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Digital tools for worker management and psycho-social risks in the workplace: Evidence from the ESENER survey

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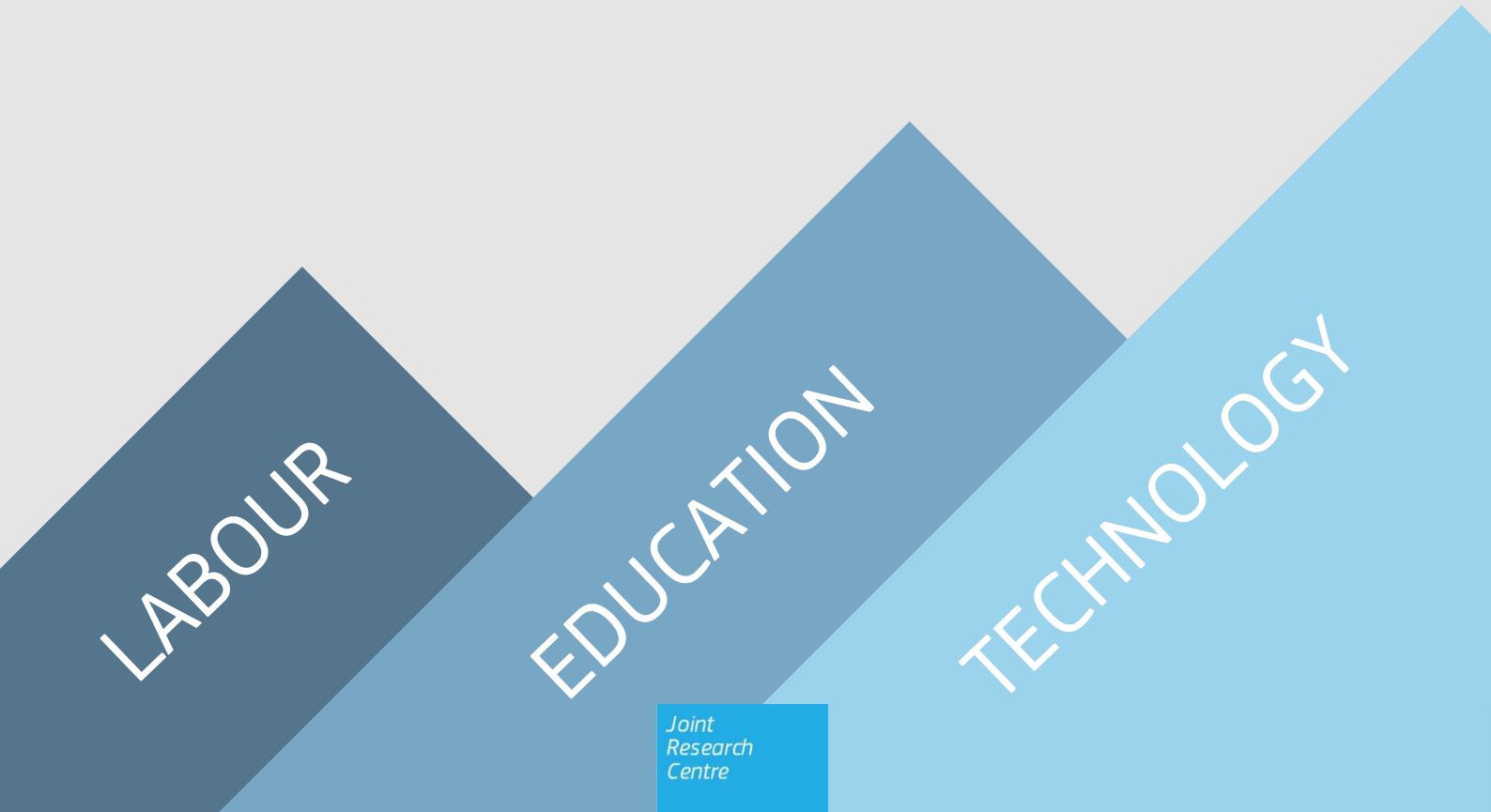

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Digital tools for worker management and psychosocial risks in the workplace: evidence from the ESENER survey

Cesira Urzí Brancati (JRC-Seville), Maurizio Curtarelli (EU-OSHA)

Abstract

This article explores the association between digital technologies that enable new forms of management and the presence of psychosocial risks in the workplace, drawing on a representative survey of European establishments (ESENER 2019). It also ascertains whether occupational safety and health (OSH) preventive measures and policies may play a mitigating role in managing risks and reducing the potentially negative impact of technology. In line with the literature and with prior expectations, our analysis reveals that digital technologies enabling the new forms of management are associated to increased psychosocial risks, which in turn can result in work-related stress and other mental health issues. It also confirmed that OSH measures, such as having an action plan to prevent work related stress, help reducing psychosocial risks in the workplace, but do not mitigate the relationship between psychosocial risks and management technologies.

Keywords: algorithmic management; digitalisation; workplace monitoring; psychosocial risks; work related stress.

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Contents

1 Introduction

The fast progress of digital technologies is changing the work environment and the nature of work processes. Wearable and tracking devices, digital labour platforms, advanced robotics, and artificial intelligence (AI) , affect not only what workers do and how they do it, but also the way in which work is managed and organised. Employers are increasingly using digital systems and technologies to optimise resource allocation, improve work processes and procedures, support decision-making and ultimately increase labour productivity.

These forms of worker management enabled by digital technologies are sometimes also referred to by the umbrella term of 'algorithmic management'. Lee et al (2015) define algorithmic management as 'software algorithms that assume managerial functions'; Möhlmann and Zalmason (2017) define it as a set of practices of supervision, governance and control driven by algorithms, Maatescu and Nguyen (2019) add that these practices are implemented through technological tools and techniques that structure working conditions and the remote management of workers. Wood (2021) reports that while algorithmic management is central in digital labour platforms, it has also been identified in more conventional settings, such as warehouses, factories, retail and even marketing firms.

It is generally recognised that technological advances have been accompanied by an increased prevalence of psychosocial risks in most economic sectors (EU-OSHA, 2010; Leka et al., 2011). Psychosocial risks are among the most challenging issues in occupational safety and health Workers experience stress when the demands of their job exceed their capacity to cope with them. In addition to mental health problems (e.g. depression), prolonged stress can lead to physical health problems, such as heart disease and musculoskeletal disorders.[1] From an employer's perspective, they are an issue as they lead to absenteeism, lower productivity and financial losses (Leka and Cox, 2008).

The object of this article is to explore the association between digital technologies that enable new forms of management and the presence of psychosocial risks in European workplaces. It also ascertains whether OSH preventive measures and policies may play a mitigating role in managing the risks and reducing the potentially negative effects.

The original contribution of this paper is the empirical analysis carried out, which draws on a unique set of data, the EU-OSHA *European Survey of Enterprises on New and Emerging Risks* (ESENER) 2019. Such data allow us to identify a set of management tools based digital technologies and systems as well as the presence of psychosocial risks and mitigating measures at the establishment level in a representative sample of European establishments.

The ESENER dataset contains information on the presence of digital technologies and tools that can be used to enable the algorithmic management of workers. In particular, it reports the presence of machines, systems or computer monitoring workers' performance in an establishment; machines, systems or computer determining the content or pace of work; wearable devices, such as smart watches, data glasses or other (embedded) sensors. The ESENER data also collects information on the presence of any of the following psychosocial risks in an establishment: time pressure; long or irregular working hours; having to deal with difficult customers, patients, pupils, etc.; fear of job loss; and poor communication or cooperation within the organisation. Finally, ESENER contains also information regarding the following OSH measures aimed at preventing psychosocial risks in the workplace: the presence of an action plan to prevent work-related stress; reorganisation of work in order to reduce job demands and work pressure; confidential counselling for employees; training on conflict resolution; intervention if excessively long or irregular hours are worked; allowing employees to take more decisions on how to do their job.

[1] EU-OSHA, psychosocial risks and stress at work.

The findings from the empirical analysis confirm that management technologies are indeed associated with an increase in psychosocial risks, which can result in work-related stress, and that is especially true for technologies used to monitor workers' performance.

The association between OSH preventive measures and the presence of psychosocial risks in the workplace is more ambiguous. While some measures, such as having an action plan in place to reduce stress and allowing employees to take more decisions on how to do their job are associated with a decrease in psychosocial risks, others appear to be associated with a reported higher presence of psychosocial risks in the workplace.

In addition, when assessing the possibility of a mitigating role of OSH measures with respect to the psychosocial risks associated with management technologies, we found evidence mixed. More specifically, while having an action plan to reduce work-related stress appears to be successful at actually mitigating risks (even after accounting for endogeneity bias), it does not reduce the increase in psychosocial risks associated with the presence of digital management technologies. One of the possible explanations is that the action plans adopted by the establishments do not account specifically for psychosocial risks associated with new forms of management technologies. Indeed, the EU-OSHA publication on 'How to Tackle Psychosocial Issues and Work-related Stress' states that the intervention strategy should always be tailored to the problem in hand.[2]

In this sense, more evidence is clearly needed to understand how to design appropriate preventive measures to deal with the increased psychosocial risks related to digitalisation.

The remainder of the paper is organised as follows: section 2 provides a brief overview of the literature on new forms of worker management enabled by digital technologies, AI and Algorithm; section 3 describes the conceptual approach of this paper; section 4 presents the data and methodology for the empirical analysis; section 5 describes the results and section 6 concludes.

2 New forms of management enabled by AI and algorithms: an overview

In general terms, an algorithm is 'a set of rules that must be followed when solving a particular problem'.[3] In this article, however, we focus on a more specific meaning and refer to software algorithms, that is, 'computer-programmed procedures for transforming input data into a desired output' (Kellogg et al., 2020).

Algorithmic management is marked by a departure from forms of management relying on human supervisors to direct workers, and is based on the use of digital tools to collect real-time data on workers' performance and behaviour, which are then used to support (automated or semi-automated) decision-making on work organisation (Berastegui,2021; Kellog et al., 2020). Indeed, Wood (2021) also highlights that even in the most extreme settings (digital labour platforms) management functions are never fully automated or handled entirely by algorithms, they are rather a combination of human and algorithmic *actants*.

As pointed out by Kellogg et al (2020), and based on extensive evidence, algorithms – and the data they process – are more comprehensive than any kind of system previously used to support workers' management as they can rely on large amounts of data collected through a wide range of digital devices,[4] including wearables devices.[5] Based on such data, software algorithms can instantane-

[2] https://osha.europa.eu/en/publications/te4502967enc-how-tackle-psychosocial-issues-and-reduce-work-related-stress

[3] Oxford dictionary definition.

[4] For example sensors, cameras and audio devices can record body movements and speech; text data, video-based recognition techniques and natural language processing algorithms to monitor emails or chats in real time to assess worker's mood or productivity.

ously compute, save and provide real-time information to managers (and workers), including completion rates, client comments and number of page views (Kellog et al, 2020).

Forms of management based on algorithms include systems of varying degrees of complexity, which typically rely on a number of shared features (Maatescu and Nguyen, 2019). Such features include prolific data collection and monitoring of workers through digital technology; real-time responsiveness to data that informs management decision-making; automated or semi-automated decision-making; transfer of performance evaluations to rating systems or other types of metrics; the use of nudges[6] and penalties to influence worker behaviours (Maatescu and Nguyen, 2019).

