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When the Algorithm Sets the Pace: Digital Management, Worker Voice and Job Quality

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Research Article

Keywords: Algorithmic management, Worker voice, Job quality, Psychosocial risks, Digital surveillance, Occupational health, European Union

Posted Date: November 10th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11660421/v1

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Additional Declarations: The authors declare no competing interests.

Research article

When the Algorithm Sets the Pace: Digital Management, Worker Voice and Job Quality

Abstract

Software that allocates tasks, sets the pace of work, monitors behaviour and rates performance has moved from delivery platforms into ordinary workplaces, yet comparative evidence on how widely it is used, who is shielded from it and what it does to job quality remains thin. This study reanalyses the published results of the European Agency for Safety and Health at Work (EU-OSHA) OSH Pulse survey of about 27,250 workers in 29 countries (spring 2022) and sets them against the 2024 establishment survey (ESENER) and the 2025 OSH Pulse wave. A country-by-sector panel of the organisational model index shows that 63 percent of its variation lies between countries and 12 percent between sectors; sector rankings agree across countries (Kendall's W = 0.28), with commerce, transport and food, ICT and finance, and administrative services highest. Countries with statutory agreement or co-determination rights over new technology do not show lower adoption (difference -0.11 index points; exact permutation p = 0.44). Published regressions link each additional digital management practice to 0.21 more psychosocial risks and 0.17 more health complaints; worker consultation is associated with reductions equal to 0.51 (95% interval 0.32 to 0.70) and 0.78 (0.50 to 1.06) of one practice. Raising consultation to all workers would offset 15 percent of the average psychosocial burden and 22 percent of the health burden, and a package of effective measures 53 and 74 percent. The findings are associations from self-reports, and the panel tests describe variation among cell means rather than sampling error.

Purpose - This study measures the diffusion of digital worker management across European countries and sectors, asks whether worker voice institutions are associated with less adoption, and quantifies how far worker consultation offsets the job quality costs of digital management.

Design/methodology/approach - The paper reanalyses published OSH Pulse 2022 results: a two-way variance decomposition and Tukey non-additivity test on a 29-country by 8-sector panel, Kendall's W, exact permutation and bootstrap comparisons of voice regimes, and delta-method and Monte Carlo accounting built on published regression coefficients.

Findings - Country differences dominate sector differences in adoption; sector ranks are stable; voice regimes are not associated with lower adoption; and consultation is associated with sizeable but partial offsets of psychosocial and health burdens.

Research limitations/implications - The analysis uses published aggregates and coefficients, cross-sectional self-reports and a coarse regime classification, and cannot establish causal effects or test whether consultation moderates the effect of digital management.

Practical implications - Employers and regulators should treat consultation on digital systems as one component of a package that includes information, awareness and transparency, and should extend algorithmic management safeguards beyond platform work.

Social implications - Because most workers already experience some form of digital management, protection that applies only to platform workers will miss most of those affected.

Originality/value - The paper brings comparative panel evidence, institutional comparison and transparent accounting together, and shows how the current regulatory and survey evidence on digital management fits.

Keywords Algorithmic management, Worker voice, Job quality, Psychosocial risks, Digital surveillance, Occupational health, European Union

Paper type Research article

1. Introduction

Managers have always allocated tasks, watched performance and set targets. What is new is that software now does these things continuously and at scale, using data about the worker, the task and the customer, and that it increasingly does so without a manager in the loop. Delivery platforms were the first visible example, with drivers and couriers receiving jobs, routes and ratings from an app. The same logic has reached warehouses, call centres, hospitals and offices, where systems schedule shifts, suggest the next task, count keystrokes and rate responses. The question this paper asks is what these systems do to the quality of work and whether workers' ability to speak about them makes a difference.

Evidence has grown but remains uneven. Case studies of platform and warehouse work describe loss of autonomy, opacity and intensified pace (Rosenblat and Stark, 2016; Wood et al., 2019; Kellogg et al., 2020). Surveys of regular workplaces are rarer. The EU-OSHA OSH Pulse survey of 2022 asked about 27,250 workers in 27 EU Member States, Iceland and Norway about the digital technologies they work with, the risks they perceive and the preventive measures they have, and the Agency's 2024 establishment survey asked more than 41,000 employers about the same technologies from the other side (EU-OSHA, 2025a; Pesole, 2023). Together they show that digital management is common and that workers' experience of it is not benign: 58 percent of workers in 2022 said digital technologies determined the pace of their work, and 78 percent reported at least one form of digital management or surveillance (Pesole, 2023).

Two gaps remain. The first is comparative. We know the average, but not how much of the variation lies between countries and how much between sectors, nor whether countries whose law gives workers a say over new technology differ from others. The second concerns voice. Employee voice is widely believed to improve working conditions (Freeman and Medoff, 1984; Mowbray et al., 2015), and European regulation increasingly relies on information and consultation rights over algorithmic systems, most visibly in Directive (EU) 2024/2831 on platform work. Yet how much consultation offsets the harms associated with digital management has not been quantified with comparative data.

This paper addresses both gaps with published results of the OSH Pulse survey. It builds a panel of the organisational model index across 29 countries and 8 sectors from the data tables in Pesole (2023), decomposes its variance, compares countries by the form of worker voice rights, and uses the published regression coefficients to compute how far consultation and other preventive measures offset the average association of digital management with psychosocial risk and health complaints. It then places these findings against the ESENER 2024 and OSH Pulse 2025 results and the platform work directive now awaiting transposition. The analysis is descriptive and associational. The panel cells are means without sample sizes, the regressions are cross-sectional, and consultation is measured as consultation about the stressful aspects of work, not about algorithms in particular.

The contribution is threefold. It gives a quantitative map of where and in which sectors digital management has spread. It tests an institutional claim, that statutory voice rights reduce adoption, and finds little support for it. And it provides an explicit accounting of what workers' consultation is associated with, which clarifies what a regulatory strategy based on consultation can and cannot be expected to achieve.

Sections 2 and 3 review the literature and develop hypotheses, Sections 4 and 5 present data and methods, Sections 6 to 8 report results, and Sections 9 and 10 cover robustness, implications and conclusions.

1.1. Research Objectives and Questions

1) Describe how digital management is distributed across countries and sectors and partition its variance.
2) Test whether countries with statutory voice rights over new technologies show different adoption.

3) Quantify the association of digital management with psychosocial risk and health complaints.
4) Quantify how much of that association is offset by worker consultation and other preventive measures.
5) Place the findings against the latest EU survey and regulatory evidence and derive implications.

Research Questions

RQ1: Is digital management a matter of country or of sector?

RQ2: Do voice regimes predict adoption?

RQ3: How large are the associated job quality and health costs?

RQ4: How much do consultation and related measures offset?

RQ5: What does the evidence imply for regulation of algorithmic management?

2. Literature and Institutional Background

2.1. Algorithmic management and control

Algorithmic management is usually defined as the use of computer-programmed procedures to coordinate labour input (Pesole, 2023, drawing on Baiocco et al., 2022). Lee et al. (2015), studying ride-hailing drivers, introduced the term for software algorithms that assume managerial functions, and Kellogg et al. (2020) organised its mechanisms into six: restricting, recommending, recording, rating, replacing and rewarding workers. Their central argument is that algorithms are a new form of control, working at greater scale, in real time and with greater opacity than traditional supervision. Rosenblat and Stark (2016) documented how information asymmetries between a platform and its drivers shape power, and Wood et al. (2019) found that algorithmic control in the global gig economy coexists with nominal autonomy, producing flexibility and pay but also intensive work, isolation and exhaustion. Möhlmann et al. (2021) show that on platforms the matching function and the control function are intertwined, so that the same algorithm that makes work available also disciplines it.

