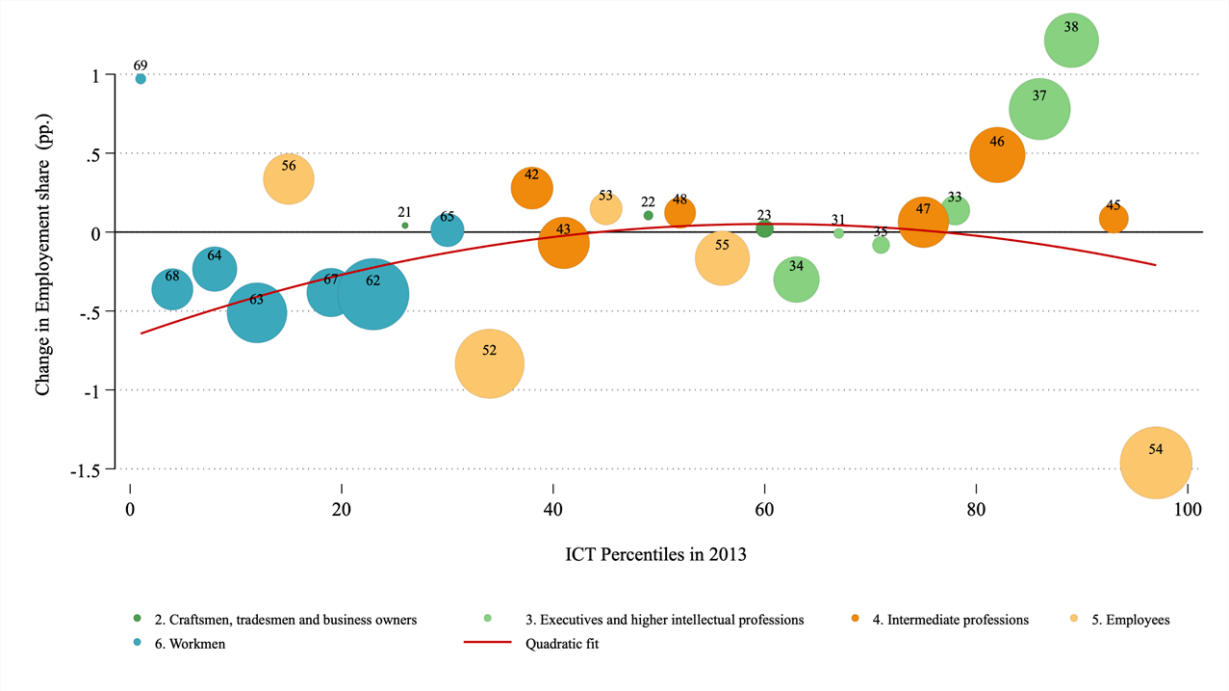
ICT Diffusion, Wages, Working Conditions and Job Satisfaction

Sarah Flèche, Eva Moreno-Galbis, Ariell Reshef, Claudia Senik

EEA Bordeaux, 2025

Employment growth in ICT-intensive occupations

Figure: Trends in Employment Shares by ICT

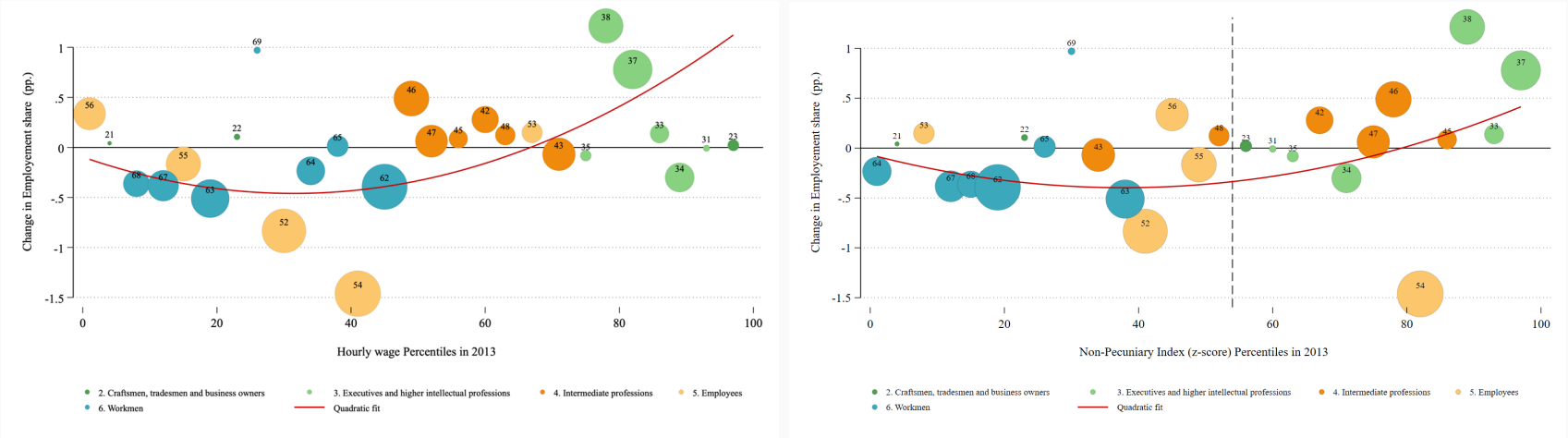


Working Conditions Survey, 2013, 2019

- Exception: office workers, occupation 54 (PCS).

Similar, but not identical trends for working conditions

Figure: Trends in Employment Shares by Wage and Working Conditions



Working Conditions Survey, 2013, 2019

- Broadly, ICT-intensive occupations also better paid, exhibit better working conditions—but rank correlations far below 1.
- These dimensions do not always align: e.g. office workers (54), sales (55), personal services (65)—but also executives (23).