Digital surveillance/monitoring is an important component of (algorithmic) management and refers to the use of digital systems and devices to instantaneously and continuously collect, store, assess and report the behaviour of employees (Ball, 2010; West and Bowman, 2014); it includes surveillance, tracking, observation, and recording functions (Stanton, 2000). It refers to the gathering of information about the work effectiveness of others (Larson and Callahan, 1990). In very general terms, effective monitoring aims to "prohibit undesirable behaviours and promotes desirable ones" (Sewell and Baker, 2010). Workplace monitoring is generally considered a legitimate function of management; employers (or managers on their behalf) may want to keep track of employee performance to monitor effort, collect reliable metrics on what work is done, how long it took, what remains to be done and what people and resources are available to carry out managerial functions (Ball, 2010; Fairweather, 1999; OTA, 1987). Similarly, firms may want to monitor their employees to protect their business, reputation, resources and equipment. On the other hand, monitoring activities must be legitimate and carried out in respect of the "human dignity, legitimate interests and fundamental rights" of the employees (EU General Data Protection Regulation (GDPR), art. 88.2)[7]. Indeed, pervasive monitoring is reported to reduce workers' autonomy and control over how a job is done, and increase workload and time pressure by eliminating any potential downtime (thus increasing time pressure and working hours). It may also lead to a perceived invasion of privacy and to a breakdown in trust, and therefore a worsening of communication and cooperation within the workplace and a decrease in job satisfaction (Jensen and Raver, 2012; Stanton, 2000).

Digital surveillance is also reported to increase concerns of job insecurity, pushing workers to work long hours out of fear of not achieving the targets set by the employer; in addition, if workers feel that decisions are made based on data that they have neither access to nor power over and such data may be used for appraisal and performance evaluation and can impact negatively on career development, or may be used for workplace restructuring, job description changes or even firing (EU-OSHA, 2019). All in all, the burden of being under constant surveillance and monitoring can be detrimental for the worker's mental health.

Invasive employee control and monitoring may also lower employee morale and result in higher employee turnover (Ajunwa, Crawford and Shultz, 2017). On the other hand, performance monitoring may have positive impact if workers can use feedback to advance their careers, get better pay, and have their health and safety protected (EUOSHA, 2018). For instance, in their 2012 study, Sewell, Barker and Nyberg (2012) stress employees' ambiguity towards performance monitoring, in that some claimed that motivated, high performers who were identified as such would see it as fair and objective, whereas low performers would see it as intrusive or oppressive.

[5] Wearable technologies provide employers with real time information on the conditions and context of work; this allows for faster detection, prediction and analysis across many industrial workplace settings (Richardson and Mackinnon, 2017); wearable devices can also be used to give workers instructions via text and images, as reported by Gent (2018) in his study of UK supermarket warehouse workers.

[6] Positive reinforcementreinforcement, as put by Thaler and SunsteinSunstein (2008), "A nudge [...] is any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and cheap to avoid. Nudges are not mandates. Putting fruit at eye level counts as a nudge. Banning junk food does not." (Thaler and Sustain, 2008).

[7] General Data Protection Regulation (GDPR), EU 2016/679.

The use of systems, machines or computers to determine content or pace of work, common within algorithmic management practices, is often linked to an intensification of work, and therefore with workers' stress and mental health issues. Henderson, Swann and Stanford (2018) explain how employers use monitoring and supervising systems in combination with tools to directly control the pace and intensity of work to extract maximum work effort from employees. Research dating back to the 1990s demonstrated a clear link between performance monitoring – carried out with or without the use of digital devices –– and employee stress (Smith et al, 1992; Aiello, 1993; Aiello and Svec,, 1993).

The speed of computing processes and automated direction can result in a hectic pace of work to meet deadlines and achieve targets, hence leading to *quantitative overload*, i.e., performing a high amount of work in a given timeframe (Berastegui, 2021). To make matters worse, workers who are managed with the support of digital tools and systems determining content and pace of work are more likely to be exposed to *information overload*, and are therefore more likely to experience feelings of guilt and anxiety about their inability to meet the demands placed upon them. This can result in "relentless self-exploitation, often justified by both workers and employers as 'flexible working'" (Berastegui, 2021: 36). But if overload is an issue, underload is nonetheless also of concern as it is associated with frustration, stress and anxiety. The breakdown of jobs into very simple or standardised tasks, and the overall simplification of work favouring the development of repetitive tasks, are related to *qualitative underload* (that is, performing tasks and assignments that are well below worker abilities), and therefore are associated with higher levels of psychological distress and job dissatisfaction (Berastegui, 2021). In addition, working under time pressure to meet tight deadlines has been linked to high levels of strain, stress, depression and anxiety (Cooper and Roden, 1985; Kushnir and Melamed, 1991; Narayanan et al. 1999) that may ultimately result in a lower level of worker's performance (Westman and Eden, 1992).

Algorithmic management practices may also be linked to increased isolation and lack of social support among workers. Social support refers to the degree to which individuals perceive that they are valued and supported in the workplace by supervisors, co-workers and the organisation itself (Eisenberger et al., 2002; Sias and Gallagher, 2009; Kossek et al., 2011). All in all, a supportive work environment is characterised by positive social interactions helping workers to cope with uncertainty or stressful circumstances. When human supervisors are replaced by automated or semi-automated digital systems, workers are deprived of this source of organisational support and are exposed to increased stress, anxiety and even burnout (Berastegui, 2021).

Algorithmic control is implemented also through rules. As in traditional bureaucracies, the new forms of management enabled by digital technologies and systems involve precise rules that workers must comply with. These rules are implemented through the digital tools and interfaces, which is seen as a major source of disempowerment for workers as these tools demarcate all the possible aspects of the work process. Workers cannot act in a way not foreseen and included in the digital tool, and therefore do not have the possibility to choose how to carry out and complete a task This can obviously negatively impact on workers wellbeing, as the decrease in autonomy may increase stress and anxiety.

In conclusion, worker management practices enabled by a number of digital technologies and tools –– clustered under the umbrella term of 'algorithmic management' – are frequently reported in association to psychosocial risks and to increased mental health issues for workers. However, it should be mentioned that a large part of the literature consists of studies that are qualitative in nature, whereas this paper aims to provide a systematic and cross-industry, quantitative evidence of the phenomenon across industries. In addition, as mentioned in the introduction, this is the first study that assessed the joint relationship between management technologies, OSH preventive measures and psychosocial risks in the workplace at the European level, as the analyses are carried out using the EU-OSHA *European Survey of Enterprises on New and Emerging Risks* (ESENER) 2019 dataset, representative of establishments operating in all economic sectors in the European Union.

3 Conceptual Approach

The aim of this paper is to investigate: 1) whether the use of selected management tools enabled by digital technologies and systems is associated to the presence of specific psychosocial risks in the workplace – which could result in an issue for workers' health; 2) the potential mitigating role of preventive health and safety measures in the workplace – which can allow for a safer and healthier working context. In line with the existing literature, our hypothesis is that the use of selected technologies may be associated with increased psychosocial risks by boosting job demands and decreasing workers' autonomy; however, we posit that OSH preventive measures in the workplace can be of help to manage and mitigate such increased risks.

According to EU-OSHA, psychosocial risks are "those aspects of work design and the organisation and management of work, and their social and environmental context, which may have the potential to cause psychological or physical harm".[8] According to the Directive 89/391/EEC on Safety and Health of Workers at Work,[9] employers are required to develop prevention measures which cover "technology, organization of work, working conditions, social relationships and the influence of factors related to the working environment". Similarly, employers are expected to discuss with the employees or their representative the possible impacts of new technologies introduced. By directly involving workers in organisational decision-making, many of the OSH measures adopted to prevent the rise of psychosocial risks act by shifting the locus of control, which according to established literature moderates the relationship between performance monitoring and stress (Kolb and Aiello, 1996).

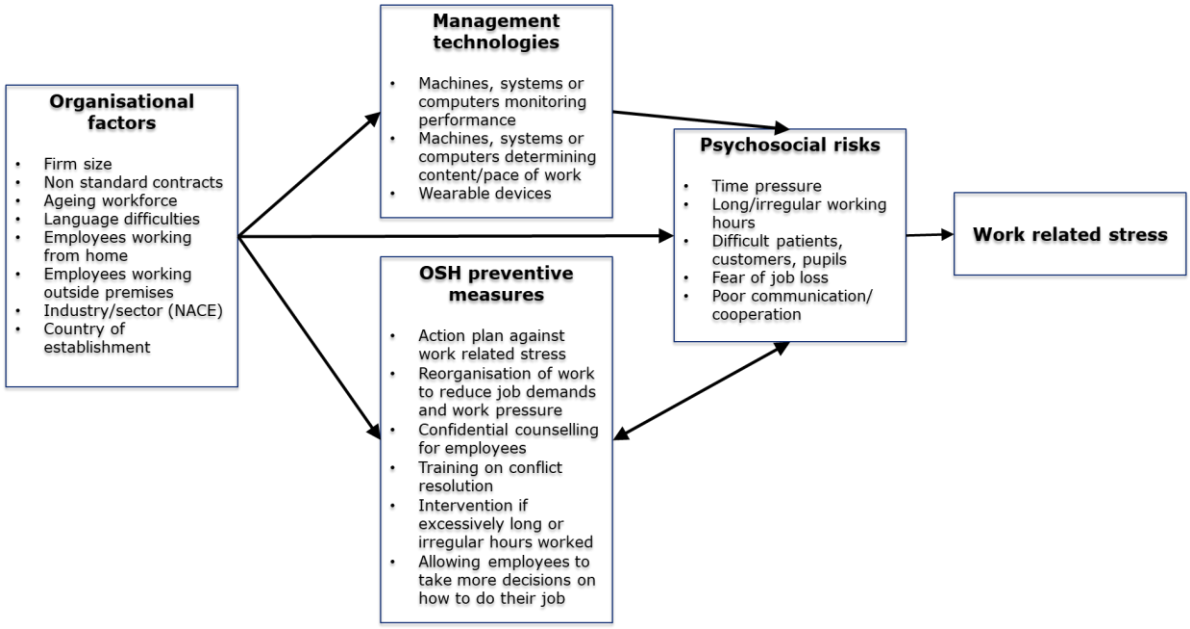
The empirical analysis also takes into account a range of organisational factors (for instance company size, ageing workforce, the use of external contractors and so on) which may have a direct association with the presence of psychosocial risks in the workplace, but also an indirect one, through monitoring technologies and OSH policies. In other words, an attribute such as company size may be directly linked to the presence of psychosocial risks, such as time pressure, because of how the work is organised in large companies. However, it may also have an indirect effect, e.g., through digital technologies or OSH preventive measures because they are more likely to be adopted in large companies as suggested for instance by Nordlöf et al. (2017). Organisational factors, including the social and cultural context at work and in the country in which a firm operates, are likely to influence the impact of the adoption of monitoring technologies on the awareness of psychosocial risks. For instance, Nebeker and Tatum (1993) found that monitoring practices were more likely to induce stress on employees when used to enforce difficult work standards (such as minimum results, benchmarks, etc.); Stanton (2000) highlights how organisational trust affects the perceived fairness of monitoring activities; in other words, if digital monitoring technologies are introduced following a consultation with the staff being the subject of the monitoring, employees would feel less stressed and would be less inclined to interpret the introduction of the technologies as threatening. Job design and other organisational factors, such as cohesive work groups, fair contractual treatments, teleworking and increased use of information and communication technology (ICT) in the workplace; downsizing, outsourcing, subcontracting and globalisation, an ageing workforce, may affect how monitoring is perceived and how it is associated with psychosocial risks.