Parent-Rocheleau and Parker (2022) treat algorithms as work designers, arguing that they shape job characteristics such as autonomy, task variety and feedback, and that their effects depend on design choices and on how they are implemented. Jarrahi et al. (2021) review algorithmic management in work contexts more broadly and call for research on how workers respond. These studies mostly concern platforms. Evidence from regular workplaces is thinner, but the EU-OSHA study of worker management through artificial intelligence reports that such systems can reduce job control by determining content, pace and schedule, and can also help with task matching and safety (EU-OSHA, 2022). Eurofound (2020) and Ajunwa et al. (2017) address the surveillance side, including the privacy and legal questions that arise when monitoring extends beyond work activities, and Bernhardt et al. (2023) make the case for worker technology rights in a data-driven workplace.

2.2. Job quality and health

Job quality is multidimensional, covering earnings, autonomy, intensity, working time, prospects and the social environment (Muñoz de Bustillo et al., 2011). Algorithmic management bears most obviously on autonomy and intensity. Karasek (1979) put decision latitude and demands at the centre of the study of work stress, and a system that sets pace and sequence reduces the first while often raising the second. Zuboff (1988) anticipated this in her account of information technology as an instrument of control, and the EU-OSHA analysis of the OSH Pulse data reports that technology adoption is associated with more time pressure, poorer communication and, to a lesser degree, less autonomy, while reducing exposure to violence and harassment for workers in contact with the public (Pesole, 2023). A review of workers' health under algorithmic management points to stress and anxiety as recurrent outcomes (Vignola et al., 2023), and an analysis of the earlier ESENER establishment survey links digital tools for worker management to psychosocial risks (Urzì Brancati and Curtarelli, 2021).

2.3. Worker voice and its institutions

Hirschman (1970) distinguished exit, voice and loyalty as responses to decline in organisations, and Freeman and Medoff (1984) argued that unions act mainly through the voice face, improving communication and reducing quits. Mowbray et al. (2015) review the employee voice literature and conclude that it covers a wide range of channels, from direct dialogue to collective representation, with varying evidence on outcomes. For digital management, voice is plausibly important for three reasons. Workers often cannot see what data are collected or how they are used. Algorithmic systems embed design choices that may have health implications that managers do not foresee. And a duty to consult can lead to adjustments before a system is deployed. Pesole (2023) reports that some Member States require agreement or co-determination before new technologies are introduced (Germany, the Netherlands, Austria, Finland and Sweden), others consultation only (Belgium, France and Romania), and Italy collective agreement. Whether these differences show up in adoption is an empirical question that the literature has not answered.

2.4. Regulation

Regulation of algorithmic management is moving. Directive (EU) 2024/2831 on improving working conditions in platform work was adopted on 23 October 2024, published on 11 November 2024, entered into force on 1 December 2024 and must be transposed by 2 December 2026. Its Chapter III (Articles 7 to 15) addresses algorithmic management, with provisions on transparency, human oversight of significant decisions, protection of health and safety against algorithm-induced stress and overwork, and information and consultation of workers' representatives before introducing or substantially changing automated systems (Directive (EU) 2024/2831). National drafts have begun to appear; for example, the Dutch government published a draft bill on 29 June 2026 (Global Workplace Insider, 2026). The directive applies to platform work. Evidence on regular workplaces, which this paper uses, speaks to whether similar protections would matter beyond platforms.

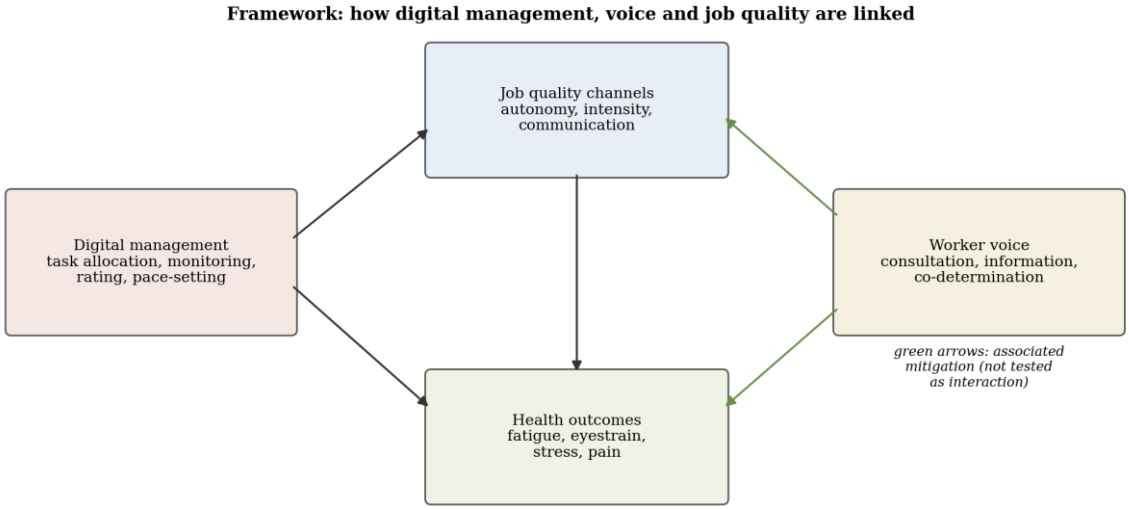
2.5. Gap

The literature has described the mechanisms of algorithmic control and documented its association with strain, but it has not quantified how adoption varies across countries and sectors in a comparable survey, whether institutional voice rights are associated with adoption, or how much consultation offsets. This paper provides those quantities from published data.

3. Framework and Hypotheses

Figure 1 summarises the framework. Digital management practices, such as automatic task allocation, monitoring and rating, affect job quality channels (autonomy, intensity and communication) and, through them or directly, health. Worker voice may reduce these effects, through consultation before deployment, information about how systems work and measures that address stress. Adoption itself may be shaped by institutional context, by the sector's tasks and by firm size.

Figure 1. Framework linking digital management, job quality, health and worker voice.



Conceptual framework; not an estimated model. The mitigation arrows describe associations in additive models.

Six hypotheses follow.

H1: Variation in adoption of digital management is larger between countries than between sectors.

H2: The ordering of sectors by adoption is similar across countries, with commerce and transport, ICT and finance, and administrative services highest.

H3: Countries with statutory agreement or co-determination rights over new technologies have lower adoption than other countries.

H4: Each additional digital management practice is associated with higher psychosocial risk and more health complaints, with standardised effects of at least 0.1.

H5: Worker consultation is associated with reductions in psychosocial risk and health complaints equal to at least one third of the effect of one practice, and universal consultation would offset a meaningful but partial share of the average burden.

H6: Risk profiles differ by occupation, with the loss of autonomy not concentrated in the occupations with the highest time pressure.

H1 and H2 are tested with a variance decomposition and rank concordance, H3 with permutation tests, H4 and H5 with accounting on published coefficients, and H6 with rank correlations. All are associational.

4. Data

4.1. The OSH Pulse survey

The OSH Pulse survey is a Flash Eurobarometer commissioned by EU-OSHA and fielded in spring 2022 by telephone. It interviewed a representative sample of about 27,250 workers aged 16 and over in the 27 EU Member States, Iceland and Norway about psychosocial risks, health complaints, digital technologies at work, and preventive measures (Pesole, 2023). Workers were asked which technologies they use, whether the organisation uses digital technologies to supervise or monitor work, allocate tasks or shifts automatically, have performance rated by third parties or monitor vital signs, and whether digital technologies determine the pace of their work or increase surveillance. These items are combined into an organisational model indicator that counts, from 0 to 6, the practices a worker reports. The psychosocial risk indicator counts, from 0 to 6, six risks (time pressure or overload, violence or abuse, harassment or bullying, poor communication or cooperation, lack of autonomy and other sources of stress), and the health

indicator counts, from 0 to 7, work-related health complaints in the previous 12 months. Table 1 lists the sources and measures.