Digitization, working conditions and job satisfaction

Research question: did digitization affect working conditions and job satisfaction?

- Digitization $\Rightarrow$ massive overhaul of work practices, all areas of economy.

Understudied channel: consequences on non-pecuniary aspects of jobs

- Most of the literature dedicated to understanding the wage and employment impacts (e.g. Autor et al., 2003; Goos and Manning, 2007; Goos et al., 2009; Michaels et al., 2014; Frey and Osborne, 2017; Arntz et al., 2016).
- Recent work considers other dimensions (see next slide).
- We focus on multi-dimensional non-pecuniary working conditions.

Recent literature shows ICT associated with...

- **improving communication among workers** (Hart and Moore, 2005; Dessein and Santos, 2006; Cremer et al., 2007)
- **reducing information asymmetries** (Jensen and Meckling, 1992)
- **increasing productivity** (Institute for Prospective Techno. Studies, 2013)
- **less autonomy, longer working days, worse work-life balance, greater work intensity** (Bloom et al., 2014, Martin and Omrani, 2015; Martin, 2017; Menon et al., 2020; Gihleb et al., 2020; Caselli et al., 2021)
- **negative consequences for health and well-being** (Schwabe and Castellacci, 2020; Gunadi and Ryu, 2021; Bolli and Pusterla, 2022; Lordan and Stringer, 2022; Kortmann et al., 2022; Haepp, 2021; Blasco et al, 2024...)

Recent literature shows ICT associated with...

- **improving communication among workers** (Hart and Moore, 2005; Dessein and Santos, 2006; Cremer et al., 2007)
- **reducing information asymmetries** (Jensen and Meckling, 1992)
- **increasing productivity** (Institute for Prospective Techno. Studies, 2013)
- **less autonomy, longer working days, worse work-life balance, greater work intensity** (Bloom et al., 2014, Martin and Omrani, 2015; Martin, 2017; Menon et al., 2020; Gihleb et al., 2020; Caselli et al., 2021)
- **negative consequences for health and well-being** (Schwabe and Castellacci, 2020; Gunadi and Ryu, 2021; Bolli and Pusterla, 2022; Lordan and Stringer, 2022; Kortmann et al., 2022; Haepp, 2021; Blasco et al, 2024...)

...but overall, very weak causal identification.

This paper

1. **Study multiple components of working conditions.**
2. **Leverage matched employee-employer panel of The Working Conditions Survey, never used in this context.**
3. **Causal inference: develop theory-consistent IV strategy using establishment-level ICT adoption.**
4. **Estimate overall consequences of ICT adoption on job satisfaction—via both wages and working conditions.**
5. **Main findings: positive effect of ICT adoption on wages and working conditions, but small impact on job satisfaction.**
    - ICT affects dimensions of WCs that workers care relatively little about.
    - Heterogeneous effects across WC dimensions, types of workers and firms.

Model

- Worker utility: $u(w, q) = \log w + \theta \log q$, with $\theta > 0$. (⏩ separable, col 4+5)
- Firm profit: $\pi = y + \gamma(q) - w$, where y is match output.
- Firm benefit from quality: $\gamma(q) = \alpha q - \frac{1}{2} q^2$.
- Worker and firm maximize total surplus, Nash-bargain over it:

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

- Considering $\pi = y \cdot q - \frac{1}{2} q^2 - w$ provides similar conclusions
- Can entertain more flexible functional forms, giving rise to nuances, but KIS.
- **Public sector:** bargain over q for a given w
- **Private sector:** bargain over q and w

Solution public sector

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

- LHS ; marginal utility gain of the worker from higher q. RHS : marginal cost of the firm when q increases marginally.
- Solution implies $q > \alpha$ and
- parameter restrictions ensure the existence of solution, where

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

Solution private sector

- System of equations implicitly determines (w^*, q^*):

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

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

- Solution implies $q > \alpha$ and:

	Effect on q^*	Effect on w^*
y	↑	↑
α	↑	↑
β	↑	↑
U	↑	↑
θ	↑	↑

The effect of ICT

- Denote ICT as t.
- Assume $y(t)$ with $y'(t) > 0$, or $\alpha(t)$ with $\alpha'(t) > 0$.
- Then $dw^*/dt > 0$ and $dq^*/dt > 0$.
- **Through its impact on overall surplus, digitalization increases both work quality (i.e. working conditions) and wages.**
- **Suggests using establishment-level variation in ICT availability as IV to identify worker outcomes.**
- Bargaining power (β) and worker types (θ) modulate these effects:
  - $\beta \uparrow \Rightarrow dw^*/dt > 0 \uparrow$ and $dq^*/dt > 0 \uparrow$
  - $\theta \uparrow \Rightarrow dw^*/dt > 0 \downarrow$ and $dq^*/dt > 0 \uparrow$
  - This can help explain heterogeneous effects across workers.

Data: The Working Conditions Survey 2013, 2019

- **Employee part:**
  - Wages.
  - Working conditions: organization, cooperation, conflicts, schedules, physical efforts or risks, safety, hardship and work rhythms.
  - Socio-demographic characteristics of individuals (gender, age, education, marital status, children, type of employment contract).
  - Weekly minutes spent using at least one of the following ICTs: computer, laptop, professional email address, internet and intranet—**Information available only in 2013 and 2019 waves.**
  - Job satisfaction—**available only in 2019.**
- **Employer part—never used in this context:**
  - General establishment characteristics, workforce management, work organization, employee representation,...
  - **Share of workers who use the internet in the workplace**.

