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How digital technology is reshaping the art of management

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How digital technology is reshaping the art of management

Maria Cesira Urzì Brancati (JRC Sevilla), Maurizio Curtarelli (EU-OSHA), Sara Riso (Eurofound), Sara Baiocco (DG EMPL)

Abstract

This study describes how the digitisation of the workplace may contribute to the emergence of data-driven management, and how this, in turn, may affect work organisation and aspects of job quality, such as occupational health and safety. It summarises and defines the technologies that enable data-driven management and provides a snapshot of their diffusion across Europe. The paper shows how some technologies are fairly widespread, while other are found only in a minority of establishments. The descriptive analysis presented in this research report shows that the use of technologies enabling data-driven management may have both positive and negative impacts on workers and working conditions. Better establishment performance, provision of training, greater job complexity and worker autonomy are among the positive impacts associated with the presence of some digital technologies for data-driven management. By contrast, lower workers' well-being and a higher prevalence of reported psychosocial risks in the workplace are among the negative impacts at the establishment level. The paper suggests that workplaces can introduce a number of measures to mitigate the potentially negative impact of data-driven management on workers' wellbeing.

Keywords: data-driven management; algorithmic management; psychosocial risks; digitisation; work organisation; working conditions.

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Baiocco, S., Fernández-Macías, E., Rani, U. and Pesole, A., The Algorithmic Management of work and its implications in different contexts, Seville: European Commission, 2022, JRC129749

Available at: https://joint-research-centre.ec.europa.eu/publications/algorithmic-management-work-and-its-implications-different-contexts_en

Executive summary

This report is the product of a collaboration between the JRC, EU-OSHA and Eurofound. It illustrates how the process of workplace digitisation facilitates the emergence of data-driven management, and how this, in turn, may affect work organisation and aspects of job quality, such as occupational health and safety. Workplace digitisation is the process through which analogue or mechanical elements of the physical world are converted into bytes (and vice versa) via means of sensors or rendering devices (Fernandez-Macias, 2018); it is enabled by technologies such as the Internet of Things (IoT), Artificial Intelligence (machine learning or deep learning), or wearables, which use cameras, sensors, and other devices to collect, transmit, store and process massive amounts of data, not only on the work environment, but also on workers' activity in itself. This process is the basis for data-driven management in that the collected and processed data can be used to assist or even (partly) automate managerial decision making.

Data-driven management is an umbrella concept that may refer to decision-making in the more general process of goods production or service delivery (e.g. use of raw material or energy, logistics, sales, etc.), or to specific work-related aspects (e.g. recruitment, workshift organisation, tasks assignment, performance evaluation, etc.). An extreme example of how the availability of big data can revolutionise management practices can be found in the digital labour platform economy, where data-driven management takes the form of algorithmic management. In digital labour platforms, most managerial functions are replaced by software algorithms, that is, 'computer-programmed procedures for transforming input data into a desired output'. Albeit typical of digital labour platforms, data-driven forms of management are not uncommon in traditional workplaces, especially in large firms and in sectors such logistics (both in warehouse and delivery work) and to a lesser degree retail, manufacturing, marketing, consultancy, banking, hotels, call centres, and among journalists, lawyers and the police.

This report draws from different data sources – The Community survey on ICT usage and e-commerce in enterprises; The European Company Survey (ECS); and The European Survey of Enterprises on New and Emerging Risks (ESENER) – to provide a snapshot of the distribution of technologies enabling data-driven management across Europe. The distribution of enabling technologies suggests that the potential for data-driven management practices to spread to traditional workplaces is quite large, especially in some EU member states. In particular, some enabling technologies are fairly widespread, while others are found only in a minority of establishments; for instance, approximately Enterprise Resource Planning (ERP) and Customer Relations management (CRM) software are present in more than a third of European enterprises with 10 or more employees; the Internet of Things is present in approximately 29% of the EU27 enterprises; AI in 8%; and wearable devices only in fewer than 6% of European enterprises. Finally, according to the ICT survey, 14% of the enterprises with 10 or more workers analyse big data internally from any source, whereas according to the ECS, data analytics is present in just about over half of the establishments. The discrepancy with the ICT survey reported above probably relates to the more general understanding of data analytics in the ECS survey where the relevant question makes no reference to use of 'big data'. It should also be noted that there is substantial heterogeneity across countries, and that the presence of each technology is more likely in larger establishments.

In terms of impacts, the report examines the relationship of selected technologies with work organisation and workplace well-being. In particular, the report investigates the use of data analytics, that is, the 'use of digital tools for analysing the data collected within the establishment or from other sources' (Eurofound and Cedefop, 2020) and shows its association with several aspects of work organisation and workplace practices, namely: job complexity and autonomy, collaboration with other establishments, pay schemes, training opportunities, establishment performance and workplace well-being. The descriptive analysis shows that establishments using data analytics (to improve production and monitor employee performance) tend to perform better, provide higher levels of training, and are characterised by performance-related pay, greater job complexity and worker autonomy; in addition, these establishments are more likely to engage in the design and development of new products or services. However, the use of data analytics is also associated with somewhat lower worker wellbeing, especially if used for employee monitoring.

The report also examines other technologies that can be used for data-driven management, such as wearables, and other devices determining the content or pace of work, or monitoring worker performance, and their association with occupational health and safety, as measured by the (reported) presence of psychosocial risks in the workplace. Estimates drawn from the ESENER survey suggest that the presence of such technologies is associated with a higher prevalence of reported psychosocial risks in the workplace, and in particular time pressure and long or irregular working hours.

The report suggests a number of measures that workplaces can introduce to mitigate the potentially negative impact of data-driven management on workers' wellbeing. For instance, prior to adopting a technology that can enable data-driven management, establishments can involve their workforce and discuss its possible impacts with them. Having an action plan to reduce stress in place would also help mitigate some of the negative effects on OSH.

Contents

1 Introduction

Every time we go to work, clock in or scan our id-card, turn on our computer, or use our company's digital equipment, we produce an extraordinary amount of data that machines, digital devices, sensors and so on are able to capture, store, and process, often without our knowledge. The vast amount of data collected and processed through digital devices can then be used to make the workplace safer, our performances more efficient, or the companies we work for more productive. At the same time, there is a real danger that employers use these data to invade employees' privacy, exert unfettered control, or make potentially unfair decisions affecting their working lives, for example on wages or promotions. The process of data collection, storage and processing by means of sensors or digital devices is what is commonly referred to as the "digitisation of the workplace" (1), a key driver of the digital revolution (Eurofound 2018). Employers' ability to back-up their decisions with the information provided by these data is what can be referred to as "data-driven management". More formally, data-driven management can be defined as decision-making backed up by a (perceived) objective representation of the situation provided by the (available) data.

Like algorithmic management, data-driven management is a term popularised by Lee, Kusbit, Metsky, and Dabbish (Lee, et al. 2015) referring to work settings, in which "human jobs are assigned, optimized, and evaluated through algorithms and tracked data" (Lee, et al. 2015),. More generally, data-driven management may apply to decision-making in the process of goods production or service delivery (e.g. use of raw material or energy, logistics, sales, etc.), as well as to specific work-related aspects (e.g. recruitment, workshift organisation, tasks assignment, performance evaluation, etc.), giving rise to what has been defined as the "datafication of the workplace" (Sánchez-Monedero and Dencik 2019). In both cases, it affects workers and the workplace; however, when data-driven management is applied to generic aspects of production or service delivery processes, its impacts on work are indirect. For example, choices related to the timeline or the size of production or concerning the overall business model can affect the level of employment, employment relationships and the nature and quality of work. By contrast, when applied specifically to work-related aspects, it has direct implications on work organisation, working conditions and job quality (Kellogg, Valentine and Christin 2020, Wood 2021). This report only focuses on the direct effects of data-driven worker management.

To a certain extent, worker management has strived to be data driven since the dawn of the industrial revolution, with Taylor's scientific management theories and the Gilbreths' motion studies. By breaking down jobs into smaller tasks and collecting enough information on how each task was carried out, it was deemed possible to devise the optimal (most efficient, fastest and cheapest) way to perform a task and impose it upon workers. In Taylor's conception of scientific management, workers were not allowed to make decisions about their work or evaluate actions that might produce a better result; monitoring was a means to make sure work tasks were executed properly and to prevent workers from slowing or sabotaging the modes of production; high performers would be rewarded, whereas low performers would be dismissed. In this sense, a worker in a pin factory of two centuries ago is not that different from a modern warehouse picker or a driver for a ride hailing app. In addition, Taylor's scientific management showed no concern for workers' satisfaction or motivation and was only interested in increasing productivity (OTA 1987, Ball 2010, Rosenblat, Kneese and Boyd 2014). Data were already crucial in that they invested employers with the knowledge and determination of how work was performed, therefore increasing their ability to control the workplace (OTA 1987).