Figure 1 summarises the main variables considered in our approach, the links and interactions among them, and ultimately their expected impact on workers' health. It should be noted that while most relationships are supposed to go more or less in one direction, OSH measures can both affect and be affected by the presence of psychosocial risks – hence the double arrow. A more detailed explanation is provided in the next section (data and methods).

[8] https://osha.europa.eu/en/themes/psychosocial-risks-and-stress.

[9] Section II, 5, g.

Figure 1: Conceptual Approach – Main variables at the workplace level



4 Data and Methods

The empirical analysis draws on data from the European Survey of Enterprises on New and Emerging Risks (ESENER) 2019. It is a survey of establishments carried out every five years since 2009 by EU-OSHA. In the third ESENER survey, 45,420 establishments with at least 5 employees from 33 participating European countries were surveyed. The survey is answered by the person "who knows best about health and safety in the establishment" and is characterised by a holistic view on health and safety risks and management in the workplace. It addresses topics concerning the physical and psychosocial risks present in the workplace and how these risks are managed, the drivers and barriers for OSH management in the organisation and workers' participation in OSH management. The questionnaire underpinning the third ESENER wave included also some questions with regard to the use of digital technologies and systems to monitor workers, and its potential impact on psychosocial risks. ESENER-3 allows to analyse the relation between reported psychosocial risk factors and use of digital technologies at establishment level, and link this to the measures taken to tackle the issue. The dataset contains also variables capturing information on organisational aspects that are also covered in the analysis.

The final sample includes all 33 countries in the ESENER survey (EU27 plus UK, Norway, Switzerland, Iceland, North Macedonia, and Serbia) to have a more complete picture, for a total of 45,174 observations, and it is representative of European establishments with five or more employees. Table 1 reports summary statistics for all variables described in the conceptual approach.

Table 1: Summary Statistics – data weighted using establishment proportional weights

	Mean	SE	Min	Max	Obs
Psychosocial Risks					
Time pressure	0.45	0.50	0	1	45,174
Poor communication or cooperation within the organisation	0.18	0.39	0	1	45,092
Fear of job loss	0.11	0.32	0	1	44,760
Having to deal with difficult customers, patients, pupils etc.	0.61	0.49	0	1	45,170
Long or irregular working hours	0.23	0.42	0	1	45,302
Psychosocial risks: cumulative index (0-5)	1.58	1.28	0	5	45,420
Management technologies					
Machines, systems or computer monitoring workers performance	0.09	0.29	0	1	45,198
Machines, systems or computer determining the content or pace of work	0.13	0.33	0	1	45,142
Use of wearables, such as smart glasses, sensors…	0.05	0.22	0	1	45,273
All management technologies (0-3)	0.27	0.58	0	3	45,420
OSH preventive measures and policies					
Action plan to prevent work related stress	0.40	0.49	0	1	20,143
Reorganisation of work to reduce job demands and work pressure	0.45	0.50	0	1	44,275
Confidential counselling for employees	0.42	0.49	0	1	44,328
Training on conflict resolution	0.36	0.48	0	1	44,534
Intervention if excessively long or irregular hours	0.32	0.47	0	1	43,721
Allowing employees to take more decisions on how to do their job	0.70	0.46	0	1	44,312
Organisational factors					
Atypical work contracts (subcontractors, temp agency workers, volunteers)	0.33	0.47	0	1	45,322
Employees with difficulties understanding language spoken	0.08	0.26	0	1	45,222
Employees working from home	0.13	0.34	0	1	45,267
Employees working outside the premises	0.43	0.50	0	1	45,159
Proportion of workers aged 55 and over					
None	0.23		0	1	44,274
<25%	0.53	0.50	0	1	44,274
>25%<50%	0.31	0.46	0	1	44,274
>50%	0.06	0.25	0	1	44,274
Establishment size					
5-9	0.47		0	1	45,420
10-49	0.32	0.47	0	1	45,420
50-249	0.29	0.45	0	1	45,420
250+	0.28	0.45	0	1	45,420

Source: Authors' elaborations using ESENER 2019 data; data weighted using establishment proportional weights.

Psychosocial risks

The ESENER dataset contains five variables related to the reported presence of specific psychosocial risks in the workplace. They are: time pressure; long or irregular working hours; having to deal with difficult, customers, patients, pupils, etc.; fear of job loss; and poor communication or cooperation within the organisation.

The presence of a psychosocial risk is reported at the establishment level by the person interviewed,[10] and therefore it does not reveal how many workers are exposed to it and it can be influenced by the level of awareness the respondent has of the existing risks. Indeed, it should be mentioned that since risk reporting may vary according to who answers the survey, different respondents can be sources of bias - therefore it is crucial to account for it in the empirical analysis.

Psychosocial risks indicators are dichotomous variables equal to 1 if they were reported in the establishment and 0 otherwise. The cumulative indicator for workplace psychosocial risks (PR) is equal to the sum of all dichotomous psychosocial risk indicators at the establishment level (0-5). As already mentioned, all these risks are somehow related to management practices enabled by digital technologies and systems.

Summary statistics in Table 1 show that having to deal with difficult customers, patients, clients and time pressure are the most widespread psychosocial risks, as they are present in 61% and 45% of the establishments, respectively. They are followed by the risk of long/irregular working hours (present in 23% of the establishments), poor communication of cooperation (18%) and fear of job loss (11%). The average score on the cumulative psychosocial risk indicator is equal to 1.58.

To illustrate the extent of heterogeneity in risk prevalence, Table 7 (in appendix) summarises the psychosocial risk indicator by country and economic sector. The figures are sorted by country first and sector second. The value of the PR indicator represents the average number of risks by country-sector combination. Blue cells display higher values on the PR indicator, whereas red cells display the lowest. The country which reported the highest number of psychosocial risks is Denmark. (2.47 risks on average), whereas the sector is "Human health and social work activities" (Q) with an average of 2.08 risks, most likely driven by the presence of difficult customers, patients, and so on. It is worth mentioning that this does not necessarily mean that workplaces in a specific country (Denmark in this case) have a higher prevalence of psychosocial risk factors compared to workplaces in other countries: a country may score higher due to its higher level of awareness of psychosocial risks in workplaces, which can be due in turn to a variety of reasons (e.g. more awareness-raising campaigns/initiatives). Italy reports the lowest number of psychosocial risks, with an average of 0.82 risks (1.45 in the "Human health and social work activities" sector).[11]

Manufacturing is the sector with the lowest score on the psychosocial risks indicator, with average of 1.2 psychosocial risks reported. The relative low score of manufacturing most likely depends on the type of psychosocial risks included in the analysis, which appear to be more typical of the service sector – especially having to deal with difficult clients, patients etc. – which is the most prevalent risk. Indeed, this is probably why service sector activities, including not only human health and social work activities, but also public administration, education, accommodation/food services, and entertainment, report the highest average number of psychosocial risks should not be surprising given, as already mentioned, that the most widespread risk consists in having to deal with difficult customers, patients, pupils, etc. and some of the psychosocial risks considered in the analysis are more common in the services rather than in manufacturing. Nevertheless it is also worth mentioning that in most of the service activities there has been an increasing use of non-standard and temporary employment contracts, which may be more frequently associated with long or irregular working hours, and increased time pressure. By contrast, in other sectors, such as manufacturing, contact with external individuals is very limited, and irregular or long working hours are not common, which may help explain the differential prevalence of psychosocial risks in these sectors.

[10] The person interviewed can be: the owner or a partner of the firm; the managing director, site or branch manager; another manager; the health and safety officer; an employee representative in charge of health and safety or; another employee in charge of the subject; an external health and safety consultant.

[11] It should be mentioned that Italy ranks low on psycho-social risks even in other surveys, such as the European Working Conditions Survey (EWCS), which may indicate low awareness of psychosocial risks in the workplace.

Management technologies

The digital technologies and systems, which can enable algorithmic management practices, analysed in this study are: 1) Machines, systems or computer monitoring workers' performance – enabling the management function of control. In order to make sure the objectives of the organisation are met, the management function of control relies on performance measurement, evaluation and corrective action (discipline). 2) Machines, systems or computer determining the content or pace of work; these enable the management function of organisation and direction, by assigning duties and establishing how they should be performed; 3) Wearable devices, such as smart watches, data glasses or other (embedded) sensors (allowing for data gathering and feed into the other systems). These are the relevant management technologies surveyed by ESENER and included in the dataset.

Summary statistics shown in Table 1 reveal that the management technologies object of this study are relatively little widespread in European establishments; for instance, the most frequently reported technology, machines, systems or computers determining the content or pace of work, is present in approximately 13% of the establishments, whereas machines, systems or computers monitoring performance are present in about 9% of the establishments. Finally, wearable devices are present only in 4.5% of the establishments. This shouldn't be surprising given that nearly half of the establishments in our sample are rather small (between 5 and 9 workers) and that these technologies are more likely to be adopted in large firms.

Even in this case, there is substantial heterogeneity of adoption both across countries and economic sectors. To compare countries and sectors, we look at the cumulative management technology index attained by summing up the number of technology by establishment, by country and economic sector as shown in Table 8 (in appendix). Finland has the highest score, with an average of 0.83 management technologies adopted across all establishments (with 5 or more employees in the country), whereas Estonia has the lowest, with 0.33. In terms of economic sectors, unsurprisingly management technologies are more prevalent in Transportation and storage (H), Manufacturing (C), and the electricity, gas and steam sector (D).

Given that, at least at the aggregate level, there does not appear to be a strong correlation between the distribution of psychosocial risks as reported by European workplaces by country and economic sector and the distribution of management technologies, we assume that other factors, and especially organisational factors and firm characteristics play a larger role.

OSH preventive measures in the workplace

For the purposes of our study, we selected the following workplace policies aimed at preventing psychosocial risks as reported in ESENER data: firstly, a variable indicating whether the establishment had in place an action plan to prevent work-related stress.[12] This OSH preventive measure is likely to consist of a document or other hard evidence including the actions specifically foreseen by the management to prevent work-related stress. The other OSH measures included in the study are: reorganisation of work in order to reduce job demands and work pressure; confidential counselling for employees; training on conflict resolution; intervention if excessively long or irregular hours are worked; allowing employees to take more decisions on how to do their job[13].

[12] It should be noted though that the latter question is only asked to establishments with 20 or more employees, therefore substantially reducing the final sample size on which the empirical analysis has been carried out.

[13] Similarly to what it has been done for the other variables included in the study, OSH preventive measures are built as dichotomous variables equal to 1 if the measure has been introduced in the establishment and 0 otherwise; a lack of answer is treated as a missing variable.

Summary statistics in Table 1 show that the greatest majority of establishments have put in place at least one measure to prevent psychosocial risks. The OSH measure introduced in most establishments (70%) consist in allowing employees to take more decisions on how to do their job, therefore increasing their autonomy and counteracting the potentially negative effect of monitoring/management technologies. Around 45% of the establishments have introduced measures allowing the reorganisation of work to reduce job demands and work pressure. Only 32% of the establishments have adopted measures to mitigate the risk of long or irregular hours, whereas confidential counselling for employees has been introduced by 42% of the establishments and conflict resolution training by 36%. Finally, approximately 40% of the establishments (with 20 or more employees) report having an action plan to prevent work related stress.
To investigate the heterogeneity across countries and sectors, we focus on one OSH preventive measure in particular, that is the presence of an action plan to prevent workplace stress, because it is arguably the most relevant and complete. Table 9: OSH preventive measures and policies: action plan to prevent work related stress - by country and economic sector

summarises the proportion of establishments that have adopted an action plan to prevent work-related stress by country and sector of economic activity. Sweden, UK, and Denmark are the countries in which a larger share of establishments adopted an action plan to prevent stress, with 71%, 71% and 66% of the establishments reporting it respectively. By contrast, only between 9% and 14% of the establishments in Czechia, Estonia or Serbia report the adoption of an action plan to prevent stress. In terms of sectors of economic activity, human health and social work activities (57%), other services (49%) and financial services (49%) are the sectors in which an action plan is more frequently adopted, whereas agriculture, mining and real estate activities are the sectors in which this OSH preventive measure is less prevalent.