Key variables

- Hourly wage.
- Non-Pecuniary Working Conditions Index (NPI or WC) .
  - Average of following 12 indicators (defined in z-scores): learning, autonomy, support, stability, physical comfort, physical safety, psychological safety, standard working hours, not working on the weekend, work-life balance, flexibility and an unconstrained work pace
  - Follows Eurofund.
- Share of daily working hours using ICT.
- Share of workers who use the internet in the establishment: 0%, <10%, 10-50%, >50% .

⏩ Detailed NPI components

⏩ PCS codes

Remarkably similar descriptive statistics across samples

	Employee sample			Empl. panel sample			Merged empl.–firm		
	Obs.	Mean	SD	Obs.	Mean	SD	Obs.	Mean	SD
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Male	50,313	0.44	0.50	25,078	0.43	0.50	23,867	0.43	0.49
Age	50,309	43.91	10.62	25,075	44.60	9.38	23,865	43.85	10.43
No Diploma	50,242	0.06	0.24	25,052	0.05	0.22	23,852	0.06	0.23
CEP, Brevet	50,242	0.07	0.025	25,052	0.05	0.22	23,852	0.06	0.23
CAP, BEP	50,242	0.25	0.43	25,052	0.25	0.043	23,852	0.25	0.43
Baccalaureate	50,242	0.18	0.38	25,052	0.18	0.39	23,852	0.18	0.38
BAC+2	50,242	0.15	0.36	25,052	0.17	0.37	23,852	0.15	0.36
BAC+3 or BAC+4	50,242	0.16	0.36	25,052	0.17	0.37	23,852	0.16	0.37
BAC+4 or more	50,242	0.14	0.34	25,052	0.14	0.34	23,852	0.14	0.35
In couple	50,308	0.77	0.42	25,074	0.79	0.41	23,865	0.77	0.42
Has children	50,313	0.60	0.49	25,078	0.66	0.47	23,867	0.61	0.49
Immigrant	50,313	0.09	0.29	25,078	0.07	0.25	23,867	0.08	0.27
Full-time worker	50,074	0.81	0.39	24,986	0.81	0.39	23,848	0.83	0.38
ICT	45,334	0.44	0.39	22,534	0.46	0.38	21,818	0.45	0.39

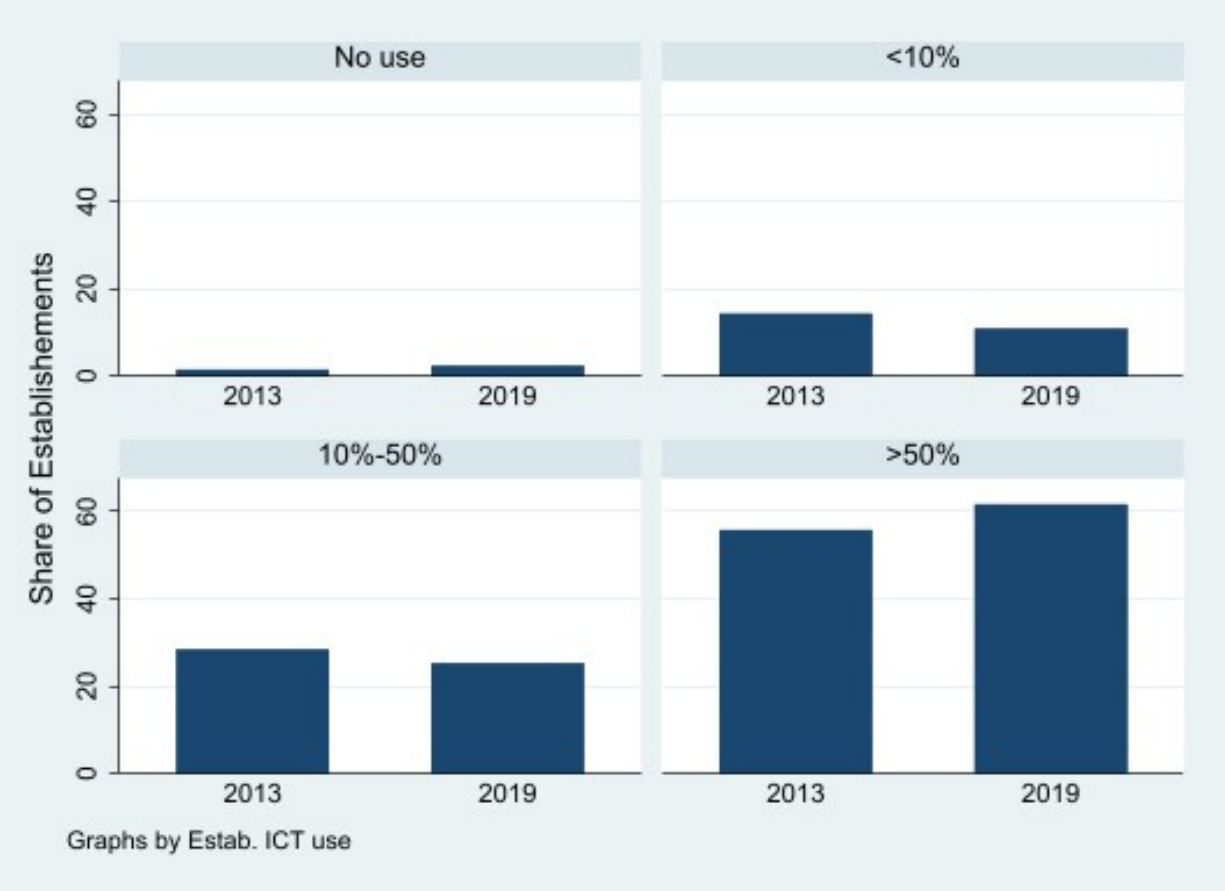
ICT intensity increases within workers from 2013 to 2019