(1) A formal definition of digitisation can be found in chapter 2.

The difference in today's workplace is that the availability of massive amounts of data coupled with technologies that collect them in real time and the increased processing power of enabling technologies has implications that are not only quantitatively, but also qualitatively different both for worker management and for the concept of management in itself. On the one side, many managerial functions, and especially the most standardised, can be increasingly automated; on the other, workers who are constantly monitored and evaluated may be subject to an increase in their workload, a decrease in their autonomy or creativity, and an invasion of their privacy, and therefore experience a drop in their well-being, as well as in productivity.

An extreme example of how the availability of big data can revolutionise management practices can be found in the digital labour platform economy, where data-driven management takes the form of algorithmic management. In digital labour platforms, most managerial functions are replaced by software algorithms, that is, 'computer-programmed procedures for transforming input data into a desired output' (Kellogg, Valentine and Christin 2020, 341, Barocas, et al. 2014, Gillespie 2014). As pointed out by Kellogg, Valentine and Christin (2020), based on extensive evidence, algorithms – and the data they process – can be more comprehensive than any kind of system previously used to support the management of workers precisely because they can rely on large amounts of data collected through a wide range of digital devices.

As suggested by the literature and confirmed by the remainder of this report, albeit typical of digital labour platforms, data-driven forms of management are not uncommon in traditional workplaces, especially in large firms and in sectors such logistics (both in warehouse and delivery work) and to a lesser degree retail, manufacturing, marketing, consultancy, banking, hotels, call centres, and among journalists, lawyers and the police (Wood 2021)

Theoretical models, such as the Job Demand-Control (JDC) model by US sociologist Robert Karasek (R. A. Karasek 1979) and some qualitative studies (Wood 2021, Bérastégui 2021) suggest a potentially negative impact of data-driven management on workers' well-being, as a result of combined low control (autonomy) and high demand (as a result of intensification of work and increased workload). However, not many studies have so far produced robust quantitative evidence, with some exceptions. Urzì Brancati and Curtarelli (2021) carried out an empirical analysis drawing on a unique set of establishments survey data (ESENER 3, described in the following chapter) to investigate the impact of management technologies on occupational safety and health (OSH).

This report contributes to the literature by providing some descriptive evidence and a simplified analytical framework to illustrate how, as a result of enabling technologies, such as the Internet of Things (IoT), Artificial Intelligence (machine learning or deep learning), or wearables, the process of workplace digitisation facilitates the emergence of data-driven management, and how this, in turn, may affect work organisation and aspects of job quality, such as occupational health and safety. Secondly, it provides a summary and a definition of the technologies likely to enable data-driven management and a snapshot of their diffusion across Europe. Thirdly, the report zooms in on selected technologies and looks at their potential impact on work organisation and workplace well-being. In particular, chapter 4 investigates data analytics, that is, the 'use of digital tools for analysing the data collected within the establishment or from other sources' (Eurofound and Cedefop, 2020) and shows its association with several aspects of work organisation and workplace practices, namely: job complexity and autonomy, collaboration with other establishments, pay schemes, training opportunities, establishment performance and workplace well-being. Chapter 5 illustrates the relationship between technologies that can be used for data-driven management, such as wearables, and other devices determining the content or pace of work, or monitoring worker performance, and occupational health and safety. Chapter 6 concludes.

1.1 Policy context in the EU

"A Europe fit for the digital age" is one of the European Commission's six political priorities for the years 2019-2024([2]). One of its key pillar is the European strategy for data (2020)([3]), which aims to make the EU a leader in a "society empowered by data to make better decisions – in business and the public sector". At the same time, the strategy sets out the need to protect citizens from the potential harm associated with emerging digital technologies by building "on a strong legal framework – in terms of data protection, fundamental rights, safety and cybersecurity" (COM(2020/66)). The strategy sets out the plan to create a single market for data; new regulation for data governance to boost data sharing across sectors and Member States ([4]); a European Data Act aiming to ensure fairness by setting up rules regarding the use of data generated by Internet of Things (IoT) devices ([5]). In addition, the European Commission has proposed a declaration on digital rights and principles to the European Parliament and Council (COM(2022)27)([6]) in line with European values..

Currently, the three most relevant legal references for data-driven management at the EU level are: the (EU) 2016/679 General Data Protection Regulation (henceforth GDPR) ([7]); the 2021 proposal for a 'Directive on improving working conditions in platform work' (COM(2021) 762) ([8]); and the 2021 Artificial Intelligence Act (COM(2021/206) ([9]), which builds on the Communication on Artificial Intelligence of 2018 (COM (2018) 237) ([10]).

The GDPR provides a single legal interface to the entire EU digital market; it regulates the processing of personal data, whereby 'processing' means 'any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction' (GDPR, art. 4, definitions). Even though the GDPR does not include specific protection for workers or employees, many of its provisions apply to the employment relationship. According to article 19, processing personal data during a person's employment may take place if it is both necessary and proportionate. Consent is not used as a legal ground for data processing in the workplace due to the power imbalance between employers and employees: because the employer has authority over the employee and the employee is financially dependent on the employer, permission from an employee to an employer to process their personal data is not considered to be freely given (Todolí-Signes 2019). Article 22 prohibits fully automated decisions in terms of dismissing or punishing individual workers (based on processed data) without meaningful intervention of a human manager (Wood, 2021). However, the exact meaning of what would constitutes a meaningful intervention is debated.

([2]) https://european-union.europa.eu/priorities-and-actions/eu-priorities_en
([3]) EU Communication 2020/66: 'A European strategy for data' https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0066&from=EN
([4]) Data Governance Act https://digital-strategy.ec.europa.eu/en/policies/data-governance-act
([5]) Dta Act https://digital-strategy.ec.europa.eu/en/policies/data-act
([6]) https://op.europa.eu/en/publication-detail/-/publication/6a2cfdb8-2101-11ec-bd8e-01aa75ed71a1/language-en
([7]) Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation) (Text with EEA relevance). https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0679&from=EN
([8]) Proposal for a Directive of the European Parliament and of the Council on improving working conditions in platform work, https://ec.europa.eu/commission/presscorner/detail/en/ip_21_6605
([9]) Proposal for a Regulation of the European Parliament and of the Council Laying Down Harmonised Rules on Artificial Intelligence (Artificial Intelligence Act) and Amending Certain Union Legislative Acts, COM (2021) 206 final (April 22, 2021). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0206
([10]) Communication from the Commission to the European Parliament, The European Council, The Council, The European Economic and Social Committee and the Committee of the Regions, Artificial Intelligence for Europe, COM (2018) 237 final (June 26, 2018).

According to Todolí-Signes (2019), only human intervention that can change the outcome produced by a computer system by accessing different aspects can be interpreted as such. Article 22(3) also sanctions the right to an explanation; when an automated decision is taken, the data controller has the obligation to inform the data subject of the reasons that led to that decision and provide details as to what parameters it has used to reach the decision in question.

The 2021 proposal on platform work (COM(2021)762) tries to overcome some of the limitations of GDPR regarding automated decisions and establishes a number of requirements for digital labour platforms to strengthen (platform) workers' rights. Chapter III, article 6, 8 and 9 refer to the use and key features of automated monitoring systems and automated decision-making systems and require that platforms inform, explain and consult the workers or their representatives when such systems affect their working conditions. In addition, article 6 reiterates the limits to data processing already established in the GDPR, namely, that platforms are not allowed to process data that are not strictly necessary for the performance of the worker's contract, such as data on conversations, on the health or emotional state of the worker and so on. Article 7 recognises the potential time pressure that automated systems might create for platform workers and establishes that digital labour platforms must "evaluate the risks of automated monitoring and decision-making systems to the safety and health of platform workers and ensure that such systems do not in any manner put undue pressure on platform workers or otherwise put at risk the physical and mental health of platform workers". Regrettably, a similar disposition is not (yet) envisaged for workers outside digital labour platforms.