Table 1. Data sources and measures

Source	Content	Use in this paper
EU-OSHA OSH Pulse 2022 (Flash Eurobarometer)	About 27,250 workers aged 16 and over in 27 EU Member States, Iceland and Norway, telephone, spring 2022; worker reports on digital technologies, psychosocial risks, health complaints and preventive measures	Country × sector panel (Pesole, 2023, Table B); published OLS coefficients (Tables 3 and 4); descriptive statistics (Table 1); occupation risks (Table A)
Organisational model indicator	Count (0–6) of: digital technologies determine pace of work, increase surveillance, supervise or monitor work and behaviour, automatically allocate tasks or shifts, rating by third parties, monitoring of heart rate, blood pressure or posture	Measure of algorithmic and surveillance management
Psychosocial risk indicator	Count (0–6): time pressure or overload, violence or abuse, harassment or bullying, poor communication or cooperation, lack of autonomy, other source of stress	Job-quality outcome
Health outcomes indicator	Count (0–7) of work-related health complaints in the past 12 months, excluding "none"	Health outcome
Preventive measures	Awareness-raising, counselling or psychological support, information and training on coping with stress, consultation of workers about stressful aspects of work, other measures	Worker voice and mitigation
EU-OSHA ESENER 2024	More than 41,000 establishments in 30 countries; first findings published 2025	Employer-side context
EU-OSHA OSH Pulse 2025	25,688 interviews, fieldwork 31 March–14 April 2025	Updated worker-side context
Directive (EU) 2024/2831	Platform work directive; Chapter III on algorithmic management; in force 1 December 2024; transposition by 2 December 2026	Regulatory context

Notes: Sources are listed in full in the reference list. The OSH Pulse 2022 statistics are unweighted as published by Pesole (2023).

Four sets of published results are used. Table 1 of the source report gives unweighted descriptive statistics, among them the mean of the organisational model indicator (1.96, standard deviation 1.44), the psychosocial indicator (1.37, 1.37) and the health indicator (1.67, 1.57), and the prevalence of five preventive measures. Tables 3 and 4 give OLS coefficients with robust standard errors for the psychosocial and health indicators. Table A gives the prevalence of each psychosocial risk by occupation. Table B gives the mean of the organisational model indicator for each combination of 29 countries and 8 sectors, which supplies the panel at the centre of the analysis. Table 2 reports the descriptive statistics together with the recent EU results.

Table 2. Descriptive statistics, OSH Pulse 2022 and recent EU surveys

Item	Value	Source
Digital technologies determine the speed or pace of work	58%	OSH Pulse 2022
Digital technologies increase surveillance of the worker	43%	OSH Pulse 2022
Organisation uses digital technologies to supervise or monitor work and behaviour	29%	OSH Pulse 2022
… to allocate tasks, working time or shifts automatically	31%	OSH Pulse 2022
… to have performance rated by third parties	32%	OSH Pulse 2022
… to monitor heart rate, blood pressure or posture	9%	OSH Pulse 2022
Mean organisational model indicator (SD)	1.96 (1.44)	OSH Pulse 2022
Workers reporting at least one form of digital management	78%	Pesole (2023)

Item	Value	Source
Severe time pressure or overload / lack of autonomy	45% / 17%	OSH Pulse 2022
Stress, depression or anxiety / overall fatigue / headaches or eyestrain	28% / 38% / 36%	OSH Pulse 2022
Mean psychosocial risk indicator (SD) / health indicator (SD)	1.37 (1.37) / 1.67 (1.57)	OSH Pulse 2022
Consultation about stressful aspects of work / awareness-raising / information on coping with stress / counselling / other	44% / 62% / 44% / 42% / 30%	OSH Pulse 2022
Establishments using systems that automatically allocate tasks, working time or shifts / monitor performance or behaviour	more than 10% / 7%	ESENER 2024
Establishments using digital technologies that consult employees about them, 2019 → 2024	24% → 35%	ESENER 2024
Establishments with employee participation in designing psychosocial risk measures, 2019 → 2024	61% → 55%	ESENER 2024
Workers saying digital technologies determine the pace of work / increase workload / cause isolation / reduce decision latitude over methods	48% / 28% / 30% / 16%	OSH Pulse 2025

Notes: Percentages from the OSH Pulse 2022 are unweighted sample shares as reported by Pesole (2023); ESENER and OSH Pulse 2025 figures are as reported in EU-OSHA releases and infographics.

4.2. Recent EU evidence

The 2024 European Survey of Enterprises on New and Emerging Risks (ESENER) interviewed establishments in 30 countries, more than 41,000 in all (EU-OSHA, 2025a). Its first findings report that more than one in ten EU establishments use systems that automatically allocate tasks, working time or shifts and 7 percent use technologies to monitor performance or behaviour; that among establishments using digital technologies, 35 percent consult their employees about them, up from 24 percent in 2019; that 56 percent include them in risk assessment; and that employee participation in designing measures against psychosocial risks fell from 61 percent in 2019 to 55 percent in 2024 (EU-OSHA, 2025a; 2025b). The 2025 OSH Pulse wave, a Flash Eurobarometer with 25,688 interviews in the EU27 (fieldwork 31 March to 14 April 2025), reports that 48 percent of workers say digital technologies determine the speed or pace of their work, 28 percent that they increase workload, 30 percent that they cause isolation and 16 percent that they reduce the ability to decide how to work (EU-OSHA, 2025c). These figures are used as context.

4.3. Data limits

Five features limit what can be concluded. First, the panel cells in Table B are means of a 0 to 6 index without sample sizes or standard errors, so sampling error in each cell is unknown. Second, the published descriptive statistics are unweighted, which matters because larger firms are under-represented: 70 percent of the sample works in firms with fewer than 250 employees, and digital management is more common in larger firms (Pesole, 2023). Third, the regression coefficients come from linear models of count indices, with no interaction terms. Fourth, the variables are self-reports by workers, and the preventive measure on consultation concerns stressful aspects of work, not digital systems specifically. Fifth, the survey is cross-sectional.

5. Methodology

5.1. Variance decomposition of the panel

Let x_ij be the mean organisational model index for country i (i = 1, …, a with a = 29) and sector j (j = 1, …, b with b = 8). With one observation per cell, the two-way analysis of variance without replication partitions the total sum of squares into country, sector and residual parts:

$SS_C = b \sum_i (\bar{x}_{i.} - \bar{x}_{..})^2$, $SS_S = a \sum_j (\bar{x}_{.j} - \bar{x}_{..})^2$, $SS_E = SS_T - SS_C - SS_S$,

with a - 1, b - 1 and (a - 1)(b - 1) degrees of freedom, mean squares MS = SS/df and F = MS/MS_E. Under a random-effects reading, the variance components are estimated by $\hat{\sigma}^2_C = (MS_C - MS_E)/b$ and $\hat{\sigma}^2_S = (MS_S - MS_E)/a$, with residual variance MS_E, and their shares of the sum are reported (Searle et al., 1992). Because there is one observation per cell, interaction cannot be separated from error, and additivity is checked with Tukey's (1949) one-degree-of-freedom test. With $a_i = \bar{x}_i. - \bar{x}..$ and $b_j = \bar{x}_.j - \bar{x}..$,

$SS_N = [\Sigma_i \Sigma_j a_i b_j x_{ij}]^2 / (\Sigma_i a_i^2 \Sigma_j b_j^2)$, $F = SS_N / [(SS_E - SS_N)/(df_E - 1)]$.