	Merged employee-firm sample				
	Both 2013 and 2019			2013	2019
Variable	Obs.	Mean	SD	Mean	Mean
	(1)	(2)	(3)	(4)	(5)
ICT	21,818	0.45	0.38	0.38	0.54
Log Hourly Wage	23,032	2.98	0.43	2.96	3.00
NPI	20,811	0.63	0.12	0.63	0.64
Learning	22,478	0.60	0.24	0.59	0.61
Autonomy	23,432	0.56	0.21	0.56	0.56
Support	23,725	0.81	0.25	0.81	0.82
Stability	23,247	0.68	0.18	0.66	0.70
Physical comfort	23,802	0.59	0.34	0.58	0.60
Physical risk	23,807	0.74	0.29	0.73	0.74
Psychological safety	22,764	0.57	0.21	0.57	0.57
Standard working hours	23,862	0.77	0.31	0.77	0.78
Not working weekend	23,862	0.68	0.38	0.68	0.68
Flexibility	22,572	0.62	0.21	0.62	0.62
Work-life balance	22,759	0.40	0.14	0.40	0.40
Uncons. work pace	22,602	0.55	0.23	0.55	0.56

- **Small trend in wages, WCs—and lots of heterogeneity.**

ICT intensity increases over time within establishments

Figure: Distribution of establishments by ICT intensity



Empirical strategy 1 : WLS

$$Y_{ijet} = \beta \cdot ICT_{it} + X_{it}\gamma + X_{et}\delta + \alpha_t + \alpha_{r(i,t)} + \alpha_j + \alpha_e + \alpha_i + \varepsilon_{ijet}, \quad (1)$$

- Y_{ijet} : log hourly wage or working conditions for individual *i* in occupation *j*, working in establishment *e* in year *t*
- ICT_{it} : share of normal workday hours spent using ICT.
- X_{it} : individual socio-demographic controls (gender, age, education, marital status, children, immigration status, full/part-time).
- X_{et}: establishment-level controls (workforce size, presence of staff delegate, presence of staff union, existence of health and safety committee).
- 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 regressions weighted using sampling weights.

WLS results: ICT associated with greater WCs, wages

Table: The Relationship Between 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: Non-Pecuniary 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.	20,099	19, 948	19, 948	8,776	5,264	2,370
Individual Controls	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓
Region Fixed Effects	✓	✓	✓	✓	✓	✓
Occupation FE 4-digits		✓	✓	✓	✓	✓
Establishment Controls			✓			
Establishment FE				✓		
Worker Fixed Effects					✓	✓
Establishment*Worker FE						✓

- No effect on wages within establishments (column 4).
- Heterogenous effects by NPI Components.
- Similar—but not identical—effects by public and private sector.

Empirical strategy 2 : W2SLS

$$Y_{ijet} = \beta \cdot ICT_{it} + X_{it}\gamma + X_{et}\delta + \alpha_t + \alpha_{r(i,t)} + \alpha_j + \varepsilon_{ijet}$$

with "first stage"

$$ICT_{it} = \lambda_1 \cdot I(\chi_{10-50})_{et} + \lambda_2 \cdot I(\chi_{>50})_{et} + X_{it}\mu + X_{et}\sigma + \tau_t + \tau_{r(i,t)} + \tau_j + u_{ijet}$$

- $I(\chi_{10-50})_{et}$ and $I(\chi_{>50})_{et}$ are indicators for share of workers within establishment using internet.
- Identifying assumption: availability of internet at establishment captures "intention to treat", while workers' ICT use reflects treatment take-up.
  - Availability of **internet** affects wages and WCs only via **intensity of use of ICTs**.
  - Establishment information pertains to availability of internet **to all its employees**—while only a handful sampled in the WCS.
- IV passes "plausibly exognenous" tests (Conley, Hansen & Rossi, 2012).
- Likely that 2SLS identifies LATE $>$ ATE. E.g., individuals who know that they would see greater gains respond more intensively to the intention to treat.

W2SLS Results: ICT associated with better WCs, wages

Table: The Relationship Between ICT, Wages, and Working Conditions (W2SLS)

	Panel A (First Stage): ICT		
	(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 (instrumented)	0.649***	0.725*	0.668*
	(0.151)	(0.331)	(0.326)
	Panel C: Non-Pecuniary Index (z-score)		
	(7)	(8)	(9)
ICT (instrumented)	1.350***	1.778**	1.767**
	(0.396)	(0.680)	(0.672)
Observations	18,163	18,024	18,024
Year FE	✓	✓	✓
Region FE	✓	✓	✓
Occupation FE (4-digits)		✓	✓
Establishment controls			✓

- Strong results for NPI (C), weaker results for wages (B)
- Reminiscent of WLS results: no effects on wages within establishments.