Finally, the 2021 Artificial Intelligence Act (AI ACT) lays down the basis for the regulation of algorithmic management, and in particular it addresses i) AI systems used for recruitment; and (ii) AI systems used for promotion and termination of contracts for work, for allocating tasks, and for monitoring and evaluating workers' behaviour (p.26, n. 36). The regulation for high risk AI systems set out in chapter 2 of the Act essentially sets out design criteria that providers must put in place: a risk management system that identifies, evaluates, and mitigates risks (article 9); criteria for data governance (article 10) including "examination in view of possible biases" and that "Training, validation and testing data sets shall be relevant, representative, free of errors and complete". It should be noted that, according to the AI Act, most of the obligations fall upon the AI provider, that is, the person/body that develops or markets the AI, and not on the user (or the employer) who simply has to make sure the instructions are followed and the data inputted are relevant.

As this report shows in the next section, the potential for data-driven management practices to spread to traditional workplaces is quite large, especially in some EU member states, and it may carry some unwanted side-effects, in terms of increased time pressure, work intensity and so on. For this reason, EU legislation must be comprehensive and cover all potential impacts of data-driven management on workers. The remainder of this report investigates some impacts of data-driven management on workers that should be taken into account by the legislator – besides automation of managerial functions, privacy issues and biases that may lead to discrimination.

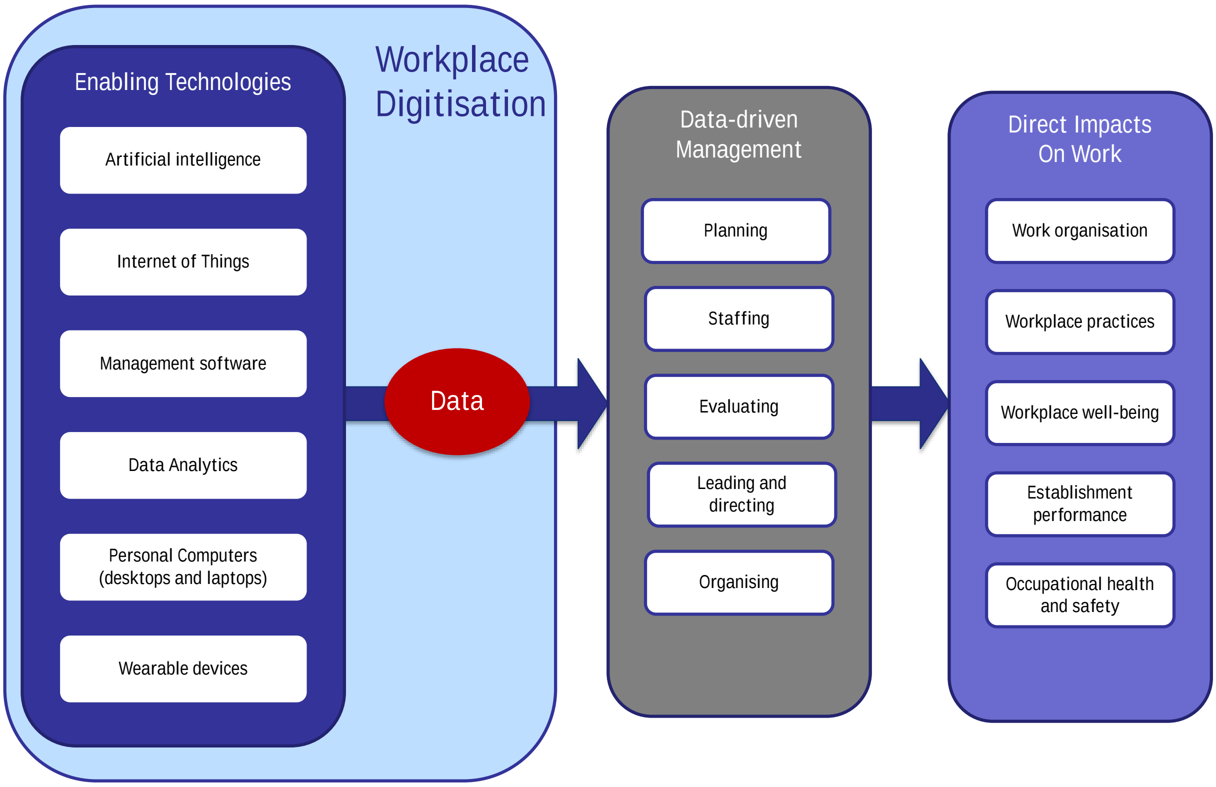
2 Simplified analytical model and key definitions

The digitisation of processes —that is, the conversion of analogue or mechanical elements of the physical world into bytes (and vice versa) via means of sensors or rendering devices— is one of the main channels through which the digital revolution is changing the nature of work (Eurofound 2018). It is driven by a number of technologies able to collect, store, process and analyse data. Not all enabling technologies considered in this report – and described in the next section - are able to perform all data functions: some can only collect and store data, while others can only process and analyse them; for this reason, firms tend to adopt several technologies at once and exploit complementarities.

Figure 1 summarises how, as a result of enabling technologies, the process of workplace digitisation facilitates the emergence of data-driven management, and how this, in turn, may affect work organisation, workplace practices and well-being, establishment performance and aspects of job quality, such as occupational health and safety.

The next subsections will describe and define the concepts expressed in Figure 1.

Figure 1. Simplified analytical approach



Source: Authors' elaboration

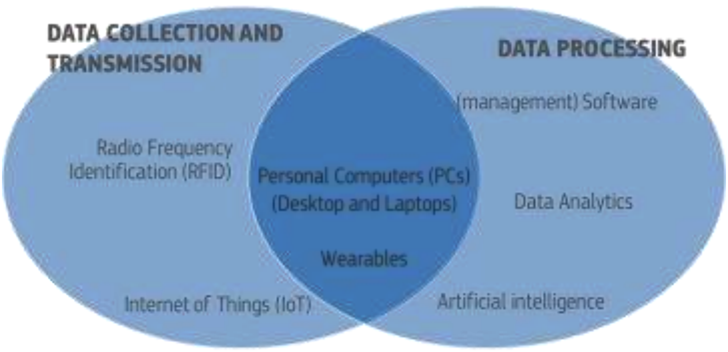
2.1 Enabling technologies

To understand how the digital technologies considered in this report enable data-driven management, we first group them according to the functions performed on/with data (Klingenberg, Viana Borges and Valle Antunes 2019). In particular, some technologies allow for data collection and transmission, while others allow for data processing and analysing; many of them, however, can do all functions. The former are technologies that collect data from their environment and are able to transfer it from one place to another; typical examples are the Internet of Things or wearable devices. The latter are technologies that transform the data they are fed with into an output, still in the form of data; examples are Artificial Intelligence, or computer software (see Figure 2).

The large amount of data involved in these processes tends to require data storage technologies, such as cloud services ([11]), which often accompany the other types of technologies mentioned below, but fall outside the scope of this report.

Digital devices often embed many of these technologies, to allow for several data functions to be performed simultaneously. As in the examples in Figure 2, digital devices, such as computers and wearables, can potentially perform data collection and transmission, as well as data processing if they embed technologies that allow these functions: often wearables used in warehouses collect and transmit data, but they also process them and send automated instructions based on the processed data. The same applies to personal computers, which can collect and transmit data (providing that they are programmed to do so and connected to the internet/intranet), and process data with the software included in the device. Digital devices are therefore crucial in the implementation of data-driven forms of management.

Figure 2 Data functions of selected enabling technologies and devices



Source: Authors' compilation

Note: the groups of technologies and devices include only technologies that are in the scope of this report and are considered in the analyses in the following chapters. It should be noted that IoT, in some cases, may include also data processing technologies and it functions, by definition, through interconnected digital devices.

([11]) According to the definitions in the Community survey on ICT usage and e-commerce in enterprises 2021 – General outline of the survey "Cloud computing refers to ICT services that are used over the internet to access software, computing power, storage capacity etc".

The list of technologies in Figure 2 could be complemented by many other technologies, including also new technological developments in the future. As of now, other technologies for data collection, transmission and/or processing include the Global Positioning System (GPS),digital sensors as well as block chains, cybersecurity systems or software interface applications, to give other few examples.

As for digital devices that embed both technologies for data collection and transmission and those for data processing, another important example is that of mobiles or smartphones. However, to maintain the focus on the technologies analysed this report, classifications and definitions in Figure 2 include only the technologies that are considered in the following chapters.

Data-driven management relies on interconnectivity and combination of different types and layers of technologies that in the end are all interrelated. In the implementation of data-driven management, these technologies are often adopted together, allowing the use of data within an organisation to coordinate operations, or work specifically. Digital devices are the 'visible' part of this technology combinations, embedding different layers of technologies and those to perform different data functions at the same time.