Because the cell values have no sample sizes, the F tests describe variation among cell means. They do not take account of sampling error in the cells and are a description of structure.

5.2. Concordance of sector rankings

Within each country the sectors are ranked from 1 (lowest index) to 8. With m = 29 countries and n = 8 sectors, R_j is the sum of ranks of sector j, and Kendall's coefficient of concordance is

$W = 12\,S / [m^2 (n^3 - n)]$, $S = \Sigma_j (R_j - \bar{R})^2$,

with $\chi^2 = m(n - 1)W$ on n - 1 degrees of freedom (Kendall and Babington Smith, 1939). W equals 1 if all countries rank sectors identically and 0 if rankings are unrelated.

5.3. Voice regimes

Following Pesole (2023, Section 5), five countries are classed as requiring agreement or co-determination for new technologies (Germany, the Netherlands, Austria, Finland, Sweden), three as requiring consultation only (Belgium, France, Romania) and one as relying on collective agreement (Italy). The country mean is the average of the eight sector values. The difference between the mean of the co-determination group and the mean of the other 24 countries is tested by an exact permutation test that enumerates all C(29,5) = 118,755 ways of assigning five countries to the group (Good, 2005), by the Mann-Whitney test (Mann and Whitney, 1947), and by a percentile bootstrap with 20,000 resamples of each group (Efron and Tibshirani, 1993). A leave-one-country-out check shows whether one country drives the result. A second comparison pools all nine named countries against the other 20.

5.4. Accounting on published coefficients

Let b_A be the coefficient of the organisational model index and b_k that of preventive measure k, with standard errors s_A and s_k, from the specification that includes all measures (Pesole, 2023, Tables 3 and 4). The standardised coefficient is $\beta^* = b\,SD(x)/SD(y)$, using the unweighted standard deviations. The offset ratio for consultation, interpreted as the number of digital management practices whose association is cancelled by consultation, is $r = |b_C|/b_A$, with variance from the delta method (Oehlert, 1992),

$Var(r) \approx r^2 [(s_C/b_C)^2 + (s_A/b_A)^2 - 2\rho\, s_C\, s_A/(b_C\, b_A)]$,

where ρ is the correlation between the two estimates, unknown and varied from -0.3 to +0.3. The average burden of digital management is $B = b_A\, \bar{x}_A$, where $\bar{x}_A = 1.96$ is the mean index. If preventive measure k, now reaching a share p_k of workers, were available to all, the associated gain would be $G_k = |b_k|(1 - p_k)$ for measures with a favourable coefficient, and the offset share is $\Sigma G_k/B$. Intervals come from 200,000 normal draws of the coefficients, assumed independent (Rubinstein and Kroese, 2017). The calculation assumes additive, linear effects, applies cross-sectional coefficients as if they were causal, and is a scale comparison, not a forecast.

5.5. Occupations

Table A gives the prevalence of each psychosocial risk for nine occupational groups. Spearman rank correlations (n = 9) between time pressure, poor communication, violence and lack of autonomy show whether occupations that are high on one risk are high on another. With n = 9, only large coefficients are informative, and exact permutation p-values are reported. Calculations use Python with NumPy and SciPy.

6. Results I: Where Digital Management Has Spread

6.1. Country and sector variation

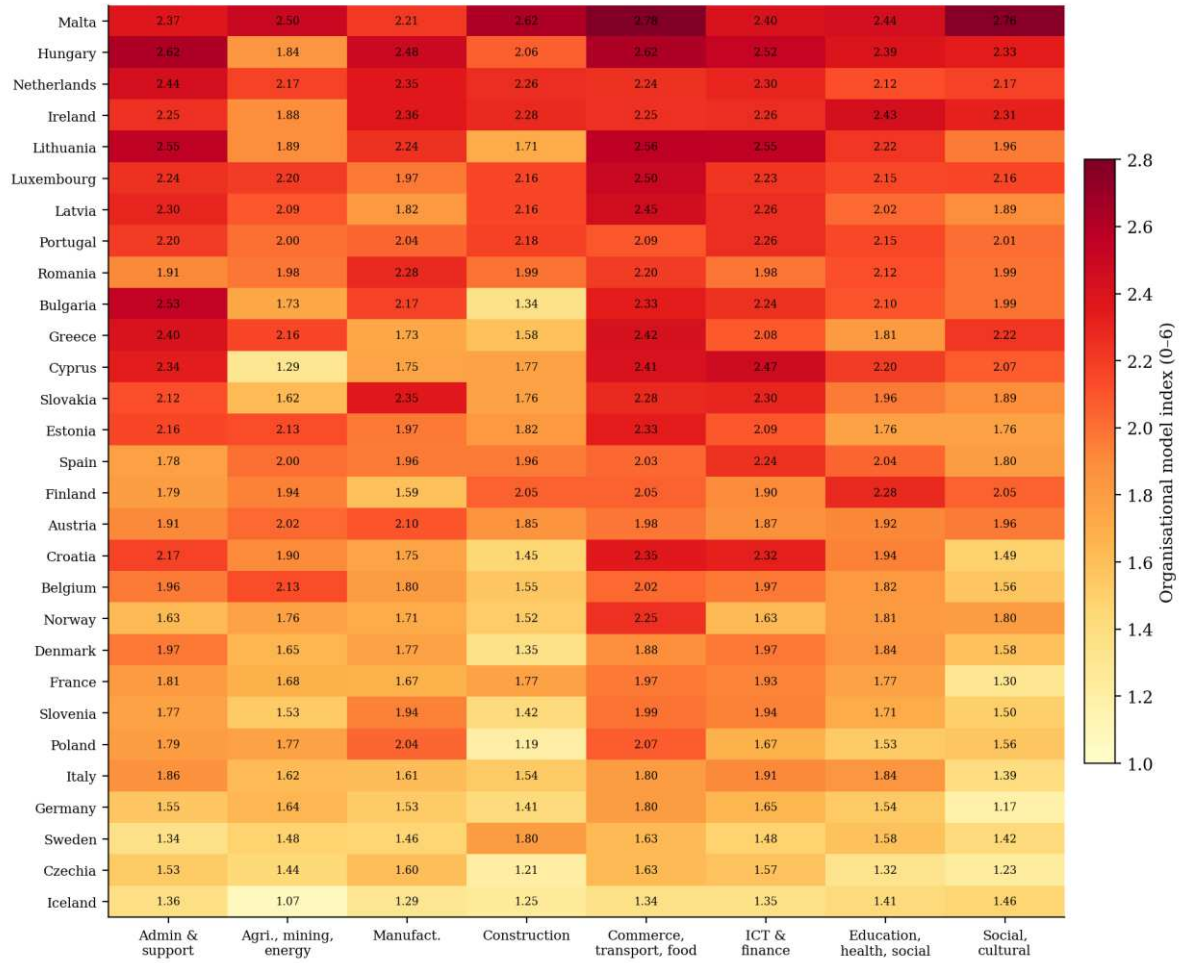
Table 3 and Figure 2 give the variance decomposition of the 232 country-sector cells. The grand mean of the index is 1.93. Country differences account for 62.7 percent of the total sum of squares, sector differences for 12.3 percent and the residual for 25.0 percent. Both effects are large relative to residual variation (country $F(28, 196) = 17.5$; sector $F(7, 196) = 13.8$; both $p < .001$). Random-effects variance components put the country share at 58.9 percent, the sector share at 12.6 percent and the residual at 28.5 percent. The country means range from 1.32 in Iceland to 2.51 in Malta (standard deviation 0.28), while the sector means range only from 1.76 to 2.15. Malta's lowest sector value (2.21) is higher than the highest sector value in Germany or Sweden (1.80 for each) and in Iceland (1.46). H1 is supported.

