Sampling weights are applied. The number of observations is 18,024. The upper bound and the lower bound for the coefficient to ICT is computed using the -plausexog- Stata command under the assumption of uniform distribution. $n \times Var_\gamma$ implies that we parametrize the variance of γ to n times the estimated variance the coefficients to the instruments in a regression of the structural equation that is augmented with the instruments.

G Additional estimation results

Table G.1: The Relationship between ICTs and Components of Working Conditions by sector (WLS)

	Wages	Learning & Development	Autonomy	Support	Stability	Physical comfort	Physical safety
		(1)	(2)	(3)	(4)	(5)	(6)
Public*ICT	0.091***	-0.131*	0.109	-0.069	0.034	0.443***	0.408***
	(0.027)	(0.071)	(0.076)	(0.073)	(0.060)	(0.051)	(0.063)
Private*ICT	0.067**	0.103	0.045	-0.031	0.013	0.507***	0.372***
	(0.027)	(0.068)	(0.074)	(0.037)	(0.063)	(0.054)	(0.057)
	Working conditions	Psycho safety	Standard workhours	Not working weekend	Flexibility	Work-life balance	Uncons. work pace
		(7)	(8)	(9)	(10)	(11)	(12)
Public*ICT	0.249***	-0.057	0.327***	0.303***	0.040	-0.082	-0.312***
	(0.060)	(0.073)	(0.060)	(0.063)	(0.074)	(0.067)	(0.073)
Private*ICT	0.281***	-0.140	0.103	0.235***	0.162**	-0.042	-0.106
	(0.064)	(0.085)	(0.063)	(0.051)	(0.069)	(0.073)	(0.072)
Obs.	18024	18024	18024	18024	18024	18024	18024
Individual Controls	✓	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓	✓
Region Fixed Effects	✓	✓	✓	✓	✓	✓	✓
Occupation FE 4-digits	✓	✓	✓	✓	✓	✓	✓
Establishment Controls	✓	✓	✓	✓	✓	✓	✓

Notes: Working condition survey merged sample for 2013 and 2019 including public and private sector. Weighted least square regressions with sampling weights defined to ensure a representative sample. All non-pecuniary working conditions have been standardized. Robust standard errors are clustered at the individual level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table G.2: The Relationship between ICTs and Components of Working Conditions by Gender (WLS)

	Wages	Learning & Development	Autonomy	Support	Stability	Physical comfort	Physical safety
		(1)	(2)	(3)	(4)	(5)	(6)
Women*ICT	0.065***	0.022	0.059*	0.015	0.001	0.176***	0.035
	(0.021)	(0.025)	(0.031)	(0.030)	(0.026)	(0.023)	(0.030)
Men*ICT	0.057**	0.031	-0.019	-0.042*	0.011	0.194***	0.244***
	(0.020)	(0.031)	(0.031)	(0.024)	(0.026)	(0.022)	(0.023)
	Working conditions	Psycho safety	Standard workhours	Not working weekend	Flexibility	Work-life balance	Uncons. work pace
		(7)	(8)	(9)	(10)	(11)	(12)
Women*ICT	0.128***	-0.032	0.071**	0.165***	0.115***	0.018	-0.046*
	(0.023)	(0.029)	(0.028)	(0.027)	(0.027)	(0.028)	(0.028)
Men*ICT	0.076**	-0.062	0.025	0.013	-0.006	-0.053	-0.051
	(0.029)	(0.040)	(0.027)	(0.021)	(0.030)	(0.033)	(0.032)
Obs.	18024	18024	18024	18024	18024	18024	18024
Individual Controls	✓	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓	✓
Region Fixed Effects	✓	✓	✓	✓	✓	✓	✓
Occupation FE 4-digits	✓	✓	✓	✓	✓	✓	✓
Establishment Controls	✓	✓	✓	✓	✓	✓	✓

Notes: Working condition survey merged sample for 2013 and 2019 including public and private sector. Weighted least square regressions with sampling weights defined to ensure a representative sample. All non-pecuniary working conditions have been standardized. Robust standard errors are clustered at the individual level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table G.3: The Relationship between ICTs and Components of Working Conditions by Working Time (WLS)