W2SLS results: NPI Components

Table: The Relationship Between ICT and Components of Working Conditions

	Learning & Development	Autonomy	Support	Stability	Physical comfort	Physical safety
	(1)	(2)	(3)	(4)	(5)	(6)
ICT (instrumented)	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 (instrumented)	-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
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	✓	✓	✓	✓	✓	✓

⏩ Results by sector

W2SLS results: Job satisfaction, ICT, W, NPI

Empirical decomposition

Table: Job Satisfaction, ICT, Wages, and Working Conditions (2019)

	Job Satisfaction (z-score)				
	(1)	(2)		(3)	
Total Effect:					
ICT (z-score)	0.126	0.262		0.307	
	(0.152)	(0.348)		(0.349)	
Direct Effect:					
ICT (ω_{ict}) (instrumented) (z-score)	-0.179	-0.067	(9.1%)	-0.024	(-7.8%)
	(0.179)	(0.344)		(0.346)	
Log Hourly Wages (z-score) (ω_w)	0.106***	0.086***		0.089***	
	(0.022)	(0.024)		(0.024)	
Non-pecuniary index (z-score) (ω_{npi})	0.391***	0.427***		0.421***	
	(0.054)	(0.038)		(0.038)	
Indirect Effect:					
ICT (z-score) ($\omega_w \pi_w + \omega_{npi} \pi_{npi}$)	0.333	0.368	(140.5%)	0.372	(121%)
Log Hourly Wages (z-score) ($\omega_w \pi_w$)	0.015	0.001	(0.37%)	-0.002	(-0.45%)
Non-pecuniary index (z-score) ($\omega_{npi} \pi_{npi}$)	0.318	0.367	(99.63%)	0.375	(100.45%)
Observations	8,504	8,411		8,411	
Individual controls	✓	✓		✓	
Region FE	✓	✓		✓	
Occupation FE (4-digits)		✓		✓	
Establishment controls				✓	

- Weak effect of ICT on JS despite its positive effect on wage and WCs.
- Explanation: ICT affects dimensions of WCs that worker values less (except Learn. & Dev.) and lowers some that worker cares about (e.g., Stability).

No interaction effects of W with NPI for Job satisfaction

Table: Wages, Individual Components of Working Conditions and Job satisfaction (WLS).

	Job Sat (z-score)	Job Sat (z-score)	Job Sat (z-score)	Job Sat (z-score)	
					Interactions with log(W)
ICT (z-score)	-0.031	0.001	0.001	0.003	
	(0.019)	(0.020)	(0.020)	(0.020)	
Log Wage (z-score)	0.033	0.032	0.033	0.029	
	(0.019)	(0.017)	(0.017)	(0.018)	
Learning and Development (z-score)	0.347***	0.361***	0.361***	0.360 ***	-0.005
	(0.017)	(0.016)	(0.016)	(0.016)	(0.017)
Autonomy (z-score)	0.060***	0.041**	0.041**	0.041**	-0.003
	(0.016)	(0.016)	(0.016)	(0.015)	(0.017)
Support (z-score)	0.035*	0.050**	0.050**	0.049**	-0.001
	(0.017)	(0.017)	(0.017)	(0.016)	(0.014)
Stability (z-score)	0.084***	0.088***	0.088***	0.086***	-0.007
	(0.019)	(0.018)	(0.018)	(0.017)	(0.015)
Physical discomfort (z-score)	0.047*	0.046	0.049	0.054*	0.022
	(0.024)	(0.025)	(0.025)	(0.024)	(0.023)
Physical risk (z-score)	-0.028	-0.006	-0.007	-0.007	-0.003
	(0.018)	(0.020)	(0.020)	(0.020)	(0.016)
Psy. Integrity (z-score)	0.054***	0.053***	0.053***	0.053***	-0.008
	(0.016)	(0.014)	(0.014)	(0.014)	(0.014)
Unusual working hours (z-score)	0.004	-0.020	-0.019	-0.020	-0.011
	(0.021)	(0.020)	(0.020)	(0.019)	(0.017)
Working Weekend (z-score)	-0.038*	-0.031	-0.031	-0.029	-0.002
	(0.018)	(0.020)	(0.020)	(0.019)	(0.017)
Flexibility (z-score)	0.034	0.039*	0.038	0.034	-0.013
	(0.019)	(0.020)	(0.020)	(0.018)	(0.018)
Work-life Balance (z-score)	0.012	0.033*	0.032*	0.033***	-0.017
	(0.017)	(0.016)	(0.016)	(0.015)	(0.015)
Unconstrained work pace (z-score)	0.131***	0.113***	0.114***	0.114***	0.006
	(0.020)	(0.017)	(0.017)	(0.016)	(0.017)
Indiv controls	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes
Occupation FE		Yes	Yes	Yes	Yes
Firm controls			Yes	Yes	Yes
Observations	8504	8411	8411	8411	8411

⏩ Back to Model

Heterogeneous effects by occupation

Table: Heterogeneous effect by occupation

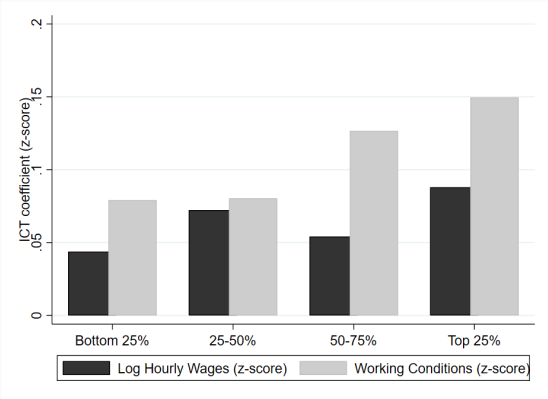
	(1) Log Hourly Wages (z-score)	(2) Working Conditions (z-score)
ICT (z-score)	0.011	0.067**
	(0.037)	(0.028)
Intermediate*ICT(z-score)	0.100**	0.060
	(0.046)	(0.042)
Employees*ICT(z-score)	0.052	0.090**
	(0.048)	(0.043)
Workmen*ICT(z-score)	0.025	-0.029
	(0.046)	(0.058)
Observations	18,005	18,005

- Larger effect on wages of intermediate occupations.
- Larger effect on WCs of office employees.
- Can be explained by variation in θ, α.