Table 3. Variance decomposition of the organisational model index across 29 countries and 8 sectors

Source	Sum of squares	df	Mean square	F	p	Share of total (%)
Country	17.735	28	0.6334	17.53	< .001	62.7
Sector	3.483	7	0.4976	13.77	< .001	12.3
Residual (country × sector)	7.083	196	0.0361			25.0
Total	28.302	231				100.0
Tukey one-degree-of-freedom test for non-additivity	0.0032	1		0.089	0.766	
Random-effects variance components (share)	country 0.0747 (58.9%); sector 0.0159 (12.6%); residual 0.0361 (28.5%)					
Kendall's W for sector ranks across countries	0.276; chi-square(7) = 55.9				< .001	

Notes: Two-way analysis of variance without replication on 232 cell means (Pesole, 2023, Table B). Cells are country-sector means of a 0–6 index and do not carry sample sizes, so tests describe variation among cells, not sampling error of individual workers. Source: author's calculations.

Figure 2. Organisational model index by country and sector, OSH Pulse 2022.



Source: Pesole (2023), Table B. Countries ordered by mean across sectors. Index counts digital management practices reported by workers (0–6).

The highest country means are in Malta (2.51), Hungary (2.36), the Netherlands (2.26), Ireland (2.25) and Lithuania (2.21), and the lowest in Iceland (1.32), Czechia (1.44), Sweden (1.52), Germany (1.54) and Italy (1.70). Pesole (2023) suggests that Hungary and Malta have a history in business process outsourcing, and that Lithuania and the Netherlands have strong ICT sectors. The test of non-additivity is not significant ($F(1, 195) = 0.09$, $p = 0.77$), which means that the country and sector effects combine additively and that a country's position is not strongly specific to the sector.

6.2. Stable sector ordering

Sector rankings are consistent across countries (Kendall's $W = 0.28$, $\chi^2(7) = 55.9$, $p < .001$). Table 4 shows that commerce, transport, accommodation and food services have the highest mean index (2.15; mean rank 6.76 of 8), followed by ICT and finance (2.05; 5.59) and administration and support services (2.02; 5.16). Construction (1.76; 2.90), social, cultural and personal services (1.82; 3.31) and agriculture, mining and energy (1.83; 3.64) are lowest. The 95 percent intervals across countries for adjacent sectors overlap, so the order within each end of the range should not be over-read. H2 is supported. The concordance is moderate, and a W of 0.28 signals that country-specific ordering is also substantial.

Table 4. Sector profile of the organisational model index (mean across 29 countries) and mean rank

Sector	Mean index	95% interval across countries	Mean rank (1 = lowest, 8 = highest)
Commerce, transport, accommodation and food	2.147	2.023–2.270	6.76
ICT and finance	2.046	1.925–2.168	5.59
Administration and support services	2.022	1.887–2.158	5.16
Education, health and social care	1.939	1.826–2.051	4.52
Manufacturing and engineering	1.915	1.798–2.032	4.14
Agriculture, mining, energy and water	1.831	1.715–1.948	3.64
Social, cultural and personal services	1.820	1.677–1.963	3.31
Construction	1.759	1.619–1.899	2.90

Notes: Intervals use the standard deviation of the 29 country values in each sector and a t distribution with 28 degrees of freedom. Source: author's calculations from Pesole (2023), Table B.

The sector pattern fits the nature of the technologies. Commerce and transport use route, shift and parcel management; ICT and finance have the data infrastructure and the work tasks that can be rated or counted; administrative services include call centres and clerical processing. Construction and personal services are more dependent on tasks that are location-specific, variable and interpersonal, which are harder to allocate and rate by software.

7. Results II: Voice Regimes and Adoption

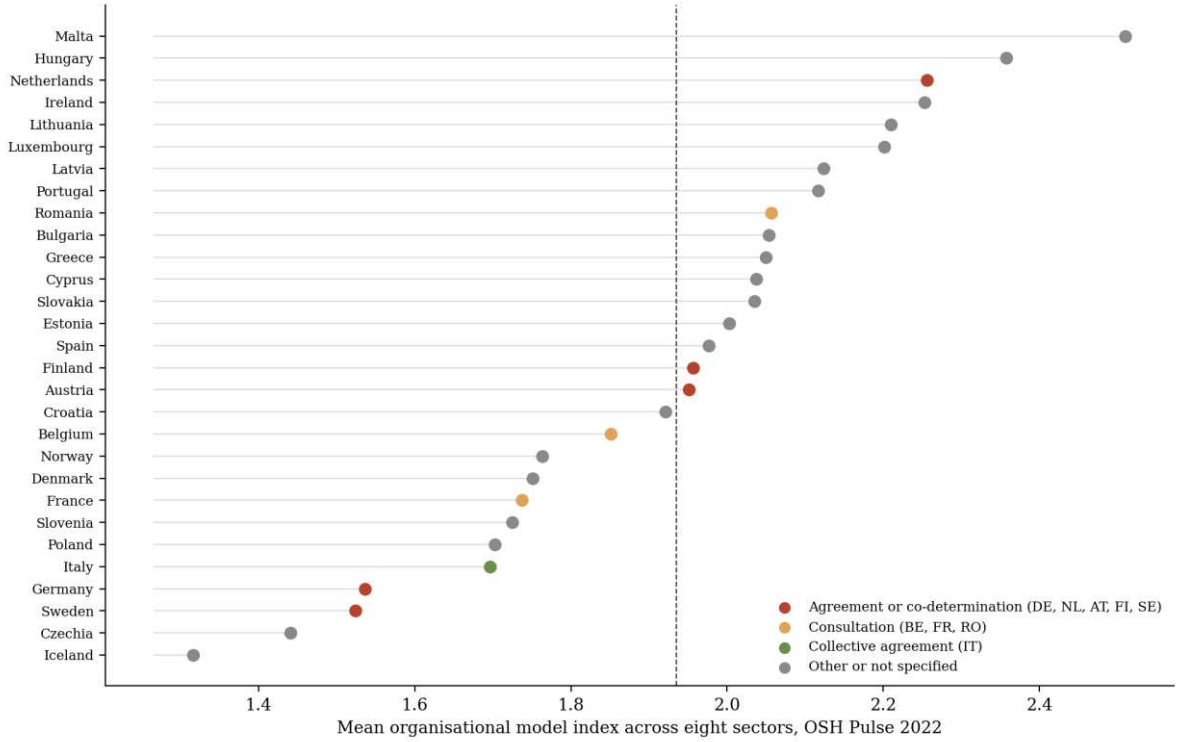
Table 5 and Figure 3 compare countries by voice regime. The five countries requiring agreement or co-determination have a mean index of 1.84, against 1.95 for the other 24 countries, a difference of -0.11. The exact permutation p-value is 0.44, the Mann-Whitney p-value 0.45, and the bootstrap 95 percent interval is -0.38 to 0.16. Leave-one-out differences range from -0.01 (dropping Sweden) to -0.22 (dropping the Netherlands). Pooling the nine named countries and comparing them with the other 20 gives a difference of -0.14 (p = 0.23). H3 is not supported: statutory voice rights are not associated with detectably lower adoption.