Organisational factors

To account for these factors in our analysis, we included measures to consider non-standard contracts (e.g. the presence of subcontractors, temporary agency workers or volunteers working in the establishment), an ageing workforce at workplace level, the presence of employees working from home or outside the employer's premises, as well as the presence of employees who have difficulties understanding the local language (as a proxy for foreign workers and potentially low group cohesion). Finally, we include more generic controls for establishment size, industrial sector and country in which the establishment is located, as they are likely to affect what technologies are introduced and how they are perceived, what policies are put in place to deal with psychosocial risks, but also how psychosocial risks are perceived and reported.

Table 1 summarises basic establishment characteristics capturing elements of work organisation. First of all, approximately 90% of the establishments are micro or small-sized, with less than 50 employees. This is an important element to account for considering that management technologies appear more likely to be introduced in larger companies, whose complex productive processes, multiple hierarchical levels and resources availability seem more likely to fit with digital technologies and systems enabling algorithmic management. Secondly, almost a third of workplaces report making use of atypical or non-standard work contracts, commonly related to workers' vulnerability and job insecurity. Three quarters of the establishments report that at least a quarter of their workforce is made up by older workers (55 and over). Only 7.6% report the presence of workers who have difficulties understanding the language spoken on the premises. There are also two indicators capturing work arrangements more likely to be object of algorithmic control and monitoring technologies, namely the presence of employees working from home (13% of the establishments) and employees working outside the premises (43%).

4.1 Psychosocial risks, management technologies and OSH preventive measures in the workplace: a snapshot

In this section, we present some simple descriptive statistics to show basic associations between our variables of interest.

Table 2 summarises the psychosocial risks composite indicator as well as the individual psychosocial risks mentioned in the previous section and compares their incidence in establishment which have introduced one of the management technologies under study, with those who didn't. The first row refers to the score on the psychosocial risks indicator (that is how many psychosocial risks are present in each establishment, from 0 to 5). The psychosocial risks indicator is nearly half a point lower in establishments that haven't adopted monitoring technologies, compared to those that have (1.54 vs. 2.00). Similarly, the score on the psychosocial risks indicator is approximately a third of a point higher in establishments that have adopted technologies determining content/pace of work compared to those which didn't (1.86 vs. 1.54); the same can be said for the last technology, since establishments using wearables report an average psychosocial risks of 1.92 vs. 1.56 of those that do not use such technology.

The following rows, describing the incidence of each individual psychosocial risk, show a similar pattern, in that establishments in which a management technology is present consistently report higher risk prevalence. For instance, while 43% of the establishments which do not use technology to monitor performance report time pressure, the proportion rises to 55% among the establishments using such technology; the difference in incidence of time pressure is very similar for the other two technologies. If we look at fear of job loss, we find that its prevalence is nearly double in establishments that adopted technology to monitor performance compared to those that didn't (18.95% vs. 10.62%). The difference is slightly smaller if we focus on technology determining content or pace of work (16.1% vs. 10.69%) and substantially smaller, but still positive, if we look at wearables (13.52% vs. 11.28%). Similarly, poor cooperation/communication is always relatively more frequent in establishments that use one of the technologies, but the higher prevalence is found in establishments that use technology to monitor performance (27.07%). By contrast, working long or irregular hours is reported more frequently in establishments that use wearable technologies (32.75%). Finally, if we focus on the most widespread psychosocial risk (that is dealing with difficult customers, patients, pupils etc.), we find once again that its prevalence is highest in establishments monitoring performance (68.72%) or using wearables (67.16%). It is also slightly higher in establishments using technology to determine content or pace of work, but the difference with those which don't is rather small (62.22% vs. 60.73%).

The positive association between psychosocial risks and management technologies is in line with our expectations. However, we should bear in mind that these are raw associations which do not account for all organisational factors. A more complete picture will be provided in the next section by means of an econometric analysis.

Table 2: Prevalence of psychosocial risks by management technology

	Machines, systems, or computers monitoring workers' performance		Machines, systems, or computers determining pace/content of work		Wearables	
	Not Present	Present	Not present	Present	Not present	Present
Psychosocial risk Index	1.54	2.00	1.54	1.86	1.56	1.92
% of establishments reporting a psychosocial risk						
Time pressure	43.95%	55.08%	43.61%	54.65%	44.46%	55.62%
Fear of job loss	10.62%	18.95%	10.69%	16.10%	11.28%	13.52%
Poor cooperation/ communication	17.47%	27.07%	17.38%	25.19%	18.07%	23.85%
Working long/irregular hours	22.29%	30.93%	22.22%	29.10%	22.62%	32.75%
Difficult clients	60.06%	68.72%	60.73%	62.22%	60.59%	67.16%

Source: authors' elaborations using ESENER 2019 data; data are weighted using establishment proportional weights.

Table 3 investigates the raw association between psychosocial risks and OSH preventive measures by comparing the incidence of the psychosocial risk indicators in establishments which have introduced an OSH preventive measure/policy with those which did not.

Taken at face value, the associations are somewhat counterintuitive, in that establishments that have introduced OSH preventive measures often report higher incidence of psychosocial risks, even though the differences are in some cases very small and may disappear once we control for other factors. If we look at each individual measure, we see that all psychosocial risk indicators are remarkably similar across establishments that have or haven't adopted an action plan to prevent work-related stress, and in some cases even lower (e.g. time pressure and poor communication/cooperation). Similarly, allowing employees to take more decisions on how to do their job is associated with lower fear of job loss and lower incidence of poor communication/cooperation. By contrast, OSH preventive measures such as the reorganisation of work in order to reduce job demands and work pressure, confidential counselling for employees, training on conflict resolution, and intervention if excessively long or irregular hours are worked are consistently associated with higher incidence of psychosocial risks.

Clearly, this does not imply a causal relationship, or a lack of success in the introduction of such measures, given that we are simply providing descriptive statistics. Indeed, the positive association is likely to be due to endogeneity bias (mainly simultaneous and reverse causality) as well as other confounding factors. Indeed, as already mentioned in the conceptual approach, establishments with higher awareness of the presence of psychosocial risks may be more likely to put in place OSH preventive measures or policies to address such risks, and this may result in a positive correlation. We will address this issue in the econometric analysis, by adding a few specifications relying on the use of instrumental variables. In addition, the positive association may also be explained by a number of confounding factors, such as company size, economic sector, or other organisational characteristics, which will be accounted for in the econometric analysis, as well as other circumstances that unfortunately we cannot control for (for example the measures introduced may need time to be effective, or they have been poorly implemented, or do not address the core issue, and so on).

Table 3: Prevalence of psychosocial risks by OSH preventive measures

		% of establishments reporting psychosocial risk				
	Psychosocial risks indicator	**Time pressure**	**Fear of job loss**	**Poor communication/ cooperation**	**Long/ irregular working hours**	**Difficult customers, clients etc.**
No plan	1.87	54.48%	14.20%	27.37%	27.82%	64.18%
Action plan to prevent stress	1.93	53.83%	15.92%	26.03%	30.90%	67.04%
No reorganisation	1.44	39.34%	11.05%	16.72%	20.81%	56.89%
Reorganisation of work to reduce job pressure	1.76	52.31%	11.83%	20.36%	26.03%	66.15%
No counselling	1.43	40.21%	10.32%	16.31%	20.64%	55.68%
Counselling	1.79	51.55%	12.86%	21.05%	26.60%	68.12%
No conflict resolution	1.45	42.61%	10.16%	16.76%	21.09%	55.07%
Conflict resolution training	1.82	49.54%	13.56%	21.23%	26.88%	71.50%
No intervention	1.41	39.60%	10.93%	16.41%	16.84%	58.12%
Intervention long working hours	1.95	56.98%	12.42%	22.48%	37.21%	66.87%
Not allowing employees	1.46	40.88%	12.03%	19.16%	20.70%	54.12%
Allowing employees to take more decisions	1.63	46.69%	11.09%	17.91%	24.21%	63.88%

Source: authors' elaborations using ESENER 2019 data; data are weighted using establishment proportional weights.

4.2 Psychosocial risks, management technologies and OSH preventive measures in the workplace: an econometric analysis

After describing the building blocks of the conceptual model presented earlier in the article (psychosocial risks, management technologies and mediating OSH policies at workplace level, and organisational factors), and having provided a quick snapshot based on descriptive evidence, we proceed with an econometric analysis, to investigate the relationship between work-related stress, management technologies and OSH preventive measures and policies accounting for organisational and other factors.

The main dependent variable, psychosocial risk (PR), is a composite indicator equal to the sum of psychosocial risks j in each establishment i:

$$PR_i = \sum_{j=0}^{5} risk_{ij} \text{ where } i = 1, \dots N \text{ and } j = 0, \dots, 5$$

Each management technology – technologies to monitor workers performance; technologies to determine content/pace of work; and wearables - is measured by a binary indicator equal to 1 if the technology is present in the establishment and 0 otherwise.

The first specification simply investigates the relationship between the psychosocial risk indicator (PR) and each the three management technologies.

We assume that the relationship is linear and can be estimated by ordinary least squares.

$$PR_i = \beta_0 + \beta_1 AM_i + \varepsilon_i \quad \text{(I)}$$

In a second and third specification, we add organisational factors (OF_i) and other controls:

$$PR_i = \beta_0 + \beta_1 AM_i + \beta_2 OF_i + \varepsilon_i \quad \text{(II)}$$

$$PR_i = \beta_0 + \beta_1 AM_i + \beta_2 OF_i + \beta_3 Other_i + \varepsilon_i \quad \text{(III)}$$

Where OF_i include: establishment size (5-9 employees; 10-49, 50-249, 250+); discrete variable indicating the proportion of workers aged 55 and older (None, <25%, >25%<50%, >50%), binary variables indicating the presence of: non-standard work contracts (subcontractors, temporary agency workers or volunteers); employees with difficulties understanding language spoken; employees working from home; employees working outside premises. Organisational factors also include sector of economic activity (NACE rev2, 1 digit) and Country in which the establishment is located. Finally, we account for potential heterogeneity in responses dues to the interviewee, by controlling for the profile of the person answering the survey (owner/partner; managing director; other manager; health and safety officer; employee representative in charge of health and safety; other employee in charge of health and safety; external health and safety consultant).

In a fourth specification, we include all indicators for OSH preventive measures to check their association with psychosocial risks:

$$PR_i = \beta_0 + \beta_1 AM_i + \beta_2 OF_i + \beta_3 Other_i + \beta_4 OM_i + \varepsilon_i \quad \text{(IV)}$$

Where OM_i is a vector of variables including:

The presence of an action plan to prevent work related stress; the presence of any of the following OSH measures: reorganisation of work to reduce job demands and work pressure; confidential counselling for employees; training on conflict resolution; intervention if excessively long or irregular hours; allowing employees to take more decisions on how to do their job. All OSH indicators are binary variables equal to 1 if the measure is present, and 0 otherwise.

It should be noted that the question ascertaining whether the establishment has an action plan to prevent workplace stress is only asked to establishments with at least 20 employees, which not only significantly reduces the sample size, but also potentially introduces bias. The sample organisational fixed effect should suffice to control for such bias, however we also show an additional specification with the full sample including all OSH measures, except the action plan to check for robustness.