⏩ By NPI components

Heterogeneous effects by firm's characteristics

A: Firm Size



B: Staff representative

C: Trade union representative

D: CHSCT

Notes: All variables have been standardized.

- Differences statistically significant for firm size and CHSCT. ▸▸ By NPI components

Conclusion

- ICT diffusion raised wages and improved working conditions.
  - Not all dimensions of WCs affected.
- ICT diffusion does not significantly increase job satisfaction.
  - ICT does not improve WCs that workers value most.
- IV estimates support conclusions of WLS.
- Heterogeneous effects of ICT on working conditions by:
  - public vs. private sector,
  - occupation,
  - firm size, CHSCT.
- Weakly heterogeneous effects of ICT by gender, part/full-time. ⏩ Tables
  - Women: gains in flexibility, not working on weekend; men gain physical safety.
  - Part-time: loss of psy. integrity; full-time: reduction in working on weekend.

BONUS SLIDES

Detailed NPI components

back to key variables

Indicator	Variable	Type
4*(*i*) Learning new things	Learning new skills on the job	Dummy
	Access to sufficient and appropriate training	Dummy
	Prospects for career advancement	Discrete
	Opportunities for professional skill development	Discrete
4*(*ii*) Autonomy	Ability to choose methods to accomplish work objectives	Dummy
	Adherence to orders	Discrete
	Influence of external client demands on work rhythm	Discrete
	Independence from colleagues' work	Dummy
3*(*iii*) Support	Support from colleagues	Dummy
	Support from manager	Dummy
	Opportunity to cooperate with other	Dummy
3*(*iv*) *Stability*	Unlimited duration contract	Dummy
	Weak probability of loosing one's job in the next six months	Dummy
	Highest seniority (normalized between 0 and 1 across individuals)	Continuous
6*(*v*) Ergonomics	Not working in painful positions	Dummy
	Not standing up a lot	Dummy
	Not walking a lot	Dummy
	Not moving loads	Dummy
	Not performing painful or tiring movements	Dummy
	Not repeating continuously the same series of gestures or operation	Dummy
4*(*vi*) Physical safety	Exposure to vibrations	Discrete
	Exposure to smoke	Discrete
	Exposure to chemical products	Discrete
	Exposure to traffic accidents	Discrete
5*(*vii*) Psychological safety	Doing things one disapproves of	Discrete
	Working under pressure all the time	Discrete
	Not experiencing tense situations with clients	Dummy
	Not experiencing tense situations with managers	Dummy
	Not experiencing tense situations with colleagues	Dummy
5*(*viii*) Standard hours	Not working on the evenings	Dummy
	Not working at night	Dummy
	Not working early in the morning	Dummy
5*(*ix*) Weekends	Not working on the evenings	Dummy
	Not working on Saturdays	Dummy
	Not working on Sundays	Dummy
5*(*x*) Work-life balance	Not contacted by colleagues outside of work hours in the last year	Dummy
	Necessity of working overtime	Discrete
	Necessity of bringing work home	Discrete
	Necessity of thinking about work outside of work hours	Discrete
	Work hours are compatible with family and social activities	Discrete
4*(*xi*) Flexibility	Possibility of freely taking a break during the day	Discrete
	No monitoring of working time	Dummy
	Possibility of freely organizing working time	Dummy
	Ability to take easily 1-2 hours off during the day	Dummy
4*(*xii*) Unconstrained Work pace	Enough time to do the job	Dummy
	Not required to work at high speed	Discrete
	No deadlines	Discrete
	Not required to do an excessive amount of work	Discrete
	Enough time to do the work	Discrete

NPI Components

Results

Table: The Relationship between ICT, Wages 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.	19,948	19,948	19,948	19,948	19,948	19,948
Individual Controls	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓
Region Fixed Effects	✓	✓	✓	✓	✓	✓
Occupation FE 4-digits	✓	✓	✓	✓	✓	✓
Establishment Controls	✓	✓	✓	✓	✓	✓

PCS codes

back to key variables

Code	Title	Public
21	Small business owners and workers	
22	Merchants and retailers	
23	Heads of businesses of at least 10 employees	
31	Liberal professions	
33	Civil service managers	+
34	Scientific and educational professionals	
35	Creative professionals (info, art, shows)	
37	Top managers and professionals	
38	Technical managers	
42	Teachers	+
43	Mid-level health and social professionals	+
44	Clergy, religious	
45	Civil service intermediate administrative	+
46	Mid-level managers & professionals	
47	Technicians	
48	Supervisors and foremen	
52	Civil service employees	+
53	Police and military	+
54	Office and admin	
55	Retail	
56	Personal service	
62	Skilled industrial workers	
63	Skilled craft workers	
64	Drivers	
65	Skilled transport and wholesale workers	
67	Unskilled industrial workers	
68	Unskilled craft workers	

WLS result: Public sector

Results

Table: The Relationship between ICT, Wages and Components of Working Conditions-public

	Learning & Development	Autonomy	Support	Stability	Physical comfort	Physical safety
	(1)	(2)	(3)	(4)	(5)	(6)
ICT	0.106	0.057	-0.030	0.008	0.501***	0.349***
	(0.069)	(0.076)	(0.058)	(0.064)	(0.056)	(0.057)
	Psycho safety	Standard workhours	Not working weekend	Flexibility	Work-life balance	Uncons. work pace
	(7)	(8)	(9)	(10)	(11)	(12)
ICT	-0.153	0.106	0.245***	0.156*	-0.048	-0.118
	(0.087)	(0.066)	(0.052)	(0.072)	(0.075)	(0.073)
Indiv controls	Yes	Yes	Yes	Yes	Yes	Yes
Year Fe	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Occupation FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10051	10051	10051	10051	10051	10051