Table 5. Worker voice regimes and adoption of digital management

Group (countries)	n	Mean index (country mean of eight sectors)
Agreement or co-determination for new technologies (Germany, Netherlands, Austria, Finland, Sweden)	5	1.845 (DE 1.536; NL 2.256; AT 1.951; FI 1.956; SE 1.524)
Consultation only (Belgium, France, Romania)	3	1.882 (BE 1.851; FR 1.738; RO 2.056)
Collective agreement (Italy)	1	1.696
Other or not specified	20	1.977
All countries not in the co-determination group	24	1.954
Difference, co-determination minus others		−0.109; exact permutation p = 0.441 (118,755 assignments); Mann–Whitney p = 0.448; bootstrap 95% interval −0.377 to 0.160
Difference, all nine named countries minus the other 20		−0.137; permutation p = 0.232
Leave-one-country-out, co-determination group		−0.012 (drop Sweden) to −0.224 (drop Netherlands)

Notes: Regime classification follows the summary in Pesole (2023, Section 5), which lists countries requiring agreement or co-determination, consultation only, or collective agreement; the classification is a coarse summary and not an exhaustive legal coding. Source: author's calculations.

Figure 3. Mean organisational model index by country and worker voice regime.



Sources: Pesole (2023), Table B and Section 5; author's calculations. Dashed line: mean of 29 countries. Regime classification is a coarse summary.

The group is heterogeneous. Germany (1.54) and Sweden (1.52) are among the lowest in the sample, and the Netherlands (2.26) is the third highest. Italy, with collective agreement, is lower (1.70), and Belgium (1.85) and France (1.74) are close to the mean of the sample, while Romania (2.06) is above it. An unadjusted look at sector means suggests that any difference lies in the high-adoption sectors: the co-determination group is about 0.25 lower than other countries in commerce, transport and food (1.94 against 2.19), ICT and finance (1.84 against 2.09) and administration (1.81 against 2.07), and close to zero or positive in construction and agriculture. This pattern rests on five countries and is exploratory.

The absence of a clear regime effect does not mean that voice rights are unimportant. They may affect how systems are designed and used, and not whether they are adopted, and the regime classification, a summary from a policy report, is coarse. The result does show that adoption is largely driven by factors other than formal consultation rules, such as industrial structure and technology supply, which cautions against treating voice rights as a brake on adoption.

8. Results III: Job Quality, Health and Voice

8.1. The association of digital management with strain

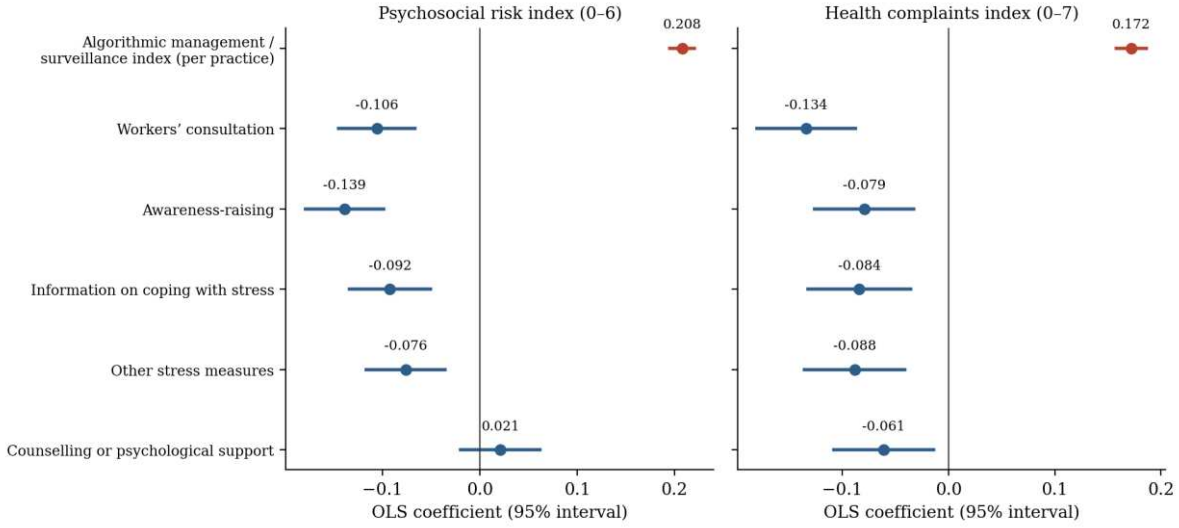
Table 6 and Figure 4 reproduce the published coefficients. Each additional digital management practice is associated with a 0.208 higher psychosocial risk index (95 percent interval 0.195 to 0.221) and a 0.172 higher health complaints index (0.158 to 0.186), controlling for occupation, workplace, employment status, age, firm size and preventive measures. In standardised units these are 0.22 and 0.16, and one standard deviation of the organisational index (1.44 practices) corresponds to 0.30 more psychosocial risks and 0.25 more health complaints. At the mean index of 1.96, the average burden is 0.41 points on the psychosocial index (29.8 percent of its mean) and 0.34 points on the health index (20.2 percent). H4 is supported by the published coefficients.

Table 6. Published associations of digital management and preventive measures with psychosocial risk and health complaints

Variable	Psychosocial risk: coefficient (SE)	95% interval	Standardised	Health complaints: coefficient (SE)	95% interval	Standardised
Organisational model index (per practice)	0.208 (0.0065)	0.195 to 0.221	0.219	0.172 (0.0072)	0.158 to 0.186	0.158
Workers' consultation	−0.106 (0.0201)	−0.145 to −0.067	−0.039	−0.134 (0.0236)	−0.180 to −0.088	−0.043
Awareness-raising	−0.139 (0.0206)	−0.179 to −0.099	−0.050	−0.079 (0.0238)	−0.126 to −0.033	−0.025
Information on coping with stress	−0.093 (0.0213)	−0.134 to −0.051	−0.034	−0.084 (0.0247)	−0.133 to −0.036	−0.027
Other stress measures	−0.076 (0.0206)	−0.117 to −0.036	−0.026	−0.088 (0.0241)	−0.136 to −0.041	−0.026
Counselling or psychological support	0.021 (0.0208)	−0.020 to 0.062	0.008	−0.061 (0.0240)	−0.108 to −0.014	−0.019

Notes: OLS with robust standard errors, specification with occupation, workplace, employment status, age, firm size and all preventive measures (N = 24,367; R-squared 0.069 and 0.034). Standardised = b × SD(x)/SD(y) using the unweighted standard deviations in the source. Source: Pesole (2023), Tables 1, 3 and 4; author's calculations.

Figure 4. Associations of digital management and preventive measures with psychosocial risk and health complaints.



Source: Pesole (2023), Tables 3 and 4 (column 3). Lines are 95% intervals from robust standard errors.

8.2. The association of consultation and other measures

Worker consultation about stressful aspects of work is associated with a 0.106 lower psychosocial index (-0.145 to -0.067) and a 0.134 lower health index (-0.180 to -0.088). Awareness-raising (-0.139 and -0.079) and information on coping with stress (-0.093 and -0.084) have similar magnitudes, and so do other stress measures. Counselling or psychological support is not associated with lower psychosocial risk (+0.021; interval -0.020 to 0.062) but is associated with fewer health complaints (-0.061). Standardised coefficients are small, between -0.02 and -0.05, which reflects the binary nature of the measures and the count scales of the outcomes.

The offset ratio, shown in Table 7, is 0.51 (95 percent interval 0.32 to 0.70) for psychosocial risk and 0.78 (0.50 to 1.06) for health. In words, a workplace that consults workers about stressful aspects of work reports about as much strain as a workplace with half a digital management practice fewer for psychosocial risk, and about as much health strain as one with four-fifths of a practice fewer. The intervals widen only slightly

if the two estimates are correlated (standard errors of 0.093 to 0.103 and 0.131 to 0.150 for correlations from -0.3 to +0.3). H5, for the lower bound of one third, is supported for both outcomes.