Internet of things

Internet of things (IoT) is a system of interconnected sets of entities encompassing smart devices, sensors, and products collecting and analysing data and autonomously performing actions; it relies on ubiquitous and pervasive connectivity, computing capability, and large amounts of data. The fields of application for IoT technologies are numerous and diverse, including transportation and logistics; healthcare; smart environments (home, office, plant); and, of course, the personal and social domain (Atzori, Iera and Morabito 2010, Eurofound 2020, Khodadadi, Dastjerdi and Buyya 2016). The term IoT was coined by British technology pioneer Kevin Ashton in 1999 to illustrate how connecting Radio-Frequency Identification (RFID) tags to the Internet would allow the collection, processing and transmission of data without the need for human intervention, thereby greatly reducing costs (Kramp et al, 2013). Although IoT systems can be used in any setting, when used in the workplace they collect data on the production or service delivery processes, and therefore enable data-driven forms of management.

Artificial Intelligence

The European Commission Artificial Intelligence Act (AI Act) defines AI as software that, for a given set of human-defined objectives, can generate outputs such as content, predictions, recommendations, or decisions influencing the environments they interact with. AI systems are developed with one or more of the techniques and approaches listed below:

— machine learning, including supervised, unsupervised and reinforcement learning, using a wide variety of methods including deep learning

— logic and knowledge-based approaches, including knowledge representation, inductive (logic) programming, knowledge bases, inference and deductive engines, (symbolic) reasoning and expert systems;

— statistical approaches, Bayesian estimation, search and optimization methods

The AI technologies surveyed by Eurostat's ICT Survey include: text mining, computer vision, speech recognition or image recognition, natural language generation, machine learning or deep learning. The technologies surveyed also include AI-based software for robotic process automation and technologies enabling physical movements of machines thanks to autonomous decisions based on observation of surroundings (e.g. self-driving vehicles, autonomous robots or drones).

Data analytics

In statistics, Data Analytics (DA) is the process of examining datasets in order to draw conclusions about the information they contain, increasingly with the aid of specialised systems and software([12]). Data analytics can be categorised into descriptive, predictive and prescriptive analytics (T. Davenport December 2013, Sharda, Delen and Turban 2015, Berndtsson, et al. 2018)While the descriptive approach uses a dataset for a better understanding of past events, predictive and prescriptive analytics are more advanced techniques. Predictive analytics are used to predict future outcomes and trends by uncovering previously unidentified data patterns, and prescriptive analytics assesses current data to help companies automate decision making. These techniques can be applied to sets of big data that often contain unstructured and semi-structured data. Both predictive and prescriptive analytics increasingly exploit AI techniques (machine learning or natural language processing) for more precise predictions and larger scale business optimisation. The main difference between artificial intelligence and data analytics is that, while both techniques are able to generate predictions, an AI system is also able to make assumptions, test and learn autonomously.

Wearable devices

The reflection and orientation paper on smart wearables published in 2016 by the European Commission defines wearable devices as "body-borne computational and sensory devices which can sense the person who wears them and/or their environment" ([13]). Wearable devices can interact with each other directly either wirelessly or through another device (such as a smartphone). Smart wearable devices may have control, communication and data storage functions. A wearable may contain several types of sensors, integrated as a system on a module. The sensors sense physiological phenomena from the user or from surrounding environment. The wearable processes this information and acts (e.g. display some visual content, play some audio content, send an alert, provide force feedbacks) on the user."

Management software applications

Management software applications, such as software for Customer Relationship Management (CRM) and Enterprise Resource Planning (ERP), have long been used for data elaboration to inform management decision-making, relying on data collected through interconnected computers across different business functions (Sánchez-Monedero and Dencik 2019)

CRM refers to an integrated management information system that is used to schedule, plan and control the sales and pre-sales activities in an organization. CRM systems comprise of hardware, software and networking tools to improve customer tracking and communication. The software processes data about customers to improve customer service by facilitating communication, for instance with more user-friendly mechanisms to log a complaint, or pre-empt problems ([14]).

ERP is a commonly used software application to facilitate the flow of data across several functions of an enterprise, such as planning, purchases, marketing, sales, customer relationship, finance and human resource ([15]).

([12]) https://ec.europa.eu/eurostat/cros/system/files/dawosreport_0.pdf
([13]) Smart Wearables: Reflection and Orientation Paper, available at: https://ec.europa.eu/newsroom/document.cfm?doc_id=40542
([14]) https://ec.europa.eu/eurostat/cros/content/Glossary%3ACustomer_Relationship_Management_%28CRM%29_en .
([15]) https://ec.europa.eu/eurostat/statistics-explained/index.php?title=E-business_integration#Enterprise_resource_planning_.28ERP.29 .

Other management technologies

This report also presents descriptive statistics on the distribution and potential impacts of other technologies enabling data-driven management, such as 'machines, systems or computer determining the content or pace of work' or 'monitoring performance'.

These technologies can be employed to facilitate the management of different aspects of an organisation, from security to energy consumption, from the supply of raw materials or components to marketing and sales. When enabling technologies are adopted and used for purposes that directly involve workers, for example for monitoring purposes or for Human Resources (HR) practices, the implications of data-driven management are directly affecting workers. Otherwise the impacts are likely to be indirect. Regardless of the purpose for which a technology is introduced in an organisation, its deployment should take into account both intended and unintended consequences, direct and indirect effects for workers (Edwards and Ramirez 2016).

2.2 Data driven management

In the words of F.W. Taylor, management is an art of knowing what to do, when to do and see that it is done in the best and cheapest way. In the context of a firm, it can be described as the process by which an organisation uses resources, mainly people, to efficiently achieve a set of goals (Cole and Kelly 2020). It then follows that under data-driven management, the use of resources is made efficient as a result of decisions backed up by data. This definition is, however, somewhat tautological, so to try and understand what data-driven management actually means, the best option is to break down the concept of management itself into its components, that is, into managerial functions, and see to what extent each function can be informed or automated as a result of data availability.

The first attempt to classify managerial activities into specific functions date back to the French engineer Henri Fayol at the beginning of the 20th century. According to Fayol, the five essential functions of management were: forecast & plan, organise, command, coordinate, and control. The more modern and commonly accepted version of the five functions of management was proposed by Koontz and O'Donnell (1972) who replaced harsh words such as "command" with more employee friendly terms such as leading and directing. The basic ideas remained however unchanged. According to Koontz and O' Donnell, the five essential functions of management are:

1. *Planning*: the process of appraising the present position of an organisation (setting the premises); anticipating and forecasting the future environment; formulating long term and short term goals; selecting the strategies for their realization, and evaluating alternatives. Planning involves thinking creatively about issues at hand.
2. *Organising*: the process of identifying and classifying activities; assigning duties; and providing the necessary authority to carry out such duties – in other words, it involves the design of individual jobs within an organisation. The organising function is vital because it provides an organisation with a structure.
3. *Staffing* is the process of filling positions within the organisation through proper and effective selection. The staffing process has the following steps: personnel acquisition (which may include forecasting staffing needs, recruitment, and selection) and personnel retention (which may include transfer and promotion, training, and remuneration).
4. *Directing* and leading is the process in which the manager instructs, guides and oversees workers' performance to achieve the planned goals. It involves influencing and motivating and can be considered the executive function of an organisation (whereas the other managerial functions can be seen as preparatory).

5. *Controlling* is the process of ensuring the objectives of the organisation are met. Controlling ensures that all other functions are executed correctly and everything occurs in conformity with standards. An efficient system of control helps to predict deviations before they actually occur. It includes the establishment of standard performance, measurement and evaluation of actual performance, and corrective action.

These activities are common to each and every manger irrespective of their level or status.

While, to the best of our knowledge, not much has been written on the managerial functions affected by data-driven management, the literature on algorithmic management can provide some useful insights.

Data-driven management is an umbrella concept that includes algorithmic management. Algorithmic management is defined as the use of computer-programmed procedures (i.e. the algorithms), which can be both AI or non-AI powered, to coordinate labour input in an organisation (i.e. the management) (Baiocco, et al. 2022). As such, algorithmic management is a particular form of data-driven management that is applied specifically to worker management and it involves some degree of data processing through algorithms, in addition to data collection. In general terms, an algorithm is 'a set of rules that must be followed when solving a particular problem'. For the scope of this report, however, the term is more specific and refers to software algorithms, that is, 'computer-programmed procedures for transforming input data into a desired output' (Kellogg, Valentine and Christin 2020). Algorithmic management is most developed in digital labour platforms, where it leads to higher degree of automation of management functions in comparison to its applications in other work settings (Wood, 2021). However, even in digital labour platforms, algorithmic management does not reach a full degree of automation, but rather requires a combination of human activity and algorithms (Wood, 2021).