	Wages	Learning & Development	Autonomy	Support	Stability	Physical comfort	Physical safety
		(1)	(2)	(3)	(4)	(5)	(6)
Part-time*ICT	0.094*	0.053	0.054	0.002	0.060	0.141***	0.154***
	(0.052)	(0.041)	(0.058)	(0.045)	(0.046)	(0.033)	(0.031)
Full-time*ICT	0.054***	0.021	0.013	-0.017	-0.005	0.194***	0.136***
	(0.015)	(0.024)	(0.024)	(0.020)	(0.022)	(0.018)	(0.021)
	Working conditions	Psycho safety	Standard workhours	Not working weekend	Flexibility	Work-life balance	Uncons. work pace
		(7)	(8)	(9)	(10)	(11)	(12)
Part-time*ICT	0.063*	-0.128***	0.023	-0.065*	0.098**	-0.027	-0.058
	(0.033)	(0.041)	(0.029)	(0.035)	(0.039)	(0.041)	(0.036)
Full-time*ICT	0.111***	-0.030	0.054**	0.122***	0.045*	-0.016	-0.047*
	(0.023)	(0.030)	(0.023)	(0.018)	(0.024)	(0.025)	(0.025)
Obs.	18024	18024	18024	18024	18024	18024	18024
Individual Controls	✓	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓	✓
Region Fixed Effects	✓	✓	✓	✓	✓	✓	✓
Occupation FE 4-digits	✓	✓	✓	✓	✓	✓	✓
Establishment Controls	✓	✓	✓	✓	✓	✓	✓

Notes: Working condition survey merged sample for 2013 and 2019 including public and private sector. Weighted least square regressions with sampling weights defined to ensure a representative sample. All non-pecuniary working conditions have been standardized. Robust standard errors are clustered at the individual level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table G.4: The Relationship between ICTs and Components of Working Conditions by Firm Size (WLS)

	Wages	Learning & Development	Autonomy	Support	Stability	Physical comfort	Physical safety
		(1)	(2)	(3)	(4)	(5)	(6)
Size1*ICT	0.043*	0.028	0.046	-0.021	-0.042	0.217***	0.144***
	(0.026)	(0.036)	(0.040)	(0.035)	(0.032)	(0.027)	(0.036)
Size2*ICT	0.072**	0.027	-0.009	-0.026	0.036	0.171***	0.144***
	(0.034)	(0.033)	(0.040)	(0.034)	(0.035)	(0.025)	(0.026)
Size3*ICT	0.054**	0.027	0.011	-0.025	0.033	0.180***	0.110***
	(0.022)	(0.033)	(0.031)	(0.030)	(0.031)	(0.024)	(0.023)
Size4*ICT	0.088***	0.023	0.041	0.051*	-0.001	0.151***	0.176***
	(0.024)	(0.034)	(0.032)	(0.028)	(0.031)	(0.025)	(0.023)
	Working conditions	Psycho safety	Standard workhours	Not working weekend	Flexibility	Work-life balance	Uncons. work pace
		(7)	(8)	(9)	(10)	(11)	(12)
Size1*ICT	0.079**	-0.055	-0.034	0.082***	0.053	-0.062	-0.078 *
	(0.036)	(0.051)	(0.030)	(0.028)	(0.040)	(0.040)	(0.042)
Size2*ICT	0.080**	-0.091***	0.058**	0.043	0.061*	-0.016	-0.065**
	(0.029)	(0.034)	(0.028)	(0.026)	(0.032)	(0.034)	(0.031)
Size3*ICT	0.126***	-0.013	0.090***	0.121***	0.063**	0.005	-0.011
	(0.027)	(0.029)	(0.034)	(0.025)	(0.029)	(0.031)	(0.031)
Size4*ICT	0.150***	-0.009	0.123***	0.138***	0.027	0.029	-0.028
	(0.030)	(0.032)	(0.028)	(0.024)	(0.029)	(0.034)	(0.034)
Obs.	18024	18024	18024	18024	18024	18024	18024
Individual Controls	✓	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓	✓
Region Fixed Effects	✓	✓	✓	✓	✓	✓	✓
Occupation FE 4-digits	✓	✓	✓	✓	✓	✓	✓
Establishment Controls	✓	✓	✓	✓	✓	✓	✓