Table 7. Offset ratios and burden accounting

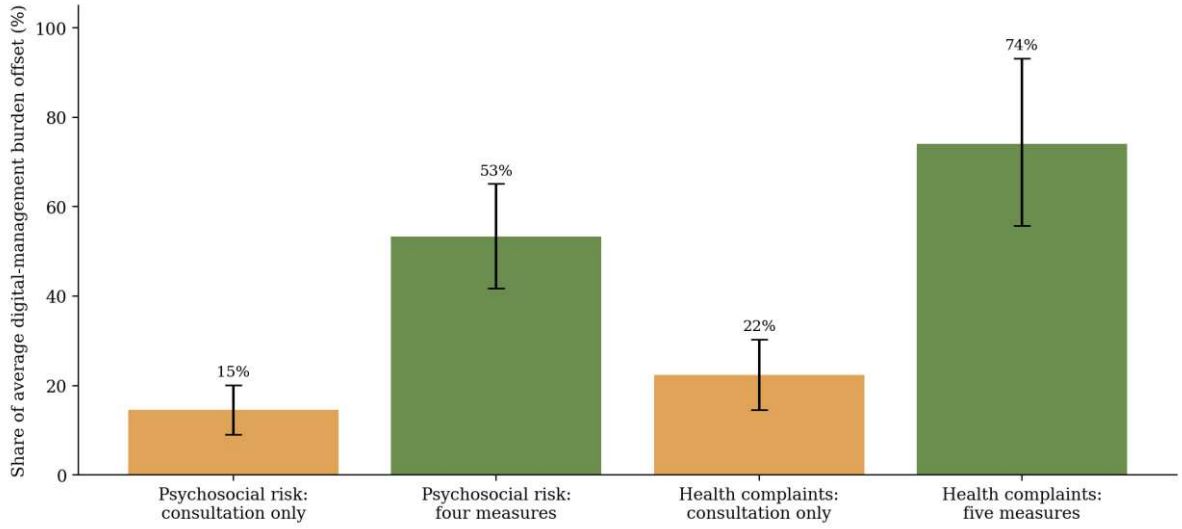
Quantity	Psychosocial risk	Health complaints
Effect of one standard deviation (1.44) of the organisational index	+0.30 points	+0.25 points
Average burden at mean index 1.96 (share of the outcome mean)	0.408 (29.8%)	0.337 (20.2%)
Offset ratio: |consultation| ÷ |one practice| (95% interval)	0.51 (0.32–0.70)	0.78 (0.50–1.06)
Standard error of the ratio with correlation −0.3 / 0 / +0.3 between coefficients	0.093 / 0.098 / 0.103	0.131 / 0.141 / 0.150
Gain if consultation reached all workers (44% now): b × (1 − 0.44)	0.059	0.075
… as share of average burden (95% Monte Carlo interval)	14.6% (9.1–20.1)	22.3% (14.5–30.3)
Gain if all effective measures reached all workers	0.217 (four measures)	0.249 (five measures)
… as share of average burden (95% Monte Carlo interval)	53.3% (41.8–65.1)	74.0% (55.8–93.2)

Notes: Burden = b(index) × 1.96. Gain = sum of −b × (1 − current prevalence) for each preventive measure. Intervals from 200,000 normal draws of the coefficients, assumed independent. The calculation is associational and assumes additive effects. Source: author's calculations from Table 6 and Pesole (2023), Table 1.

8.3. A voice gap

Consultation reaches 44 percent of workers. If it reached all workers, the associated gain would be 0.059 on the psychosocial index and 0.075 on the health index, which is 14.6 percent (95 percent Monte Carlo interval 9.1 to 20.1) and 22.3 percent (14.5 to 30.3) of the average digital management burden. If all workers also had awareness-raising, information on coping with stress and other measures, the gain would be 0.217 on psychosocial risk, or 53.3 percent of the burden (41.8 to 65.1), and, with counselling, 0.249 on health complaints, or 74.0 percent (55.8 to 93.2). These are associational and additive estimates (Figure 5), so they indicate scale and not what an intervention would deliver. Consultation alone leaves most of the burden in place, and even a full package of measures leaves about half of the psychosocial burden. A regulatory approach that relies on consultation therefore needs to be accompanied by limits on what systems can do.

Figure 5. Share of the average digital-management burden that preventive measures would offset if they reached all workers.



Source: author's calculations (Table 7). Bars are point estimates; whiskers are 95% Monte Carlo intervals. Associational, additive accounting.

8.4. Occupations

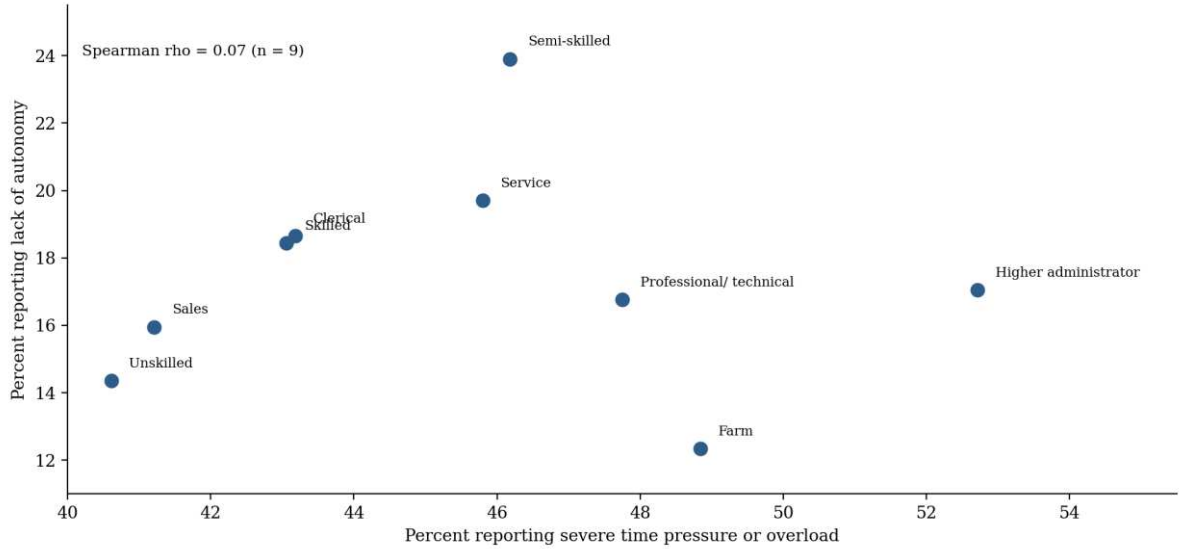
Table 8 and Figure 6 give risks by occupation. Lack of autonomy varies from 12.3 percent among farm workers to 23.9 percent among semi-skilled workers, a ratio of 1.9, and time pressure from 40.6 percent among unskilled workers to 52.7 percent among higher administrators. The two are not related across occupations (Spearman rho = 0.07, p = 0.86): the occupation with the highest time pressure, higher administrators, has middling autonomy loss (17.1 percent), and semi-skilled workers, with the highest loss of autonomy, have middling time pressure (46.2 percent). Violence and lack of autonomy are more strongly but not significantly related (rho = 0.57, p = 0.11). H6 is supported, with the caveat that nine occupations give little power. The report also finds that remote workers working from home have lower psychosocial risk than workers at employers' premises, which it attributes to the weight of professionals and administrators among them (Pesole, 2023).