4.2.1 Endogeneity issues: instrumental variable approach

As already mentioned in the previous section, we cannot exclude a relevant source of endogeneity bias when investigating the relationship between psychosocial risks and OSH preventive measures and policies, because of potential simultaneity/reverse causality. In other words, the positive association shown in Table 3 may be due to the fact that establishments characterised by high levels of psychosocial risks, would be more likely to adopt an action plan to prevent stress because they are aware that such risks could result in increased work-related stress in the future.

To address this potential source of endogeneity bias, we adopt an instrumental variable (IV) approach. The IV approach is based on the identification of an observable variable z1 not present in equation (eq. IV)) which is highly correlated with the OSH measures (anti-stress action plan) but uncorrelated with the idiosyncratic errors, ε_i. It should be noted that for this part of the analysis we decided to instrument only one of the OSH preventive measures, namely the presence of an action plan to reduce work-related stress, both because of its negative association with the dependent

variable (PR, the sum of the psychosocial risks reported at workplace level), and because it appears as more comprehensive compared with the other measures that only address one issue at a time. In addition, it is the only measure that is codified and documented.

To this end, we build two indicators as potential instruments: the first one, is meant to proxy external influences on a business health and safety culture (OSH culture). According to a study carried out for the Health and Safety Executive (HSE) in the UK by Vickers et al (2003), some of the main external influences are the nature of the particular market in which the business operates, regulatory pressures, compliance or enforcement of health and safety rules. We proxy this type of external forces by means of a composite index including: the incidence of regular risk assessments, the incidence of visits from the labour inspectorate in the past three years, and two indicators related to the main (self- reported) reasons for OSH compliance (meeting expectations from employees or their representatives and maintaining the organisation's reputation). All indicators are first calculated at the establishment level (self-reported measures) and then aggregated by country and NACE 2 digits.

The second instrument captures another side of OSH preventive measures and policies, namely health promotion. To this end, we generated indicators related to the following measures: raising awareness about healthy nutrition; raising awareness on the prevention of addiction, e.g. to smoking, alcohol or drugs; promotion of sports activities outside working hours; and promotion of back exercises, stretching or other physical exercise at work. Even in this case, all indicators were first created at the establishment level and then aggregated by country and sector of economic activity (NACE 2 digit).

We then run a two-stage least squares (IV) specification that can be written as follows:

$$PR_i = \beta_0 + \beta_1 AM_i + \beta_2 OF_i + \beta_3 Other_i + \beta_4 IV_i + \varepsilon_i \quad \text{(V)}$$

Where

$$IV_i = \beta_0 + \beta_1 OSH\ Culture_{c,s} + \beta_s Health\ Promotion_{c,s} + \beta_3 AM_i + \beta_4 OF_i + \beta_5 Other_i + \varepsilon_i$$

And c, s stand for country and sector of economic activity.

4.2.2 OSH preventive measures and policies as mitigating factor between management technologies and psychosocial risks

The last econometric specification is meant to capture the extent to which the adoption of an action plan to reduce stress can mitigate the link between management technologies and psychosocial risks.

To this end, we simply interact each management technology with the most relevant OSH preventive measures, namely the action plan to prevent stress indicator (both in instrumented and not).

$$PR_i = \beta_0 + \beta_1 AM_i + \beta_2 OF_i + \beta_3 AM_i + \beta_2 AM_i * OP_i + \varepsilon_i \quad \text{(VI)}$$

5 Results from the empirical analysis

Table 4 shows the results of the OLS specifications. The first column (baseline) shows the unadjusted association between the algorithmic management technologies and the psychosocial risk index; results in the second column are adjusted by establishment controls, while results in the third column also add country and economic sector (NACE) fixed effects. The fourth column includes all previously mentioned controls and the OSH measures indicators minus the presence of an action plan, while the last one includes all OSH measures; as already mentioned, the question on whether the establishment had adopted an action plan to prevent work related stress is only asked to larger firms (>20 employees), therefore the sample is substantially reduced. Column IV can therefore be used to check for the robustness of results between full/restricted sample.

The results from the econometric exercise confirm the pattern revealed by the descriptive statistics presented in Table 2. All three management technologies are associated with an increase in psychosocial risks in all specifications, with the exception of wearables in the last one (IV). Furthermore, the magnitude of the coefficients and statistical significance do not appear to change after accounting for organisational factors, even though it should be noted that the latter explain a much higher share of the variance. The presence of monitoring technologies is associated with an increase in work related stress of 0.329 points in the specification including all controls and a full sample (III) and 0.338 in the specification including OSH measures, but a reduced sample. This finding is in line with the literature on algorithmic management, which, especially if combined with exacting requests, has been found to cause high levels of stress (Stanton, 2000; Ravid et al, 2020). The difference and original contribution of this analysis is that most previous studies are qualitative and generally focused on a very specific sector (for instance call centres, as in Ball and Margulis, 2011) and therefore not representative of the overall population of establishments and sectors across Europe. In addition, a large share of the monitoring literature is focused on the US, while not much evidence is available for European countries. The presence of management technologies determining content or pace of work is associated with an increase in work related stress of 0.192 in the specification including all controls and a full sample (III) and 0.217 in the specification including OSH measures, but a reduced sample. Finally, the presence of wearable technologies is associated with 0.148 increase in the psychosocial risks indicator in the specification including all controls; however, its impact is reduced to a half in the final specification (V), which includes OSH measures and it becomes statistically insignificant.

The estimates on the association between psychosocial risks and OSH preventive measures are also somewhat in line with the descriptive findings presented in Table 3 with some notable exceptions. Firstly, the presence of an action plan to prevent work related stress is significantly and negatively associated with the psychosocial risks indicator (-0.171); the second OSH preventive measure that is negatively associated with a decrease in psychosocial risks is the introduction of a policy that allows employees to take more decisions on how to do their job, hence increasing their autonomy. By contrast, the other OSH preventive measures appear to be associated with an increase in psychosocial risks, as already seen in Table 3, except for confidential counselling which has no significant association. One possible explanation is that these specific measures are not enough to curtail psychosocial risks, most probably because they are not properly designed or implemented to address the core issues, whereas a coordinated action plan to address psychosocial risks associated to workplace stress may be more successful as it includes a range of measures tackling (also) the core issues. However, as mentioned in the previous section, we need further analysis to infer some causal relationship.

Finally, the association of organisational factors and psychosocial risks is in line with intuition, with larger establishments and those with more vulnerable workers (workers on atypical contracts, or workers who have difficulties understanding the language) reporting higher levels of psychosocial risks. Similarly, establishments with a proportion of employees working from home or outside the premises also report higher psychosocial risks at workplace level. By contrast, the presence of older workers (aged 55 and over) is not associated with higher psychosocial risks.

Table 4: OLS regression results – dependent variable PR indicator (0-5)

VARIABLES	(I) **Baseline**	(II) **Establishment Controls**	(III) **All Controls**	(IV) **OSH measures (F/S)**	(V) **OSH Measures (R/S)**
Management technologies					
Monitoring performance	0.363***	0.335***	0.329***	0.288***	0.338***
	(0.033)	(0.033)	(0.032)	(0.033)	(0.049)
Determining content/pace	0.195***	0.139***	0.192***	0.166***	0.217***
	(0.030)	(0.030)	(0.029)	(0.030)	(0.046)
Wearables	0.266***	0.176***	0.148***	0.125***	0.072
	(0.046)	(0.045)	(0.045)	(0.047)	(0.064)
OSH preventive measures /policies					
Stress action plan					-0.171***
					(0.034)
Reorganisation of work				0.103***	0.066**
				(0.020)	(0.033)
Confidential counselling				-0.020	-0.040
				(0.021)	(0.035)
Training on conflict resolution				0.066**	0.084**
				(0.021)	(0.033)
Intervention long/irregular hours				0.316***	0.266***
				(0.023)	(0.035)
Employees to take more decisions on how to do their job					-0.148***
				-0.065***	(0.034)
				(0.021)	
Organisational factors					
Difficulties with language		0.462***	0.346***	0.321***	0.293***
		(0.038)	(0.037)	(0.038)	(0.049)
Atypical work contracts		0.267***	0.203***	0.188***	0.211***
		(0.020)	(0.020)	(0.021)	(0.033)
Employees working from home		0.316***	0.199***	0.159***	0.147***
		(0.028)	(0.029)	(0.030)	(0.044)
Employees outside premises		0.190***	0.194***	0.175***	0.177***
		(0.019)	(0.019)	(0.020)	(0.032)
% workers aged 55 and over					
<25%		0.019	0.003	0.016	0.028
		(0.024)	(0.024)	(0.024)	(0.063)
>25%<50%		0.104***	0.046	0.069**	0.113*
		(0.029)	(0.029)	(0.030)	(0.068)
>50%		0.040	0.024	0.094**	0.099
		(0.043)	(0.043)	(0.044)	(0.092)
Establishment Size					
10-49 employees		0.190***	0.158***	0.117***	-
		(0.020)	(0.020)	(0.021)	-
50-249		0.430***	0.378***	0.317***	0.137***
		(0.029)	(0.030)	(0.031)	(0.032)
250+		0.577***	0.599***	0.530***	0.385***
		(0.045)	(0.046)	(0.049)	(0.051)
Constant	1.508***	1.116***	0.908***	0.782***	1.091***
	(0.010)	(0.022)	(0.069)	(0.070)	(0.148)
Establishment FE	NO	YES	YES	YES	YES
Sector FE	NO	NO	YES	YES	YES
Country FE	NO	NO	YES	YES	YES
Adjusted R-squared	0.0155	0.0778	0.161	0.180	0.182
Observations	44,908	43,380	42,970	39,786	17,036

*Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1*

The next step is to account for the potential endogeneity of the OSH preventive measures and policies. To this end we adopt a two stage least squares - instrumental variable approach (eq. V); we select one OSH indicator, namely the presence of an action plan to reduce work related stress and use the indicators OSH culture and health promotion described in the previous section as instruments. The first aspect we need to check is the relevance of our instruments, that is, whether they are strongly correlated with the OSH preventive measures in the first stage regression. Indeed, when the excluded instruments are only weakly correlated with the endogenous regressors, estimators can perform poorly. To this end, we calculate the robust Kleibergen-Paap Wald rk F statistic. Estimates in Table 5 show that, indeed, both instruments are highly correlated with the OSH preventive measures (F=19.16). We also run a test of over-identifying restrictions, denoted by the Sargan statistic[14], and confirm that that our instruments are indeed valid (J=0.118/p=0.7314). Finally, we can compare the OLS with the IV estimates; for simplicity, Table 5 reports only the coefficients on the OSH preventive measures (simple and instrumented) and on the three management technologies, but both specification includes all the same controls as in Table 4.

Firstly, we notice that the results hold, and that among the OSH preventive measures, the action plan to reduce stress is strongly associated with a decrease in psychosocial risks. The coefficient in the 2SLS on the OSH preventive measure in the 2SLS specification is greater by one order of magnitude, compared with the OLS results. This is most likely due to the fact that our endogenous regressor is binary, and therefore the coefficient for the IV may be inconsistent. For this reason, we also run a manual 2SLS, by first estimating the fitted values of a probit model (with bootstrapped standard errors), regressing the OSH preventive measure on the two instruments (and all other control variables), then plugging in the fitted value in the second stage regression. As column III shows, the coefficient on the instrumented variable in the manually calculated 2SLS is remarkably closer to the OLS coefficient (-0.360). We also run a treatment effects model with endogenous regressor (column IV) and find that the estimate of the coefficient of the instrumented OSH preventive measure is somewhat larger (-0.513), but still negative and highly statistically significant.