WLS results: Private sector

Results

Table: The Relationship between ICT, Wages and Components of Working Conditions-private

	Learning & Development	Autonomy	Support	Stability	Physical comfort	Physical safety
	(1)	(2)	(3)	(4)	(5)	(6)
ICT	-0.095	0.048	-0.037	0.056	0.497***	0.538***
	(0.063)	(0.068)	(0.066)	(0.057)	(0.050)	(0.056)
	Psycho safety	Standard workhours	Not working weekend	Flexibility	Work-life balance	Uncons. work pace
	(7)	(8)	(9)	(10)	(11)	(12)
ICT	0.043	0.302***	0.304***	0.144*	-0.016	-0.216**
	(0.068)	(0.056)	(0.060)	(0.060)	(0.067)	(0.068)
Indiv controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Occupation FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7918	7918	7918	7918	7918	7918

Public sector (W2SLS)

Table: The Relationship Between ICT, Wages and Individual Components of Working Conditions (W2SLS). Public sector

	Learning & Development	Autonomy	Support	Stability	Physical comfort	Physical safety
	(1)	(2)	(3)	(4)	(5)	(6)
ICT (instrumented)	3.852***	0.994	-0.195	-1.669*	1.629**	1.596*
	(0.929)	(0.892)	(0.804)	(0.812)	(0.599)	(0.733)
K-P F-stat	15.49	15.49	15.49	15.49	15.49	15.49
	Psycho safety	Standard workhours	Not working weekend	Flexibility	Work-life balance	Uncons. work pace
	(7)	(8)	(9)	(10)	(11)	(12)
ICT (instrumented)	-1.019	1.515*	0.119	1.544*	0.385	0.669
	(0.826)	(0.712)	(0.580)	(0.735)	(0.713)	(0.700)
K-P F-stat	15.49	15.49	15.49	15.49	15.49	15.49
Obs.	10,051	10,051	10,051	10,051	10,051	10,051
Individual Controls	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓
Region Fixed Effects	✓	✓	✓	✓	✓	✓
Occupation FE 4-digits	✓	✓	✓	✓	✓	✓
Establishment Controls	✓	✓	✓	✓	✓	✓

Private sector (W2SLS)

Table: The Relationship Between ICT, Wages and Individual Components of Working Conditions (W2SLS). Private sector

	Learning & Development	Autonomy	Support	Stability	Physical comfort	Physical safety
	(1)	(2)	(3)	(4)	(5)	(6)
ICT (instrumented)	1.264	-3.316	1.831	-0.243	-0.119	0.922
	(1.889)	(3.060)	(2.150)	(1.166)	(1.250)	(1.482)
K-P F-stat	2.38	2.38	2.38	2.38	2.38	2.38
	Psycho safety	Standard work hours	Not working weekend	Flexibility	Work-life balance	Uncons. work pace
	(7)	(8)	(9)	(10)	(11)	(12)
ICT (instrumented)	-0.611	-2.856	-2.343	-5.753	-3.661	-0.153
	(1.929)	(2.348)	(2.024)	(3.983)	(2.694)	(2.359)
K-P F-stat	2.38	2.38	2.38	2.38	2.38	2.38
Obs.	7,918	7,918	7,918	7,918	7,918	7,918
Individual Controls	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓
Region Fixed Effects	✓	✓	✓	✓	✓	✓
Occupation FE 4-digits	✓	✓	✓	✓	✓	✓
Establishment Controls	✓	✓	✓	✓	✓	✓

▸▸ W2SLS results

Heterogeneous effects by occupation

Table: ICT and Components of Working Conditions by occupation

	Learning & Development	Autonomy	Support	Stability	Physical comfort	Physical safety
	(1)	(2)	(3)	(4)	(5)	(6)
Managers*z_ICT	-0.074*	0.029	-0.048	-0.057*	0.069***	0.119***
	(0.031)	(0.035)	(0.033)	(0.025)	(0.021)	(0.026)
Intermediate*z_ICT	-0.005	0.064	-0.019	-0.021	0.199***	0.174***
	(0.032)	(0.047)	(0.036)	(0.030)	(0.032)	(0.048)
Employees*z_ICT	0.003	0.033	0.019	0.039	0.260***	0.083*
	(0.034)	(0.037)	(0.037)	(0.040)	(0.032)	(0.035)
Workmen*z_ICT	0.143*	-0.051	-0.013	0.032	0.153***	0.166***
	(0.060)	(0.055)	(0.039)	(0.050)	(0.038)	(0.036)

	Psycho safety	Standard workhours	Not working weekend	Flexibility	Work-life balance	Uncons. work pace
	(7)	(8)	(9)	(10)	(11)	(12)
Cadres*z_ICT	0.056	0.051*	0.080**	0.055*	0.111**	-0.035
	(0.042)	(0.024)	(0.025)	(0.024)	(0.041)	(0.037)
Intermediate*z_ICT	-0.014	0.081*	0.147***	0.045	-0.043	-0.079*
	(0.038)	(0.041)	(0.038)	(0.034)	(0.035)	(0.038)
Employees*z_ICT	-0.113***	0.159***	0.144***	0.092*	0.023	-0.030
	(0.034)	(0.030)	(0.033)	(0.039)	(0.036)	(0.036)
Workmen*z_ICT	-0.072	-0.104	-0.028	0.026	-0.091	-0.036
	(0.078)	(0.055)	(0.031)	(0.055)	(0.060)	(0.059)
Obs.	18005	18005	18005	18005	18005	18005
Individual Controls	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓
Region Fixed Effects	✓	✓	✓	✓	✓	✓
Occupation FE 4-digits	✓	✓	✓	✓	✓	✓
Establishment Controls	✓	✓	✓	✓	✓	✓