Table 8. Psychosocial risks by occupation, OSH Pulse 2022 (percent of workers)

Occupation	Time pressure or overload	Violence or verbal abuse	Harassment or bullying	Poor communication	Lack of autonomy	Other stress
Professional and technical	47.75	15.17	7.08	25.28	16.76	30.32
Higher administrator	52.71	14.24	6.45	27.83	17.05	30.18
Clerical	43.18	11.38	5.99	26.75	18.65	22.98
Sales	41.21	19.57	6.37	24.30	15.95	27.98
Service	45.80	22.74	10.14	27.01	19.70	30.47
Skilled worker	43.06	14.42	7.71	27.45	18.44	27.75
Semi-skilled worker	46.18	16.02	6.94	28.17	23.90	30.71
Unskilled worker	40.61	10.71	7.61	30.72	14.36	25.03
Farm worker	48.84	10.15	6.98	21.19	12.34	28.13
All workers	**45.96**	**15.69**	**7.33**	**26.38**	**17.72**	**28.75**

Notes: Spearman rank correlations across the nine occupations: time pressure and lack of autonomy 0.07 (p = 0.86); violence and lack of autonomy 0.57 (p = 0.11); communication and lack of autonomy 0.38 (p = 0.31). Source: Pesole (2023), Table A; author's calculations.

Figure 6. Time pressure and lack of autonomy by occupation, OSH Pulse 2022.



Source: Pesole (2023), Table A; author's calculations. Nine occupational groups.

8.5. Updating with recent surveys

The later surveys point in the same direction. ESENER 2024 shows that systems allocating tasks, working time or shifts are used by more than one in ten EU establishments, and monitoring technologies by 7 percent, while consultation of employees about digital technologies has risen from 24 to 35 percent of technology-using establishments. Over the same five years, employee participation in designing psychosocial risk measures has fallen, from 61 to 55 percent (EU-OSHA, 2025a; 2025b). The OSH Pulse 2025 shows that 48 percent of workers say digital technologies determine their pace of work and 28 percent that they increase workload (EU-OSHA, 2025c). The increase in consultation about technology is thus not accompanied by greater participation in designing measures against the risks that technology creates, and a large share of workers still report effects on pace and workload.

9. Robustness, Limitations and Validity

Several checks bear on the results. The variance decomposition is not sensitive to the choice of random or fixed effects: the country share is 59 to 63 percent in either reading, and Tukey's test finds no sign that the additive structure is wrong. The comparison of voice regimes does not depend on the test used (permutation, rank and bootstrap give p-values of 0.44 to 0.45 and an interval that includes zero), and it is not driven by one country, although the leave-one-out range (-0.01 to -0.22) shows that the point estimate is fragile. The offset ratios are not sensitive to the unknown correlation between the coefficient estimates: the standard error of the psychosocial ratio varies only between 0.093 and 0.103.

The limitations are substantial. First, the analysis uses published aggregates. The panel cells lack sample sizes, so the F tests describe variation among cell means, not sampling error, and cells for small sectors in small countries may be noisy. Second, the regressions are cross-sectional associations. Workers who report more digital management may differ in ways not captured by the controls, and consultation may have been introduced where problems were already visible, which would bias its association towards zero or even upward. The accounting treats coefficients as if they were causal, and its results should be read as scale comparisons. Third, the models are additive and linear, so the analysis cannot test whether consultation weakens the effect of digital management, which is the question of most theoretical interest. Fourth, the preventive measure concerns consultation about stressful aspects of work and not about algorithms or data use. Fifth, all variables are self-reported and the index counts practices without weighting their intrusiveness. Sixth, the regime classification is a summary of national rules in a policy report, based on

nine countries, and does not capture enforcement or the strength of works councils and unions. Seventh, the survey year 2022 followed the pandemic, when remote work and monitoring were changing quickly, and the 2024 and 2025 data are available only as published summaries. Finally, the published descriptive statistics are unweighted, and large firms are under-represented, so prevalence figures should be read with that in mind.

10. Discussion and Conclusion

10.1. Discussion

The first finding is a question of geography. Most of the variation in adoption lies between countries, not between sectors, and the gaps are large: the least intensive sector in Malta uses more digital management than the most intensive sector in Germany, Sweden or Iceland. Some of the difference is probably due to the structure of national economies, such as the role of outsourcing and ICT, and some to technology supply and management culture, which the data do not allow us to separate. The sector pattern is more orderly. Commerce and transport, ICT and finance, and administrative services have the highest adoption in nearly every country, in line with the kind of tasks that software can allocate, count and rate.

The second finding concerns institutions. Statutory rights to agreement, co-determination or consultation do not predict lower adoption, and the group of countries that have them is as varied as the sample as a whole. This is not evidence against voice rights, since they may shape how systems are designed and used and not whether they are adopted. It does suggest that debates about whether voice rights hamper digital adoption have little empirical support in these data, and that the more relevant question is what voice does once systems are in place.

On that question, the third finding is that consultation is associated with sizeable reductions in strain, but not large enough to cancel the association of digital management with it. A workplace that consults workers about stressful aspects of work reports about half a practice fewer on the psychosocial index and four-fifths of a practice fewer on the health index. If consultation were universal, it would offset 15 to 22 percent of the average burden, and a package that included awareness-raising and information would offset a half to three-quarters. Counselling shows a different pattern, with no association for psychosocial risk, consistent with the report's suggestion that stigma about disclosing mental health conditions limits its use (Pesole, 2023). The measures with the clearest associations are those that change information and participation, which is consistent with arguments that transparency and worker involvement are central to the safe use of algorithmic systems (Kellogg et al., 2020; Bernhardt et al., 2023).

The recent surveys add a note of caution. Consultation about digital technologies has become more common, yet participation in designing measures against psychosocial risks has declined, and about half of workers say that digital technologies set the pace of their work. A system in which employers consult about technology but do not involve workers in addressing its effects is unlikely to realise the offsets seen here.

10.2. Implications

For regulators, the first implication concerns scope. Directive (EU) 2024/2831 introduces transparency, human oversight, consultation and health and safety obligations for algorithmic management, but only for platform work. In the survey, 78 percent of workers reported some form of digital management or surveillance, and the associations with strain were estimated in the general workforce, so the case for extending comparable safeguards beyond platforms rests on a population that is far larger. The second implication is that consultation should be required to cover the systems themselves, the data they use and their expected effect on pace and autonomy, and that it should be accompanied by information and risk assessment, as the stronger associations of awareness-raising and information suggest. The third is that

formal voice rights should not be expected to substitute for limits on what systems may do, since consultation alone leaves most of the burden in place.

For employers, the findings suggest involving workers before deployment, explaining what data are collected and how they are used, including digital systems in risk assessment (56 percent of technology-using establishments do so) and monitoring workload and pace after deployment. For researchers and statistical agencies, the implication is that surveys should ask workers about consultation on specific digital systems, report cell sample sizes and standard errors, and allow interaction tests, so that buffering by voice can be examined directly.

10.3. Conclusion

The paper asked how widely digital management has spread, whether voice institutions are associated with less of it, and how much consultation offsets its costs. Using published results of the EU-OSHA OSH Pulse survey, it finds that adoption varies more by country (63 percent of variation) than by sector (12 percent), that sector rankings are stable, and that countries with statutory agreement or co-determination rights do not have detectably lower adoption (difference -0.11 index points, $p = 0.44$). Each practice is associated with 0.21 more psychosocial risks and 0.17 more health complaints, and worker consultation is associated with reductions equal to 0.51 and 0.78 of one practice. Universal consultation would offset 15 and 22 percent of the average burden, and a package of effective measures 53 and 74 percent.

The limits are those of published aggregates and cross-sectional self-reports. Future work should use microdata with interaction tests of consultation, link surveys of workers and employers, follow workers through the introduction of specific systems, and evaluate the implementation of the platform work directive when national laws take effect. Until then, the safest conclusion is that voice is associated with better job quality under digital management but does not by itself restore what the systems take away.

Declarations

Data availability: All data are from public sources listed in the reference list, principally EU-OSHA publications reporting the OSH Pulse and ESENER surveys. Derived calculations are reproducible from Tables 2 to 8. No new primary data were collected.

Conflicts of interest: The author declares no conflicts of interest.

Funding: This study received no funding.

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