These results confirm that establishments adopting an action plan to reduce workplace stress are indeed more successful at addressing psychosocial risks potentially linked to stress.

[14] The Sargan-Hansen test is a test of overidentifying restrictions. The joint null hypothesis is that the instruments are valid instruments, i.e., uncorrelated with the error term, and that the excluded instruments are correctly excluded from the estimated equation. Under the null, the test statistic is distributed as chi-squared in the number of (L-K) overidentifying restrictions. A rejection casts doubt on the validity of the instruments.

Table 5: OLS and instrumental variable approaches – dependent variable: PR indicator (0-5)

	OLS	2SLS	Manual 2SLS	Endogenous treatment effects
Action plan to prevent work related stress	-0.171***	-1.144**	-0.360**	-0.513***
	(0.034)	(0.513)	(0.155)	(0.144)
Tech Monitoring performance	0.338***	0.347***	0.339***	0.339***
	(0.049)	(0.0520)	(0.0489)	(0.0488)
Tech determining content/pace of work	0.217***	0.229***	0.230***	0.219***
	(0.046)	(0.048)	(0.0461)	(0.0455)
Wearables	0.072	0.102	0.124*	0.0711
	(0.064)	(0.069)	(0.0684)	(0.0638)
Establishment FE	YES	YES	YES	YES
Sector FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES
First stage				
OSH culture		0.063***	0.199***	0.275***
		(0.021)	(0.042)	(0.0375)
Health promotion		0.061***	0.198***	0.451***
		(0.014)	(0.028)	(0.0309)
F stat/Wald test		19.161	93.03	334.53
Sargan J stat (p-val)		0.118/0.731		
Observations	17,036	17,024	17,024	17,024
Adjusted R-squared	0.186	0.092	0.184	

*Robust/bootstrapped standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1*

Finally, we check whether the presence of an action plan to reduce work-related stress acts as a mitigating factor in establishments that have adopted at least one of the three selected management technologies.

Results in Table 6 show that while the presence of an action plan to reduce stress is in itself associated with a lower score on the psychosocial risk indicator, it does not appear to have a mitigating effect on the relationship between management technologies and psychosocial risk, as all coefficients on the interaction terms in column I, II and III are not statistically significant. This means that the positive association between management technologies and psychosocial risks remains the same, both in terms of magnitude and strength, regardless of whether an action plan to reduce stress has been introduced or not. The only exception appear to be the use of wearables, however it is more likely to be due to the reduction in sample size than to a mitigating effect of the OSH preventive measure.

One of the possible reasons is that while action plans to reduce stress may be effective in tackling traditional psychosocial risk factors for work related stress, they may not be specific enough to deal with OSH challenges arising from digitalisation and management technologies.

Table 6: *OSH preventive measure (action plan to reduce work related stress) as a mitigating factor between management technologies and psychosocial risks* - dependent variable: PR indicator (0-5)

	(1) Monit/ Plan	(2) Pace/ Plan	(3) Wearables/ Plan
Monitoring performance	0.306***	0.336***	0.339***
	(0.064)	(0.049)	(0.049)
Work content/pace setting	0.217***	0.190***	0.217***
	(0.046)	(0.059)	(0.046)
Wearables	0.072	0.072	0.136
	(0.064)	(0.064)	(0.094)
Action plan to prevent work related stress	-0.180***	-0.182***	-0.161***
	(0.036)	(0.036)	(0.035)
Interactions			
Monitoring*Action plan	0.071		
	(0.094)		
Determining content/pace*Action plan		0.065	
		(0.088)	
Wearables*Action plan			-0.141
			(0.122)
Constant	1.096***	1.098***	1.087***
	(0.149)	(0.149)	(0.149)
Establishment FE	YES	YES	YES
Sector FE	YES	YES	YES
Country FE	YES	YES	YES
Observations	17,036	17,036	17,036
R-squared	0.186	0.186	0.186
Adjusted R squared	0.0921	0.0921	0.0921

*Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1*

6 Discussion and conclusions

The original contribution of this paper has been to provide comparable quantitative evidence on the relationship between different management technologies, OSH preventive measures and policies, and psychosocial risks across European countries and economic sectors.

In line with the literature and *a priori* expectations, the presence of technologies monitoring worker performance and determining the content or pace of work in an establishment, all potentially used to enable algorithmic management of workers, are associated with an increase in reported psychosocial risks in the workplace. Wearables are also associated with increased psychosocial risks, but not in all specifications, possibly because they are less frequently employed for managing purposes than the other technologies.

The results also indicate that the relationship is particularly strong when it comes to technologies monitoring performance, a form of algorithmic control and evaluation. We can interpret the findings according to the Job Demand-Control (JDC) model by Karasek (1979) on occupational stress. The model posits that the combined low control (due to the presence of monitoring technologies, devices setting the content and pace of work and wearables) and high demand (as a result of intensification of work and increased workload as discussed earlier), would result in "high-strain" jobs, asso-

ciated to increased psychosocial risks and potentially work-related stress and other health issues for the worker.

The association between OSH preventive measures and psychosocial risks seems to be more complex to explain. While allowing workers to take more decision on how to do their job and having an action plan to reduce work-related stress are associated with lower reported psychosocial risks, other measures appear to be associated with increased psychosocial risks. As previously suggested this can be explained by a number of circumstances. OSH preventive measures are more frequently implemented in workplaces with increased psychosocial risks, but they take time to become effective and have an impact, or they can be not well designed and are therefore not addressing the core issue, or finally they are not correctly implemented in the workplace.

By contrast, the presence of an action plan to reduce work-related stress appears to have a negative effect on the number of reported psychosocial risks in each establishment, and the relationship can be interpreted as causal because of the robustness of the results of the instrumental variable approach. Indeed, according to EU-OSHA, being proactive and having a plan in place to pre-empt problems is the most effective way to manage psychosocial risks in the workplace.

However, it should also be mentioned that the presence of an action plan to reduce work-related stress does not necessarily mitigate the relationship between psychosocial risks and management technologies, in that the positive association between management technologies and psychosocial risks remains the same, both in terms of magnitude and strength, regardless of whether an action plan to reduce stress has been introduced or not in the establishment.

In conclusion, our analysis has confirmed that the digital technologies enabling the new forms of management are frequently associated to psychosocial risks, which in turn can result in work-related stress and other mental health issues, with a negative impact on workers' health. It also confirmed that mitigating OSH measures, such as having an action plan to prevent work-related stress, have an impact in preventing the psychosocial risks in the workplace, but may not affect the relationship between psychosocial risks and management technologies.

This finding can nevertheless be explained considering some inter-related issues stemming from limitations in the data used in this study. First, it is important to bear in mind that the dataset does not include variables regarding OSH measures specifically designed and introduced in the workplace to mitigate the impact of management technologies. Therefore, only variables related to more general OSH preventive measures aiming at reducing work-related stress in the workplace are available and could be taken into account in our analysis. Second, the variable related to the presence of an action plan to reduce work-related stress does not give account of the contents and the specific measures of the action plan itself, and therefore does not allow to assess its suitability to address psychosocial risks in relation with management technologies. Third, the simple presence of an action plan to prevent work-related stress does not guarantee that risks stemming from the use of digital and management technologies in the workplace are correctly addressed (or addressed at all), as it could have been designed without taking into account the association between psychosocial risks and digital and management technologies for a lack of awareness among establishment of that existing association. Moreover, it is also worth mentioning that the variables related to psychosocial risks included in the dataset are not specific to the use of digital technologies and in particular of management technologies, although they measure the presence of risks in areas related to management technologies.

Our work has a number of policy implications. On the one hand there is a need for surveys specifically designed to take into account the association between digital and management technologies and psychosocial risks and also to investigate more in depth the type of OSH measures specifically introduced in the workplace to address the (confirmed) association between psychosocial risks and digital and management technologies and prevent stress and other health issues in the workplace. On the other hand, there could be a lack of awareness at the workplace level about the psychosocial risks stemming from the use of digital and management technologies, which could therefore result in a lack of specific (and effective) preventive OSH measures. Therefore, awareness-raising

campaigns and other similar measures could certainly help in increasing awareness among establishments about the implications of the use of digital technologies for psychosocial risks and worker's health and get the information and knowledge needed to design and introduce specific measures to tackle the issue.

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Appendix

List of tables

List of variables and definitions

Variable name	Description
Psychosocial Risks	There may also be risks resulting from the way work is organised, from social relations at work or from the economic situation. Please tell me for each of the following risks whether or not it is present in the establishment
Time pressure	Binary variable equal to 1 if the answer is YES, 0 if the answer is NO
Poor communication or cooperation within the organisation	Binary variable equal to 1 if the answer is YES, 0 if the answer is NO
Fear of job loss	Binary variable equal to 1 if the answer is YES, 0 if the answer is NO
Having to deal with difficult customers, patients, pupils etc.	Binary variable equal to 1 if the answer is YES, 0 if the answer is NO
Long or irregular working hours	Binary variable equal to 1 if the answer is YES, 0 if the answer is NO
Psychosocial risks: cumulative index (0-5)	Discrete variable ranging from 0 to 5, equal to the sum of the five psychosocial risk indicators at the establishment level
Management technologies	Does your establishment use any of the following digital technologies for work?
Machines, systems or computer monitoring workers performance	Binary variable equal to 1 if the answer is YES, 0 if the answer is NO
Machines, systems or computer determining the content or pace of work	Binary variable equal to 1 if the answer is YES, 0 if the answer is NO
Use of wearables, such as smart glasses, sensors…	Binary variable equal to 1 if the answer is YES, 0 if the answer is NO
All management technologies (0-3)	Discrete variable ranging from 0 to 3, equal to the sum of the three technology indicators at the establishment level
OSH preventive measures	In the last 3 years, has your establishment used any of the following measures to prevent psychosocial risks?
Reorganisation of work to reduce job demands and work pressure	Binary variable equal to 1 if the answer is YES, 0 if the answer is NO
Confidential counselling for employees	Binary variable equal to 1 if the answer is YES, 0 if the answer is NO
Training on conflict resolution	Binary variable equal to 1 if the answer is YES, 0 if the answer is NO
Intervention if excessively long or irregular hours	Binary variable equal to 1 if the answer is YES, 0 if the answer is NO
Allowing employees to take more decisions on how to do their job	Binary variable equal to 1 if the answer is YES, 0 if the answer is NO
Action plan to prevent work related stress	Does your establishment have an action plan to prevent work-related stress? Binary variable equal to 1 if the answer is YES, 0 if the answer is NO
Organisational factors	
Atypical work contracts	Binary variable equal to 1 if the establishment reports the presence of atypical contracts (subcontractors, temp agency workers, volunteers), 0 if the answer is NO
Employees with difficulties understanding language spoken	Binary variable equal to 1 if the establishment reports the presence of employees with difficulties understanding language spoken, 0 if the answer is NO
Employees working from home	Binary variable equal to 1 if the establishment reports the presence of employees working from home, 0 if the answer is NO
Employees working outside the premises	Binary variable equal to 1 if the establishment reports the presence of employees working outside the premises, 0 if the answer is NO
Proportion of workers aged 55 and over	Discrete variable =1 if no employees aged 55 and over are present in the establishment; 2 = up to 25%; 3 = 25% - 50%; and 4 if > 50%
Establishment size	Discrete variable =1 if the establishment has between 5 and 9 employees; 2= 10 - 49; 3=50 - 249; and 4 if the establishment has more than 250 employees