Whether automating or assisting, algorithms can deeply transform several management functions. Kellogg and co-authors refer to the "6 Rs" mechanisms through which algorithms coordinate work (i.e. restricting and recommending, recording and rating, replacing and rewarding), while Wood (2021) mentions three main functions, namely direction, evaluation and discipline of workers through algorithmic management. Finally, Baiocco, et al. (2022) claim that the introduction of algorithms to perform the different functions of management implies a fundamental departure from traditional human management practices, with new forms of control, monitoring and disciplining of workers emerging on digital labour platforms.

The main difference between algorithmic management and generic forms of data-driven management is that the former implies more or less a substitution of human (managerial) activities with algorithm based automated procedures, whereas under the latter, management can be not only complemented, but also and especially enhanced and improved due to the use of data. In other words, under algorithmic management, especially if AI-powered, algorithms can be programmed to make autonomous decisions regarding workers (within the limits set by the law, as illustrated in section 1.1), whereas the concept of data-driven management is somewhat more nuanced and can be applied also to less sophisticated technologies that provide managers with information based on the collected and processed data, and help them make better decisions.

2.2.1 What does data-driven management look like? Examples from the literature

Logistics and warehousing is arguably one of the most automated and digitised economic sector and offers a plethora of examples of data-driven management to draw from. Typically, it is the use of the Internet of Things or wearable devices - worn on the head, wrist, chest, fingernail and feet - that provide the organisation with a variety of performance, environment and body data (Ball 2021).

Alessandro Delfanti's study of Italian Amazon warehouses reports how data collected by handheld and wearable devices are used to direct, control and evaluate workers (Delfanti 2019). Sensors track workers' every movement around the floor, and the collected data are used by algorithmic systems to allocate tasks, re-route workers (based on their location and the proximity to item's position on the shelf), and set a maximum amount of time a worker has to complete their task (referred to as 'pick rate'). At the same time, warehouse managers can see real-time data on workers' pick rate, and use such data to evaluate their performance, set standards, discuss firm productivity during meetings, and so on (Wood, 2021). Incidentally, managers can also see how many times a worker went to the bathroom, giving rise to what is known as 'function creep" ([16]).

Another example of data-driven management is illustrated in the study of a port terminal in the South of Spain (TTA Algeciras) conducted by Grande, Vallejo-Peña and Urzì Brancati - also featured in Eurofound's latest report on digitisation (Eurofound 2021). The terminal uses the Internet of Things and other ancillary digital technologies to track and maintain containers and other equipment. It is endowed with a tailor made Terminal Operating System (TOS) - an advanced computer system managed remotely - which generates automated orders by processing all the data received through IoT technology. In addition, the TOS can process and analyse data at high speed, providing useful information (e.g. a longitudinal analysis of the energy consumption of machines) to engineers and managerial staff. In this way, further improvements can be introduced by management. Finally, data collected via IoT allows engineers and other technical staff to apply predictive maintenance, as they can observe the operation of machinery in detail. The system provides warnings of any deficiencies that could develop into breakdowns, or on parts that need to be replaced in advance, based not only on the time elapsed but also on their condition. Eurofound's report also describes other examples of IoT based data-driven management, notably for the Estonian gelling agent producer Est-Agar and the Italian Centro Seia plant nursery. In both cases, IoT technology was introduced specifically to monitor the quality and quantity of work done by employees, influencing to some extent their behaviours at work, reducing informal exchanges and interactions during working time and guiding important employment decisions, for example about promotions, financial incentives or even dismissals (Eurofound 2021).

In the logistics industry, transport firms use real-time fleet management systems and GPS tracking in vehicles. Whilst this is partly to comply with working time regulations and to manage liability in the event of an accident, the performance of the driver and their vehicles are also monitored by these means (Levy 2015). Amazon installed AI powered cameras on its vans to, ostensibly, improve drivers' (or 'delivery service partners') safety ([17]). The cameras, named Driver(i), are able to capture the road ahead, the driver, and both sides of the vehicle; when detecting risky behaviour by drivers they will bark verbal warnings like "Distracted driving," "No stop detected" and "Please slow down" (Wood, 2021). The data gathered by Driver(i) are also used to evaluate workers' performance scores and can affect their chances of getting bonuses, extra pay, and prizes ([18]).

Among digital labour platforms, arguably the best-known example of data-driven management is provided by the taxi hailing app Uber. Through its smartphone app, Uber collects GPS, gyroscope and accelerometer data from drivers and store them long term for a number of purposes, such as directing, evaluating and disciplining workers, as well as informing its research in self-driving cars (Ball 2021, Wood 2021). Wood (2021) also explains that the Uber app directs the route that divers are supposed to take and fine them (at least in the US) if they follow a less efficient route or how it directs drivers to charge customers a maximum fare based on distance, city and labour supply.

([16]) Function creep" occurs when information is used for a purpose that is not the original specified purpose.
([17]) https://vimeo.com/504570835/e80ee265bc .
([18]) https://www.vice.com/en/article/88npjv/amazons-ai-cameras-are-punishing-drivers-for-mistakes-they-didnt-make

2.3 Data driven management and its potential impacts on work: an overview

As mentioned in section 2.1, the impacts of data-driven management on work take place through changes in managerial functions – in other words, when based on the extensive data collected by digital tools, managerial functions such as directing, organising, evaluating workers and so on, may be intrinsically transformed and that has an impact on work organisation, workplace practices, establishment performance, and occupational safety and health. For example, with the data-driven management, rewarding and penalising can happen in real-time, underperformance can be instantaneously identified and can result in dismissal and immediate reallocation of job tasks to other workers (Kellogg, Valentine and Christin 2020). Data-driven management, but especially algorithmic management, is reported to reduce workers' autonomy and control over how a job is done. Incentivising and influencing workers' behaviours towards desired goals through a system of nudges and penalties (Kellogg, Valentine and Christin 2020) can result in a number of issues for workers' mental health. Data-driven forms of management could also affect firms' business models, as a result of a more centralised control over processes while at the same time fragmenting production or service delivery, in time and space or across several actors (Adams Prassl 2019). This can lead to new ways of organising work and cooperation within and among enterprises. These ways could include outsourcing and subcontracting (Loebbecke and Picot, 2015).

2.3.1 Work organisation and workplace practices

Work organisation, and how jobs are designed to support it, is part of the management of the employment relationship (ECS 2019) ([19]). In its broadest sense, work organisation is about the division of labour, the coordination and control of work. It encompasses the tasks performed, who performs them and how they are performed in the process of making a product or a service. It refers to 'how work is planned, organised and managed within companies via production processes, job design, task allocation, rules, procedures, communication, responsibilities, management and supervisory styles, work scheduling, work pace, career development, decision-making processes, interpersonal and interdepartmental relationships (Eurofound 2022).

Within the framework provided by Eurofound and Cedefop's European Company Survey, aspects of work organisation potentially affected by data-driven management are collaboration and outsourcing and job complexity and autonomy. In addition, the impact of data-driven forms of management can lead to new ways of organising work and cooperation within and among enterprises, such as outsourcing and subcontracting (Loebbecke and Picot 2015).

Job complexity and autonomy are linked to the managerial function of control. Employers (or management) can exert direct control by designing jobs which give individual workers or teams more or less autonomy or challenges (problem solving). They can also exert indirect control through incentives. Managerial control is also reflected in the way tasks and responsibilities are allocated and in the way teamwork is used (Eurofound and Cedefop 2020).

Often, monitoring is linked to incentive and penalty mechanisms. Traditional forms of management rely on systems of incentives and penalties in which workers with desired behaviours are rewarded with promotions, increased pay, progressively higher responsibility, more benefits, preferred tasks, etc. while those who do not behave as desired can be dismissed according to existing regulation, policies, etc. (Ball 2021). The reward system and its quick responsiveness can lead to workers' frustration and stress when the system is intentionally not transparent; in addition, it can result more generally in a significant increased (both subjective and objective) job insecurity and work intensification (Bérastégui 2021, Eurofound 2022).

([19]) European Company Survey 2019: Workplace practices unlocking employee potential.