⏩ Back

Heterogeneous effects by firm's characteristics

Table: The Relationship between ICTs and Components of Working Conditions by firm size

	Learning & Development	Autonomy	Support	Stability	Physical comfort	Physical safety
	(1)	(2)	(3)	(4)	(5)	(6)
size_1_z_ICT	0.028	0.046	-0.021	-0.042	0.217***	0.144***
	(0.036)	(0.040)	(0.035)	(0.032)	(0.027)	(0.036)
size_2_z_ICT	0.027	-0.009	-0.026	0.036	0.171***	0.144***
	(0.033)	(0.040)	(0.034)	(0.035)	(0.025)	(0.026)
size_3_z_ICT	0.027	0.011	-0.025	0.033	0.180***	0.110***
	(0.033)	(0.031)	(0.030)	(0.031)	(0.024)	(0.023)
size_4_z_ICT	0.023	0.041	0.051	-0.001	0.151***	0.176***
	(0.034)	(0.032)	(0.028)	(0.031)	(0.025)	(0.023)
	Psycho safety	Standard workhours	Not working weekend	Flexibility	Work-life balance	Uncons. work pace
	(7)	(8)	(9)	(10)	(11)	(12)
size_1_z_ICT	-0.055	-0.034	0.082**	0.053	-0.062	-0.078
	(0.051)	(0.030)	(0.028)	(0.040)	(0.040)	(0.042)
size_2_z_ICT	-0.091**	0.058*	0.043	0.061	-0.016	-0.065*
	(0.034)	(0.028)	(0.026)	(0.032)	(0.034)	(0.031)
size_3_z_ICT	-0.013	0.090**	0.121***	0.063*	0.005	-0.011
	(0.029)	(0.034)	(0.025)	(0.029)	(0.031)	(0.031)
size_4_z_ICT	-0.009	0.123***	0.138***	0.027	0.029	-0.028
	(0.032)	(0.028)	(0.024)	(0.029)	(0.034)	(0.034)
Obs.	18024	18024	18024	18024	18024	18024
Individual Controls	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓
Region Fixed Effects	✓	✓	✓	✓	✓	✓
Occupation FE 4-digits	✓	✓	✓	✓	✓	✓
Establishment Controls	✓	✓	✓	✓	✓	✓

⏩ Average NPI-W

Heterogeneous effects by firm's characteristics

Table: ICTs and Components of Working Conditions by firm size

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

⏩ Back

Heterogeneous effects by firm's characteristics

Table: The Relationship between ICTs and Components of Working Conditions by union representative

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

⏩ Average NPI-W

Heterogeneous effects by firm's characteristics

Table: The Relationship between ICTs and Components of Working Conditions by union representative

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

⏩ Average NPI-W

Empirical strategy

- **Mediation effect: Wages, Working Conditions and Job Satisfaction**

  Total effect of ICT on job satisfaction:

$$LS_{it} = \tau + \tau_{ict}\text{ICT}_{it} + X_{it}\psi + X_{ct}\psi + \alpha_t + \alpha_{r(i,t)} + \alpha_j + \theta_{it}$$

  Direct effect of ICT on job satisfaction:

$$LS_{it} = \kappa + \omega_w \log(wage)_{it} + \omega_{npi} npi_{it} + \omega_{ict}\text{ICT}_{it} + X_{it}\delta + X_{ct}\rho + \alpha_t + \alpha_{r(i,t)} + \alpha_j + \theta_{it}$$

  where $\log(wage)_{it}$ and npi_{it} are functions of ICT_{it} use, as described in equation (1):

$$Log(wage)_{it} = \beta_w + \pi_w ICT_{it} + X_{it}\delta_w + X_{ct}\rho_w + \alpha_t + \alpha_{(r(i,t))} + \alpha_j + \epsilon_i t$$

$$NPI_{it} = \beta_{npi} + \pi_{npi} ICT_{it} + X_{it}\delta_{npi} + X_{ct}\rho_{npi} + \alpha_t'' + \alpha_{(r(i,t))}'' + \alpha_j'' + \epsilon_i'' t$$

  - $\omega_w \times \pi_w$ and $\omega_{npi} \times \pi_{npi}$: indirect effect of ICT via wages and working conditions.
  - The total effect of ICT = direct effect on job satisfaction + indirect effect via wages + indirect effect via working conditions.

⏩ Empirical decomposition results

No heterogeneous effects by gender

Table: Heterogeneous effect by gender

	(1) Log Hourly Wages	(2) Working Conditions
ICT (z-score)	0.057**	0.076**
	(0.020)	(0.029)
Women*ICT(z-score)	0.008	0.052
	(0.026)	(0.032)
Observations	18,024	18,024

⏩ Back to conclusions

Heterogeneous effects by gender

Table: The Relationship between ICTs and Components of Working Conditions by gender

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

⏩ Back to conclusions

No heterogeneous effects by working time

Table: Heterogeneous effect by working time

	(1) Log Hourly Wages	(2) Working Conditions
ICT (z-score)	0.094*	0.063*
	(0.052)	(0.033)
Fulltime*ICT(z-score)	-0.041	0.048
	(0.053)	(0.033)
Observations	18,024	18,024

⏩ Back to conclusions

Heterogeneous effects by working time

Table: ICT and Components of Working Conditions by working time

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

⏩ Back to conclusions