Table 7: Psychosocial risks indicator by country and economic sector (sorted by country first and sector second)

Country	Q	O	P	I	R	S	K	N	M	H	B	D	L	F	J	G	E	A	C	Total
Denmark	3.04	3	3.18	2.76	2.89	2.55	2.81	2.08	2.38	2.28	2.53	2.17	2.4	1.93	2.59	2.36	2.11	1.96	1.72	2.47
Sweden	2.85	2.76	2.58	2.65	2.41	2.51	2.6	2.23	2.17	2.09	1.77	2.2	2.31	1.95	2.34	2.16	2.18	1.84	1.76	2.3
Finland	2.24	1.81	2.47	2.29	2.38	2.22	2.28	2.04	2.17	2.14	1.59	2.92	2.53	1.88	1.94	1.75	2.18	1.99	1.67	2.03
Belgium	2.32	2.43	2.28	2.3	2.67	2.27	2.15	1.8	1.83	2.17	2.79	1.82	1.75	1.45	1.97	1.86	1.79	1.07	1.86	1.98
Norway	2.17	2.48	2.4	2.07	2.15	2.21	1.88	2.17	2.02	2.12	1.97	1.33	2.05	1.87	2.06	1.62	1.77	1.83	1.72	1.96
Luxembourg	1.91	1.88	2.55	2	3	1.99	1.7	1.95	1.83	2.05	3	0.65	1.67	1.62	1.9	1.9	1.26	1.91	1.6	1.87
Switzerland	1.9	2.32	2.28	2.1	2.07	2.01	1.96	1.89	1.68	1.93	3.03	1.95	1.81	1.73	1.88	1.63	1.4	1.91	1.67	1.86
Netherlands	2.4	2.64	2.52	2.08	2.11	1.85	1.43	2.05	1.93	1.74	2.99	2.5	1.59	1.55	1.56	1.61	1.13	1.31	1.53	1.85
Germany	2.18	1.9	2.18	1.88	2.44	1.95	2.29	1.94	1.69	1.65	1.45	2.59	1.45	1.64	1.64	1.55	1.38	1.97	1.63	1.8
Iceland	1.84	2.43	1.71	1.89	1.27	2.09	1.9	1.94	2.06	2.41	1.33	1.67	2.15	1.68	1.96	1.75	2.89	1.03	1.47	1.79
Estonia	2.01	1.99	1.81	2.21	2.33	1.46	1.21	2.09	2.06	1.53	1.14	1.48	1.62	2.04	1.59	1.57	2.28	1.49	1.55	1.77
Malta	1.36	2.01	2	1.94	0.72	2.2	2.09	1.72	1.91	2.31	2.3		1.89	2.49	1.48	1.52	1.18	3.07	1.53	1.75
Cyprus	2.28	2.41	1.78	1.71	1	1.75	1.18	1.75	1.59	1.63	1.61	4	1.18	1.98	1.5	1.73	1.54	1.1	2.14	1.74
Romania	1.92	1.62	1.81	1.99	1.56	1.55	1.76	1.64	1.8	1.97	2.26	1.85	0.92	2.17	2.21	1.59	1.7	1.38	1.57	1.74
UK	1.91	2.38	1.84	1.88	1.89	1.78	1.44	1.62	1.64	1.84	1.82	1.13	1.89	1.7	1.29	1.59	2.16	1.47	1.42	1.71
France	2.27	1.69	2	2.1	1.49	1.96	1.95	1.53	1.73	1.82	2.18	1.5	1.5	1.27	1.2	1.47	1.27	0.8	1.36	1.68
Latvia	2.01	2.2	2.25	2.2	1.27	1.04	1.55	1.75	1.75	1.45	1.07	1.03	1.25	1.69	1.6	1.49	2.02	1.62	1.52	1.66
Portugal	1.97	1.96	1.88	1.62	1.71	1.82	1.64	1.48	2.2	1.88	1.32	1.29	1.28	1.6	1.73	1.46	1.59	1.08	1.48	1.62
Austria	2.08	1.71	1.56	1.86	1.18	1.69	1.27	1.62	1.33	1.67	1.13	2	2.34	1.66	1.36	1.4	1.12	1.62	1.49	1.59
Slovenia	2.26	2.12	1.76	1.44	2.33	2.01	1.48	1.84	1.6	1.58	1.87	1.38	1.38	1.61	1.43	1.33	1.33	1.53	1.23	1.53
Greece	1.58	2.21	1.87	1.7	1.22	1.25	1.48	1.82	1.38	1.38	0.43	1.7	2.26	1.49	1.26	1.23	1.29	1.16	1.31	1.5
Ireland	1.74	1.54	1.67	1.78	1.76	1.08	1.47	1.48	1.38	1.52	1.51	0.65	2	1.15	1.53	1.46	1.43	0.97	1.07	1.48
Spain	1.8	1.37	1.65	1.71	1.16	1.42	1.74	1.57	1.5	1.75	1.63	2.24	1.43	1.19	1.23	1.24	1.36	0.95	1.12	1.4
Czechia	2.08	1.5	1.45	1.73	1.48	1.64	1.51	1.38	1.35	1.39	0.74	0.61	1.04	1.36	1.3	1.32	0.8	1.26	1.09	1.38
Poland	1.7	1.83	1.59	2	1.27	1.41	1.45	1.62	1.6	1.68	1.56	1.11	1.46	1.26	1.14	1.21	1.41	1.03	1	1.36
Croatia	1.42	1.7	1.27	1.56	1.21	1.55	1.22	1.35	1.46	1	1.52	1.66	1.58	1.46	1.14	1.24	1.21	1.07	1.31	1.34
Hungary	1.41	1.95	1.48	1.49	1.83	0.76	0.92	1.77	1.28	1.41	1.9	1.42	1.39	1.39	0.84	1.06	1.21	1.32	1.07	1.29
North Macedonia	1.34	1.95	1.28	1.22	1.43	0.69	1.05	0.94	1.62	1.24	0.91	2	1.28	1.27	0.7	1.16	1.93	0.92	0.95	1.19
Serbia	1.51	1.82	1.41	1.15	1.2	0.79	0.23	1.34	1.24	1.16	1.14	1.53	1.08	1.05	0.89	0.95	1.09	1.47	0.82	1.12
Bulgaria	1.41	2	1.41	1.21	0.9	1.35	1.21	0.65	1.15	1.13	1.88	1.45	0.38	1.24	1.12	1	0.73	1.1	0.78	1.07
Slovakia	1.61	1.29	1.28	0.97	1.14	0.66	1.16	0.45	0.61	1.52	0.06	1.23	0.7	0.84	0.37	0.88	0.65	1.44	0.89	0.99
Lithuania	1.44	1.93	1.07	1.03	0.44	0.5	0.91	1.01	1.31	0.8	0.49	1	0.47	1.18	0.73	0.89	1	1.55	0.73	0.95
Italy	1.45	1.4	1.09	0.96	0.09	0.9	1.29	0.98	0.9	0.9	0.79	1	0.51	0.7	1.03	0.74	0.83	0.4	0.45	0.82
Total	2.08	1.83	1.83	1.78	1.73	1.73	1.72	1.65	1.63	1.62	1.59	1.58	1.57	1.44	1.44	1.41	1.41	1.26	1.2	1.58

A-Agriculture, forestry and fishing	B-Mining and quarrying	C-Manufacturing
D-Electricity, gas, steam...	E-Water supply, sewerage, waste management ...	F-Construction
G-Wholesale and retail trade; repair of motor vehicles ...	H-Transportation and storage	I-Accommodation and food service activities
J-Information and communication	K-Financial and insurance activities	L-Real estate activities
M-Professional, scientific and technical activities	N-Administrative and support service activities	O-Public administration and defence...
P-Education	Q-Human health and social work activities	R-Arts, entertainment and recreation
S-Other service activities		

Source: authors' elaborations using ESENER 2019 data; data are weighted using establishment proportional weights.

Table 8: Management technologies by country and economic sector (sorted by country first and sector second).