2.3.2 Workplace wellbeing and occupational safety and health

One of the functions of management that is more likely to be data-driven consists in the control (surveillance and monitoring) of workers. Henderson, Stanford and Swann (2018) explain how employers use tools to directly control the pace and intensity of work in combination with monitoring and supervising systems, to extract maximum work effort from employees.

Data-driven management can result in higher isolation and lack of social support of workers, for example in cases where human supervisors are replaced by algorithms and tasks are allocated automatically on a screen of a handheld device, with little to no time for interaction. When workers are deprived of organisational support ([20]), they can experience increased stress, anxiety and even burnout (Bérastégui 2021). Co-workers and supervisors' support are both positively related to organisational support, though supervisor support has a significantly stronger effect because supervisors are seen as acting on behalf of the organisation through their responsibilities of directing and evaluating workers' performance (Kurtessis, et al. 2017). A supportive work environment is characterised by positive social interactions helping workers to cope with uncertainty or stressful circumstances.

The literature has found that management associated with technologies that determine the content or pace of work is linked to intensification of work, and therefore an increase in workers' stress and mental health issues. For example, in working contexts that rely on algorithmic management, evidence has shown that the speed of computing processes and the data-driven directions and instructions can result, for workers, in a hectic pace of work to meet deadlines and achieve targets, hence resulting in quantitative overload ([21]) (Bérastégui 2021). 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, Menon and Spector 1999) that may ultimately result also in a lower level of worker's performance (Westman and Eden 1992). To make things worse, workers subject to algorithmic management 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'" (Bérastégui 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 (Bérastégui 2021). Urzí Brancati and Curtarelli (2022) find that the presence of management technologies in an establishment is associated with a higher number of psychosocial risks and that this relationship is only partly mediated by OSH preventive measures. In particular, only allowing workers to take more decisions on how to do their job and having an action plan to reduce work-related stress are associated with lower reported psychosocial risks. In other words, being proactive and having a plan in place to pre-empt problems can be the most effective way to reduce stress in the workplace.

Working under data-driven forms of management, and especially algorithmic management, appears to be particularly demanding and straining for workers; it can therefore have a significant impact on workers' mental health, which is detrimental also for the organization in which they are

([20]) Social support refers to the degree to which individuals perceive that they are valued and supported in the workplace ((Eisenberger, et al. 2002, Kossek, et al. 2011, Sias and Gallagher 2009)

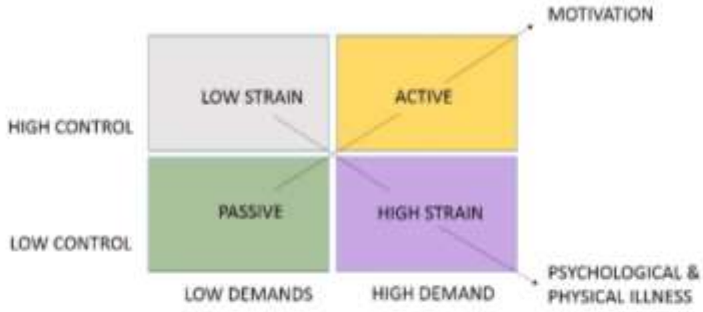
([21]) Quantitative overload can be defined as performing a high amount of work in a given timeframe.

employed. Workers can feel frustrated when recommendations are unintelligible to them, or feel powerless, especially when the algorithmic direction is perceived as unfair. When algorithms allow specific behaviours while preventing others (Kellogg, Valentine and Christin 2020) workers can experience alienation, losing control over their work and being "deprived of the right to conceive of themselves as directors of their own actions (Kellogg, Valentine and Christin 2020, 375).

Applying the Job Demand-Control (JDC) model by Karasek (1979) on occupational stress, the combined low control (as explained above) and high demand (as a result of intensification of work and increased workload), which feature jobs under data-driven management practices and in particular algorithmic management, would result in "high-strain" jobs, associated to increased stress and health issues for the worker.

In the developed Job-Demand-Control-Support (JDCS) model (Karasek and Theorell 1990, Johnson and Hall 1988), support from the organization can be seen as a mitigating factor to limit the impact of "high strain" jobs on workers' health. Yet, it should be taken into account that data-driven forms of management frequently result in isolation and lack of support from supervisors and managers. Therefore, managers' and supervisors' support cannot be considered a mitigating factor of the impact of "high strain" jobs on occupational health in this context. Yet, initiatives or measures can be adopted by the employer to mitigate the impact of these forms of management on occupational health.

Figure 3 Job Demand-control model



Source: Adapted from Karasek (1979)

Research dating back to the 1990s already demonstrated a clear link between performance monitoring – carried out with or without the use of digital devices – and employee stress (Aiello 1993, Aiello and Svec, Computer monitoring of work performance: Extending the social facilitation framework to electronic presence 1993). The burden of feeling or being under constant 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 Schultz 2017). On the other hand, performance monitoring may have a positive impact if workers can use feedback to advance their careers, get better pay, and have their health and safety protected (EU-OSHA 2018). However, intensive monitoring 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. If workers are concerned that decisions are made based on data that they have neither access to nor power over, and that 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, their concerns can result in stress and be detrimental for mental health (EU-OSHA 2019).

If job security can be defined as an employee's perception that their job (or an important aspect of their job) is secure (Burchell 2014), job insecurity refers to the potential loss of the job itself (or of one or more of its key components e.g. pay or role/responsibilities). This definition underlies the risk of loss of something of value, anticipation of the consequences of losing their job and powerlessness (Rogelberg 2017). Job insecurity is one of the most important psychosocial risk factors and a major work-related stressor linked to several negative health outcomes, such as poorer mental health (Sverke, Hellgren and Näswall 2002, Bonde 2008, Stansfeld and Candy 2006);. Perceived job insecurity may result in burnout, depression and anxiety and can also be related to poorer self-rated physical health with issues including fatigue or pain, and cardiac problems such as high blood pressure or ischemic heart disease (Hellgren and Sverke 2003, Burgard, Brand and House 2009).

According to a recent systematic review of electronic monitoring and surveillance in the workplace, wearable devices have two applications in the workplace: as part of corporate wellness programs and as part of performance management in highly automated settings such as logistics warehouses (Ball 2021). Employees who take part in corporate wellness programmes are encouraged to use output (data) from their wearables to compete or collaborate with colleagues; though the data collected by corporate wellness wearables are not seen by the employee only, but by management too, and can used to evaluate workers' performance.

Wearables used to monitor the physiological responses of employees, such as heart-rate variability or electrodermal activity (perspiration), may serve as a proxy for employees' stress responses or fatigue. Activity wristbands can thus alert employees to take breaks from work when their performance degrades in order to optimize productivity (Maltseva 2020).

3 Enabling technologies for data-driven management: a snapshot

As pointed out in chapter two, data-driven management is enabled by the use of digital technologies that collect, store, process and analyse data. The distribution of such enabling technology can therefore provide a rough idea of the potential diffusion of the phenomenon itself.

Three main sources are used to show the distribution of digital devices and technologies enabling data-driven management across Europe: *Eurostat's Community Survey on ICT usage and e-commerce in enterprises* (henceforth the ICT survey); the *European Company Survey* (ECS), and *European Survey of Enterprises on New and Emerging* Risks (ESENER).

Box 1 : The Community survey on ICT usage and e-commerce in enterprises

The Community survey on ICT usage and e-commerce in enterprises is an annual survey conducted since 2002, collecting data on the use of information and communication technology, the internet, e-government, e-business and e-commerce in enterprises.

Data provided in this domain are collected on a yearly basis by the National Statistical Institutes and are based on the annual Eurostat model questionnaires on ICT (Information and Communication Technologies) usage and e-commerce in enterprises. It supports measuring the implementation of one of the six priorities for the period 2019-2024 of the von der Leyen European Commission – A Europe fit for the digital age.

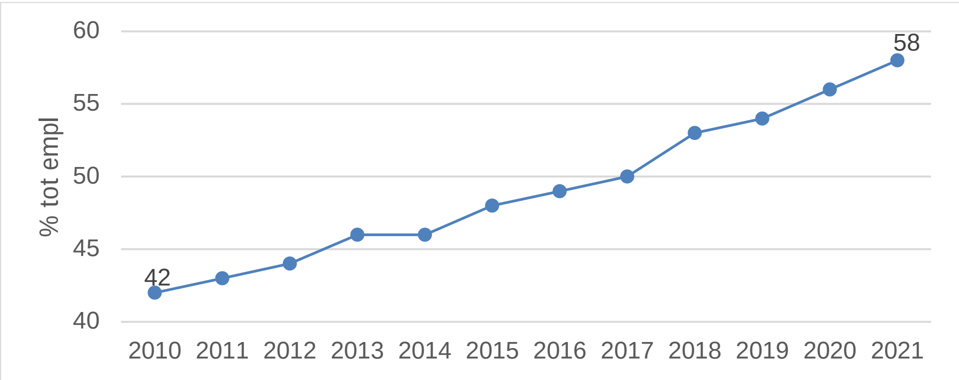
The survey population consists of enterprises with 10 or more employees and self-employed persons.