Notes: Working condition survey merged sample for 2013 and 2019 including public and private sector. Weighted least square regressions with sampling weights defined to ensure a representative sample. All non-pecuniary working conditions have been standardized. Robust standard errors are clustered at the individual level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table G.5: The Relationship between ICTs and Components of Working Conditions by staff representative (WLS)

	Wages	Learning & Development	Autonomy	Support	Stability	Physical comfort	Physical safety
		(1)	(2)	(3)	(4)	(5)	(6)
Staff_represent*ICT	0.079***	0.027	0.001	-0.022	0.029	0.159***	0.141***
	(0.017)	(0.026)	(0.029)	(0.023)	(0.024)	(0.020)	(0.022)
Nostaff_represent*ICT	0.021	0.026	0.061*	0.004	-0.044	0.240***	0.135***
	(0.034)	(0.035)	(0.035)	(0.036)	(0.032)	(0.025)	(0.029)
	Working conditions	Psycho safety	Standard workhours	Not working weekend	Flexibility	Work-life balance	Uncons. work pace
		(7)	(8)	(9)	(10)	(11)	(12)
Staff_represent*ICT	0.090***	-0.050	0.043*	0.074***	0.041	0.007	-0.059**
	(0.025)	(0.033)	(0.025)	(0.019)	(0.026)	(0.028)	(0.028)
Nostaff_represent*ICT	0.129***	-0.042	0.059*	0.123***	0.084**	-0.071**	-0.028
	(0.026)	(0.033)	(0.026)	(0.024)	(0.035)	(0.033)	(0.033)
Obs.	18024	18024	18024	18024	18024	18024	18024
Individual Controls	✓	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓	✓
Region Fixed Effects	✓	✓	✓	✓	✓	✓	✓
Occupation FE 4-digits	✓	✓	✓	✓	✓	✓	✓
Establishment Controls	✓	✓	✓	✓	✓	✓	✓

Notes: Working condition survey merged sample for 2013 and 2019 including public and private sector. Weighted least square regressions with sampling weights defined to ensure a representative sample. All non-pecuniary working conditions have been standardized. Robust standard errors are clustered at the individual level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table G.6: The Relationship between ICTs and Components of Working Conditions by union representative (WLS)

	Wages	Learning & Development	Autonomy	Support	Stability	Physical comfort	Physical safety
		(1)	(2)	(3)	(4)	(5)	(6)
Union*ICT	0.066***	0.030	-0.018	0.010	0.027	0.154***	0.130***
	(0.019)	(0.024)	(0.023)	(0.023)	(0.025)	(0.019)	(0.022)
No_union*ICT	0.054**	0.022	0.073*	-0.047	-0.022	0.227***	0.152***
	(0.023)	(0.033)	(0.041)	(0.030)	(0.032)	(0.024)	(0.025)
	Working conditions	Psycho safety	Standard workhours	Not working weekend	Flexibility	Work-life balance	Uncons. work pace
		(7)	(8)	(9)	(10)	(11)	(12)
Union*ICT	0.109***	-0.004	0.081***	0.097***	0.032	0.007	-0.051*
	(0.022)	(0.025)	(0.025)	(0.020)	(0.024)	(0.024)	(0.026)
No_union*ICT	0.093**	-0.107**	0.002	0.079***	0.085**	-0.052	-0.046
	(0.030)	(0.042)	(0.026)	(0.023)	(0.035)	(0.037)	(0.034)
Obs.	18024	18024	18024	18024	18024	18024	18024
Individual Controls	✓	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓	✓
Region Fixed Effects	✓	✓	✓	✓	✓	✓	✓
Occupation FE 4-digits	✓	✓	✓	✓	✓	✓	✓
Establishment Controls	✓	✓	✓	✓	✓	✓	✓

Notes: Working condition survey merged sample for 2013 and 2019 including public and private sector. Weighted least square regressions with sampling weights defined to ensure a representative sample. All non-pecuniary working conditions have been standardized. Robust standard errors are clustered at the individual level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table G.7: The Relationship between ICTs and Components of Working Conditions by Health and safety committee (WLS)