Country	H	C	D	B	A	K	E	J	N	G	I	R	M	Q	L	S	F	O	P	Total
Finland	0.83	0.55	1.06	0.32	0.65	0.54	0.53	0.47	0.64	0.4	0.25	0.26	0.43	0.33	0.54	0.28	0.37	0.5	0.38	0.44
Hungary	0.65	0.63	1	1.95	0.73	0.47	0.33	0.46	0.7	0.38	0.3	0.37	0.4	0.28	0.4	0.25	0.4	0.34	0.3	0.44
Ireland	0.49	0.44	0	0.51	0	0.35	0.19	0.61	0.33	0.52	0.51	0.28	0.25	0.29	0	0.44	0.49	0.51	0.1	0.42
North Macedonia	0.45	0.46	0	1.21	0.4	0.26	0.61	0.38	0.52	0.46	0.39	0.72	0.27	0.25	0	0.29	0.32	0.34	0.43	0.42
Malta	0.37	0.5		1.1	0.14	0.17	0.18	0.38	0.28	0.41	0.83	0.12	0.39	0.12	0.11	0.1	0.28	0.22	0.36	0.4
United Kingdom	0.53	0.62	1.11	0.73	0.35	0.34	0.52	0.28	0.45	0.39	0.45	0.38	0.33	0.4	0.38	0.4	0.28	0.4	0.2	0.4
Denmark	0.61	0.57	0.3	0.18	0.46	0.91	0.42	0.51	0.36	0.45	0.35	0.32	0.28	0.23	0.23	0.16	0.27	0.69	0.17	0.38
Bulgaria	0.47	0.44	0.27	1.58	0.36	0.06	0.62	0.31	0.28	0.37	0.4	0.45	0.17	0.36	0	0.37	0.24	0.25	0.34	0.36
Lithuania	0.79	0.5	0.26	0.06	0.35	0.9	1.17	0.13	0.24	0.33	0.33	0	0.22	0.12	0.1	0.01	0.24	0.58	0.13	0.36
Greece	0.31	0.45	0.3	0.55	0.45	0.19	0.37	0.4	0.26	0.35	0.41	0.16	0.27	0.35	0.25	0.39	0.21	0.17	0.38	0.35
Serbia	0.44	0.57	0.7	0.05	0.43	0	0.16	0.75	0.3	0.26	0.52	0.4	0.3	0.32	0.26	0.29	0.15	0.35	0.29	0.35
Romania	0.65	0.41	0.47	0.13	0.41	0.58	0.57	0.35	0.21	0.29	0.39	0.25	0.32	0.31	0.28	0.34	0.24	0.19	0.34	0.34
Iceland	0.67	0.72	0.54	0.67	0.44	0.28	1.28	0.57	0.26	0.42	0.16	0.12	0.2	0.21	0.21	0.25	0.18	0.3	0.09	0.32
Spain	0.4	0.41	0	0.02	0.27	0.27	0.23	0.29	0.26	0.34	0.27	0.11	0.24	0.32	0.62	0.23	0.24	0.13	0.12	0.29
Sweden	0.52	0.67	0.43	0.69	0.6	0.54	0.62	0.25	0.19	0.24	0.11	0.09	0.17	0.24	0.26	0.13	0.2	0.25	0.13	0.27
Belgium	0.42	0.53	0.12	0.46	0.32	0.27	0.44	0.15	0.22	0.31	0.36	0.15	0.28	0.13	0.09	0.05	0.23	0.2	0.11	0.26
Latvia	0.33	0.24	0.57	0.31	0.34	0.43	0.01	0.48	0.17	0.17	0.3	0.32	0.32	0.39	0.16	0.17	0.27	0.24	0.17	0.26
Cyprus	0.18	0.23	0	1.21	0.16	0.11	0.22	0.11	0.29	0.26	0.31	0.28	0.3	0.41	0.44	0.58	0.21	0.22	0.07	0.25
Norway	0.44	0.41	0.29	0.53	0.6	0.35	0.51	0.37	0.28	0.32	0.17	0.11	0.23	0.11	0.15	0.27	0.21	0.17	0.12	0.25
Austria	0.24	0.33	0.74	0.31	0.39	0.16	0.07	0.16	0.24	0.23	0.19	0.02	0.23	0.27	0.41	0.28	0.28	0.14	0.18	0.24
Germany	0.34	0.39	0.03	0.09	0.41	0.36	0.16	0.34	0.26	0.26	0.18	0.33	0.2	0.19	0.08	0.18	0.23	0.16	0.09	0.24
Luxembourg	0.25	0.47	0.86	2	0.55	0.18	0	0.14	0.12	0.32	0.19	0.33	0.29	0.09	0	0.42	0.24	0.39	0.08	0.24
Portugal	0.36	0.36	0	0.25	0.16	0.13	0.42	0.49	0.15	0.26	0.19	0.26	0.22	0.18	0.28	0.29	0.13	0.24	0.14	0.24
Slovenia	0.49	0.49	0	0.17	0.13	0.14	0.69	0.13	0.15	0.18	0.1	0.1	0.12	0.1	0	0.15	0.21	0.1	0.06	0.24
Croatia	0.27	0.49	0.68	0.02	0.07	0	0.31	0.29	0.32	0.18	0.24	0.04	0.02	0.29	0.17	0.18	0.21	0.08	0.06	0.23
Netherlands	0.28	0.47	0	0.1	0.35	0.12	0.38	0.24	0.21	0.25	0.12	0.01	0.16	0.18	0	0.14	0.29	0.28	0.19	0.23
Switzerland	0.32	0.39	0.01	1.67	0.22	0.36	0.37	0.19	0.26	0.28	0.14	0.19	0.18	0.18	0.09	0.19	0.19	0.19	0.05	0.22
Slovakia	0.22	0.35	0	0.49	0.71	0.33	0.32	0.15	0.13	0.23	0.11	0.09	0.06	0.27	0.08	0.16	0.24	0.16	0.08	0.21
Czechia	0.44	0.45	0	0.66	0.17	0.11	0.37	0.34	0.18	0.21	0.04	0.05	0.13	0.1	0	0.1	0.12	0.07	0.08	0.2
France	0.4	0.27	0.39	0.25	0.32	0.76	0.4	0.27	0.19	0.26	0.15	0.15	0.19	0.13	0.09	0.11	0.05	0.03	0.03	0.2
Italy	0.38	0.26	0.57	0.39	0.25	0.1	0.19	0.35	0.25	0.13	0.09	0.15	0.25	0.07	0.37	0.04	0.12	0.12	0.07	0.18
Poland	0.32	0.4	0.19	0.16	0.34	0.19	0.17	0.23	0.13	0.17	0.12	0.1	0.16	0.12	0.09	0.12	0.13	0.14	0.07	0.18
Estonia	0.33	0.46	0.14	0.2	0.37	0.03	0.13	0.23	0.05	0.07	0	0.07	0.08	0.03	0.07	0	0.2	0.03	0.03	0.17
Total	0.42	0.4	0.38	0.38	0.34	0.34	0.33	0.31	0.29	0.28	0.25	0.24	0.23	0.23	0.21	0.21	0.2	0.16	0.12	0.27

A-Agriculture, forestry and fishing	B-Mining and quarrying	C-Manufacturing
D-Electricity, gas, steam...	E-Water supply, sewerage, waste management ...	F-Construction
G-Wholesale and retail trade; repair of motor vehicles ...	H-Transportation and storage	I-Accommodation and food service activities
J-Information and communication	K-Financial and insurance activities	L-Real estate activities
M-Professional, scientific and technical activities	N-Administrative and support service activities	O-Public administration and defence...
P-Education	Q-Human health and social work activities	R-Arts, entertainment and recreation
S-Other service activities		

Source: authors' elaborations using ESENER 2019 data; data are weighted using establishment proportional weights.

Table 9: OSH preventive measures and policies: action plan to prevent work related stress - by country and economic sector

Country	Q	S	K	P	N	M	D	I	J	H	E	G	O	R	C	F	A	B	L	Total
Sweden	0.77	0.61	1	0.82	0.68	0.62	0.91	0.65	0.5	0.59	0.81	0.7	0.69	0.54	0.72	0.75	0.5	1	0.63	0.71
UK	0.87	0.89	0.64	0.89	0.62	0.76	1	0.64	0.55	0.57	0.69	0.7	0.71	0.67	0.62	0.58	0.44	1	0.2	0.71
Denmark	0.83	0.57	0.73	0.74	0.41	0.5	0.43	0.49	0.62	0.61	0.76	0.69	0.86	0.7	0.59	0.45	0.54	0.71	0.68	0.66
Ireland	0.77	0.71	0.53	0.54	0.45	0.65	1	0.51	0.67	0.57	1	0.61	0.65	0.57	0.48	0.32	0.54	0.5		0.58
Finland	0.65	0.78	0.7	0.62	0.53	0.58	1	0.83	0.63	0.4	0.5	0.73	0.74	0.38	0.4	0.29	0	0.36	0.76	0.57
Italy	0.66	0.39	0.48	0.52	0.55	0.56	0.5	0.49	0.54	0.54	0.41	0.35	0.48	0.24	0.44	0.69	0.22	0	0.48	0.48
Romania	0.57	0.23	1	0.51	0.54	0.53	0.56	0.52	0.6	0.51	0.23	0.5	0.29	0.57	0.41	0.56	0.43	0.5	0	0.48
Belgium	0.58	0.82	0.52	0.44	0.46	0.46	0.68	0.43	0.47	0.37	1	0.47	0.42	0.87	0.39	0.48	0.27	0.33	0.3	0.47
Norway	0.57	0.12	0.35	0.38	0.48	0.38	0	0.49	0.46	0.48	0.62	0.41	0.57	0.29	0.31	0.51	0.25	0.38	0.25	0.46
Malta	0.95	0.73	0.51	0.68	0.54	0.38		0.45	0.26	0.27	0	0.13	0.52	0.56	0.3	0.28	1	1	1	0.41
Spain	0.59	0.41	0.74	0.29	0.4	0.24		0.39	0.38	0.42	0.46	0.32	0.31	0.14	0.36	0.48	0.5	0.54	1	0.39
France	0.54	0.47	0.56	0.27	0.47	0.43	0.3	0.4	0.44	0.27	0.32	0.38	0.35	0.11	0.41	0.3	0.11	0.32	0.57	0.39
Netherlands	0.46	0.55	0.46	0.57	0.35	0.36	0	0.27	0.36	0.3	0.71	0.29	0.45	0.24	0.34	0.26	0.28	0.33	0.87	0.39
Austria	0.63	0.52	0.35	0.47	0.34	0.35	0.66	0.43	0.65	0.54	0.36	0.22	0.3	0.14	0.36	0.26	0.69	0.87	0.04	0.38
Iceland	0.26	0.52	0.42	0.5	0.6	0.23	0.82	0.51	0.32	0.36	0.39	0.21	0.61	0.64	0.42	0.09	0	0.5	0.21	0.38
Switzerland	0.55	0.33	0.41	0.32	0.28	0.32	0.04	0.31	0.29	0.15	0.23	0.26	0.38	0.1	0.26	0.1	0.01	0.08	0.11	0.29
North Macedonia	0.31	0	0.05	0.37	0.43	0.14	0.88	0.13	0.6	0.19	0.48	0.39	0	0	0.21	0.47	0.33	0.77	1	0.29
Slovenia	0.38	0.22	0.33	0.32	0.21	0.12	0.25	0.01	0.58	0.48	0.53	0.16	0.11	0.44	0.28	0.29	0	0.76	0.15	0.29
Bulgari	0.6	0.24	0.04	0.49	0.44	0.31	0	0.26	0.18	0.21	0	0.25	0.1	0.52	0.14	0.32	0	0.67	0.5	0.27
Cyprus	0.75	0.66	0.59	0.38	0.25	0.34	0	0.26	0	0.46	0	0.12	0.18		0.29	0.18	0	0	0.15	0.27
Germany	0.43	0.55	0.32	0.34	0.29	0.19	0.33	0.11	0.16	0.27	0.11	0.21	0.21	0.11	0.29	0.14	0.1	0	0.01	0.26
Lithuania	0.45	0.02	0.45	0.28	0.25	0.34	0.44	0.35	0	0.13	0.29	0.3	0.33	0	0.22	0.16	0.46	0.4	0.1	0.24
Latvia	0.55	0	0.19	0.4	0.19	0.07	0.12	0.17	0.42	0.23	0	0.06	0.13	0.2	0.3	0.07	0.23		0.04	0.23
Hungary	0.24	0	0.31	0.17	0.3	0.04	0.48	0.1	0.26	0.22	0.09	0.24	0.13	0.09	0.25	0.19	0.12	0	0.08	0.2
Greece	0.26	0.2	0	0.22	0.14	0.09	0.4	0.21	0.2	0.13	0.24	0.15	0.11	0	0.26	0.2	0.03	0.06	0	0.19
Poland	0.27	0.1	0.24	0.27	0.2	0.35	0.23	0.09	0	0.25	0	0.13	0.22	0.14	0.1	0.19	0.13	0.14	0.1	0.19
Luxembourg	0.23	0	0.33	0.16	0.25	0.25	0	0.2	0.24	0.16	0	0.21	0.04		0.16	0.13	0.5		0	0.18
Portugal	0.23	0.22	0.22	0.14	0.21	0.45	0.43	0.19	0.3	0.18	0.02	0.13	0.19	1	0.16	0.13	0	1	0	0.18
Croatia	0.17	0.34	0.51	0.19	0.33	0.19	0.34	0.28	0.33	0.15	0	0.09	0	0	0.11	0.14	0	0	0.46	0.16
Slovakia	0.15	0.11	0	0.4	0.14	0	0	0.21	0.77	0.02	0	0.07	0.03	0.13	0.16	0.2	0.08	0	0.21	0.16
Estonia	0.22	0	0.26	0.21	0.02	0	0.09	0	0.11	0.24	0.3	0.1	0.12	0	0.13	0.19	0.06	0	0	0.14
Serbia	0.12	0.1	0	0.13	0.1	0.16	0.07	0	0	0.23	0	0.16	0.12	0	0.15	0	0.44	0.95	0.17	0.14
Czechia	0.17	0	0	0.08	0.13	0.13	0	0.02	0.27	0.29	0.02	0.07	0.05	0.03	0.08	0.05	0.06	0	0.03	0.09
Total	0.57	0.49	0.49	0.44	0.42	0.4	0.4	0.39	0.39	0.37	0.36	0.36	0.34	0.34	0.34	0.33	0.25	0.25	0.25	0.4

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G-Wholesale and retail trade; repair of motor vehicles ...	H-Transportation and storage	I-Accommodation and food service activities
J-Information and communication	K-Financial and insurance activities	L-Real estate activities
M-Professional, scientific and technical activities	N-Administrative and support service activities	O-Public administration and defence...
P-Education	Q-Human health and social work activities	R-Arts, entertainment and recreation
S-Other service activities		

Source: authors' elaborations using ESENER 2019 data; data are weighted using establishment proportional weights.

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