3.1 Data collection and processing across Europe

3.1.1 Computers and connectivity

Together with mobile phones, computers connected to the internet are the most common devices that enable data-driven forms of management in traditional workplaces. When employees use interconnected computers, the employer can collect data on their activity, work processes and beyond. Between 2010 and 2021, the share of employees using a computer with an internet connection has risen steadily from 42% to 58% (Figure 4).

Figure 4 Use of computers and the internet by employees - EU27, 2010-2021



Source: Authors' elaboration based on Eurostat, 2021 – Table [isoc_ci_cm_pn2].
Note: Data for all enterprises with 10 employees or more, excluding the financial sector.

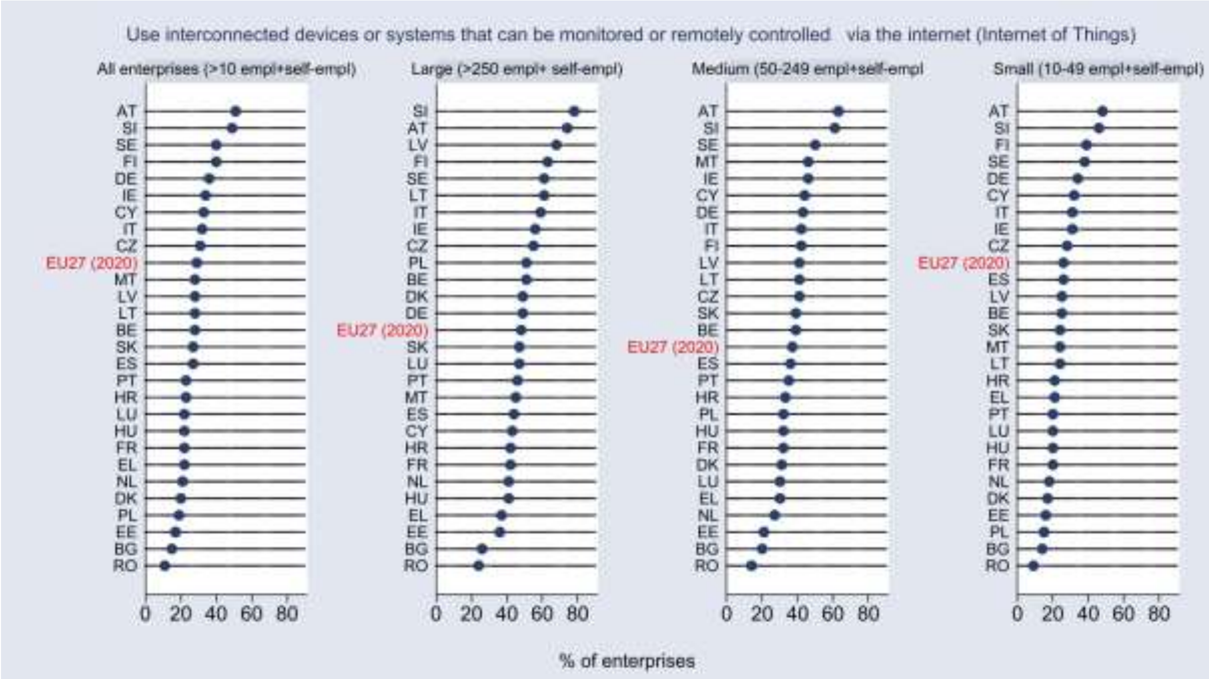
The widespread use of connected computers reflects the digitisation trend while providing a baseline for data-driven management. Conditional on the adoption of technology for data processing, which sometimes can be embedded in computers themselves, the data collected from computers can be used for management purposes at any time.

The acceleration of the digital transformation in the workplace is reflected in the broad diffusion of more complex technologies, among which the IoT, (big) data analytics and artificial intelligence are primary examples. To inform management decisions, the data collected need to be processed. For example, the IoT can be complemented by technologies to process the large amount of data collected, including some forms of AI, like machine or deep learning. However, even before the rise of AI, other technologies for data elaboration have enabled data-driven forms of management.

3.1.2 Internet of Things (IoT)

As shown in Figure 5, IoT is present in approximately 29% of the enterprises with 10 or more employees in the EU27, albeit with significant difference among member states, from approximately 51% of the enterprises in Austria to a little more than 10% in Romania. Predictably, it is also more widespread among large enterprises (48% in EU27) than medium or small sized firms, with 37% and 26% of them using IoT respectively.

Figure 5 Distribution of Internet of Things, by country and firm size (2021)

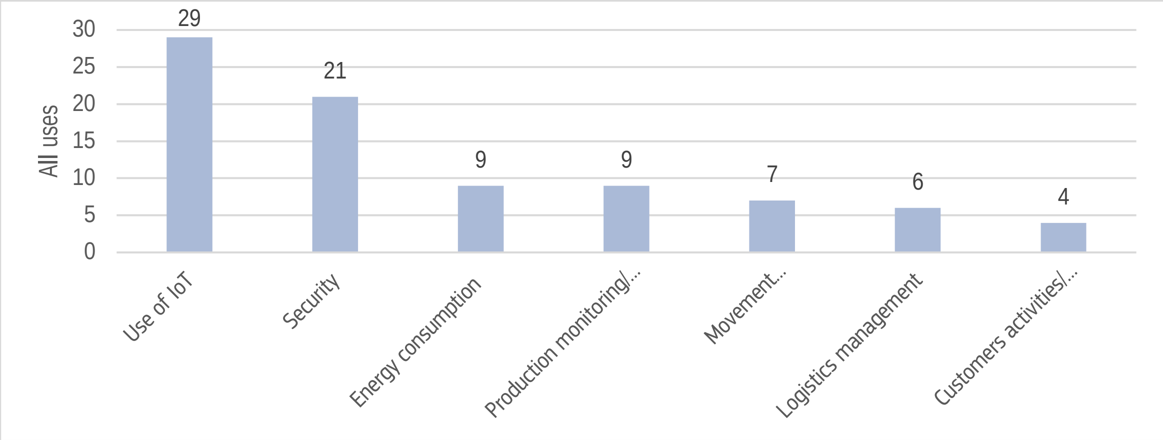


Source: Authors' elaboration based on Eurostat data 2021 [isoc_eb_iot]

The most common use of IoT is for security purposes at the enterprise's premises, as, according to the ICT survey, 21% of enterprises in the EU use IoT for this purpose. Energy consumption and production monitoring and/or automation are the following two second-most common purposes, employed by 9% of EU enterprises each. 7% and 6% of the EU enterprises use IoT, respectively, for tracking movements to offer vehicle maintenance and for logistics management. Finally, 4% of the EU enterprises use it to improve customer services, monitor customer activities and offer personalised shopping experience (Figure 6).

All these different purposes indicate that data are largely available to inform management decisions in these enterprises. Even when IoT is not used to specifically track workers' movement or monitor their activity, the processed data can still be used by management to change some aspects of work organisation or workplace practices. For instance, the use IoT for customer monitoring or products tracking, can lead to automated task or route assignment; whereas IoT systems, including interconnected cameras, for security reasons can eventually lead to new forms of pervasive monitoring of employees (Muñoz Ruiz 2022).