	Wages	Learning & Development	Autonomy	Support	Stability	Physical comfort	Physical safety
		(1)	(2)	(3)	(4)	(5)	(6)
Committee*ICT	0.079***	0.029	0.026	-0.005	0.027	0.161***	0.129***
	(0.018)	(0.023)	(0.025)	(0.022)	(0.023)	(0.019)	(0.023)
No_committee*ICT	0.018	0.021	0.007	-0.034	-0.042	0.239***	0.162***
	(0.026)	(0.039)	(0.041)	(0.034)	(0.033)	(0.026)	(0.027)
	Working conditions	Psycho safety	Standard workhours	Not working weekend	Flexibility	Work-life balance	Uncons. work pace
		(7)	(8)	(9)	(10)	(11)	(12)
Committee*ICT	0.118***	-0.013	0.068***	0.103***	0.065***	0.002	-0.037
	(0.021)	(0.025)	(0.025)	(0.021)	(0.023)	(0.023)	(0.024)
No_committee*ICT	0.066*	-0.126**	0.001	0.057**	0.030	-0.064	-0.076*
	(0.034)	(0.050)	(0.025)	(0.024)	(0.038)	(0.043)	(0.041)
Obs.	18024	18024	18024	18024	18024	18024	18024
Individual Controls	✓	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓	✓
Region Fixed Effects	✓	✓	✓	✓	✓	✓	✓
Occupation FE 4-digits	✓	✓	✓	✓	✓	✓	✓
Establishment Controls	✓	✓	✓	✓	✓	✓	✓

Notes: Working condition survey merged sample for 2013 and 2019 including public and private sector. Weighted least square regressions with sampling weights defined to ensure a representative sample. All non-pecuniary working conditions have been standardized. Robust standard errors are clustered at the individual level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table G.8: The Relationship between ICTs and Components of Working Conditions by Occupation (WLS)

	Wages	Learning & Development (1)	Autonomy (2)	Support (3)	Stability (4)	Physical comfort (5)	Physical safety (6)
Managers*ICT	0.011	-0.074**	0.029	-0.048	-0.057**	0.069***	0.119***
	(0.037)	(0.031)	(0.035)	(0.033)	(0.025)	(0.021)	(0.026)
Intermediate*ICT	0.111***	-0.005	0.064	-0.019	-0.021	0.199***	0.174***
	(0.028)	(0.032)	(0.047)	(0.036)	(0.030)	(0.032)	(0.048)
Employee*ICT	0.063**	0.003	0.033	0.019	0.039	0.260***	0.083**
	(0.030)	(0.034)	(0.037)	(0.037)	(0.040)	(0.032)	(0.035)
Workmen*ICT	0.036	0.143**	-0.051	-0.013	0.032	0.153***	0.166***
	(0.027)	(0.060)	(0.055)	(0.039)	(0.050)	(0.038)	(0.036)
	Working conditions	Psycho safety (7)	Standard workhours (8)	Not working weekend (9)	Flexibility (10)	Work-life balance (11)	Uncons. work pace (12)
Managers*ICT	0.067	0.056	0.051**	0.080***	0.055**	0.111***	-0.035
	(0.028)	(0.042)	(0.024)	(0.025)	(0.024)	(0.041)	(0.037)
Intermediate*ICT	0.128***	-0.014	0.081**	0.147***	0.045	-0.043	-0.079**
	(0.033)	(0.038)	(0.041)	(0.038)	(0.034)	(0.035)	(0.038)
Employee*ICT	0.157***	-0.113***	0.159***	0.144***	0.092**	0.023	-0.030
	(0.033)	(0.034)	(0.030)	(0.033)	(0.039)	(0.036)	(0.036)
Workmen*ICT	0.039	-0.072	-0.104*	-0.028	0.026	-0.091	-0.036
	(0.051)	(0.078)	(0.055)	(0.031)	(0.055)	(0.060)	(0.059)
Obs.	18005	18005	18005	18005	18005	18005	18005
Individual Controls	✓	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓	✓
Region Fixed Effects	✓	✓	✓	✓	✓	✓	✓
Occupation FE 4-digits	✓	✓	✓	✓	✓	✓	✓
Establishment Controls	✓	✓	✓	✓	✓	✓	✓

Notes: Working condition survey merged sample for 2013 and 2019 including public and private sector. Weighted least square regressions with sampling weights defined to ensure a representative sample. All non-pecuniary working conditions have been standardized. Robust standard errors are clustered at the individual level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.