Figure 6 Use of IoT by its purposes in enterprises - EU27, 2021

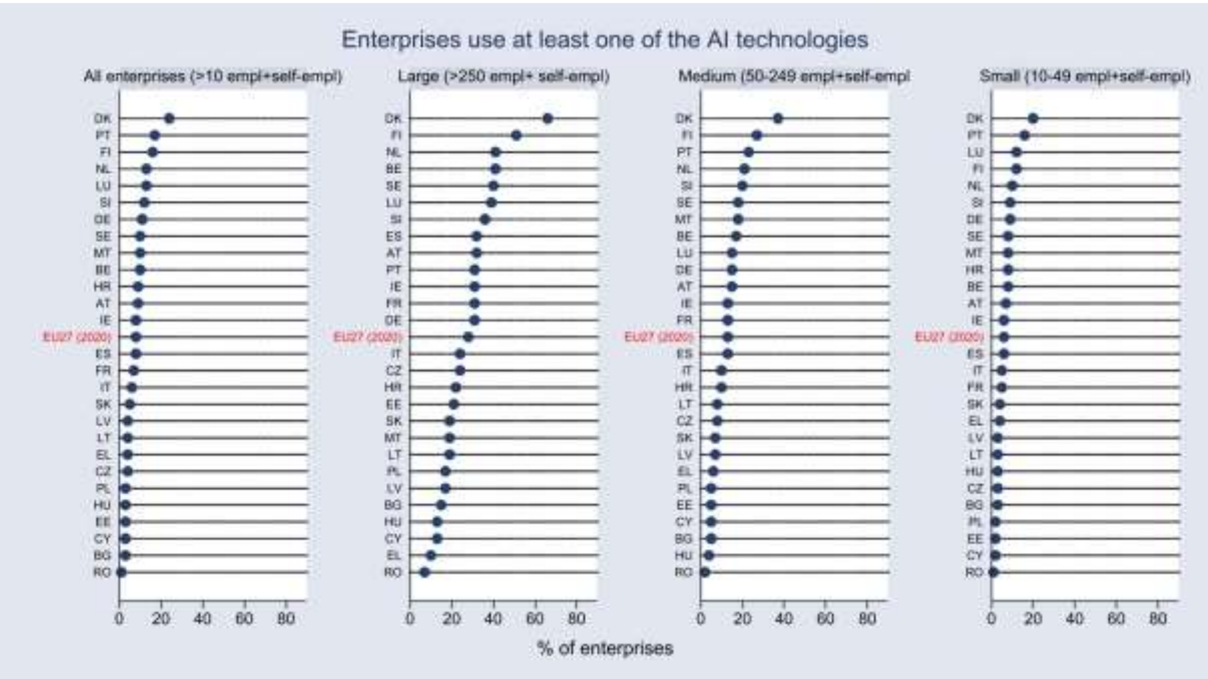


<u>Source</u>: *Authors' elaboration based on Eurostat, 2021 – Table [isoc_eb_iot]*
<u>Note</u>: *Data for all enterprises with 10 employees or more, excluding the financial sector.*

3.1.3 Artificial Intelligence (AI)

Figure 7 shows that the greatest majority of firms in Europe still do not use any AI technology. As it is present on average in 8% of EU27 enterprises with at least 10 employees. Denmark and Portugal are the countries where AI is most widespread (25% and 17% respectively), while it is present in only 1% of the enterprises in Romania. Even in this case, the technology is substantially more widespread among large firms (28% in EU27) than in medium (13%) or small (6%).

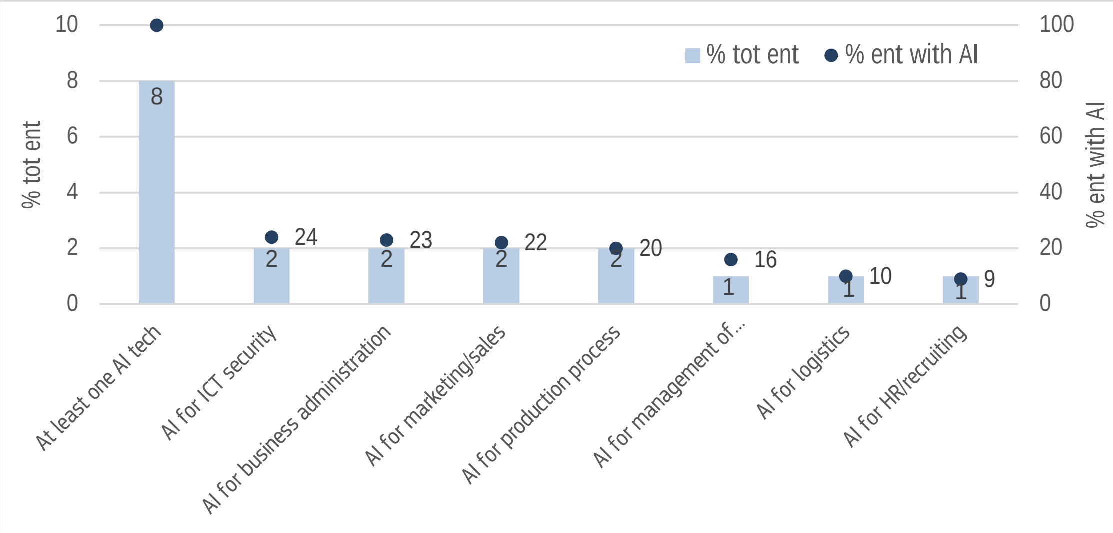
Figure 7 Distribution of Artificial Intelligence technologies, by country and firm size (2021)



Source: Authors' elaboration based on Eurostat data 2021 [isoc_eb_ai]

AI technologies can be used for several purposes. Figure 8 shows how the majority of enterprises using AI (24%) use it for ICT security purposes, followed by similar shares that use it for business administration (23%), for marketing or sales purposes (22%) or for production process (20%). Lower proportions use it for enterprise management (16%) and for logistics (10%). 9% of enterprises with AI use it for HR or recruiting purposes. This corresponds to the smallest share of enterprises with AI, and to approximately 1% of all EU enterprises. The data collected by the ICT survey specify when the technology is used for work coordination, namely, when enterprises use it for HR or recruiting, hence directly affecting workers.

Figure 8 Use of AI technology and its purposes)

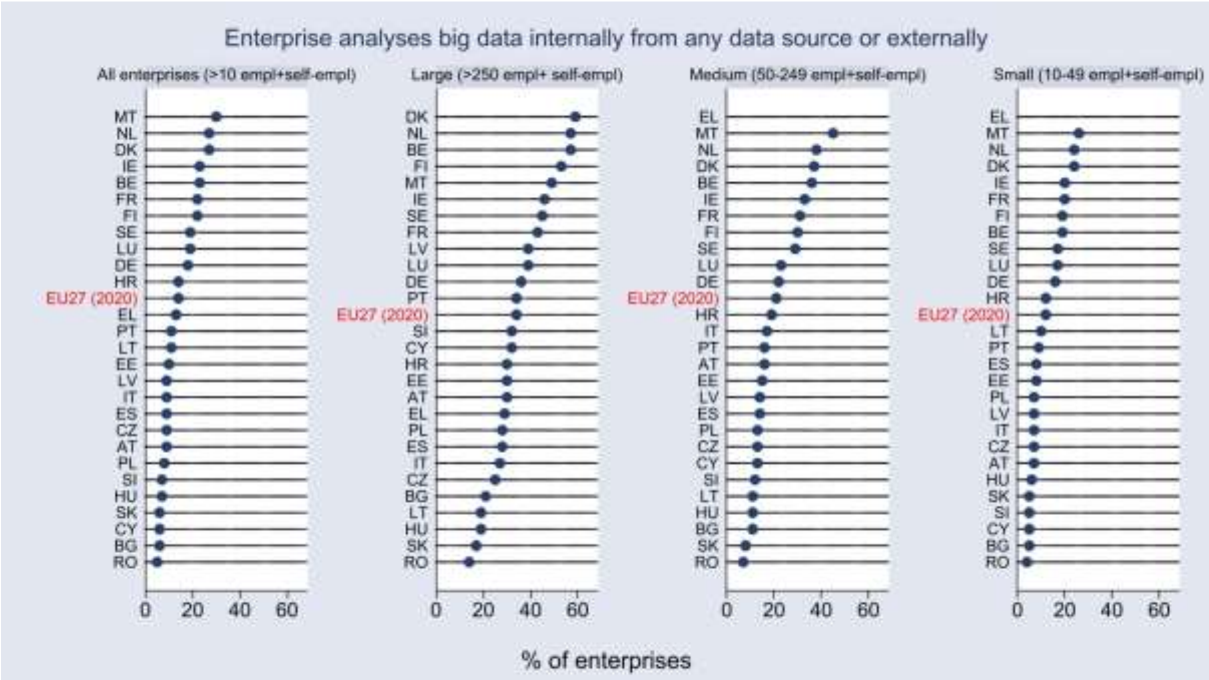


Source: Authors' elaboration based on Eurostat, 2021 – Table [isoc_eb_ai]
Note: Data for all enterprises with 10 employees or more, excluding the financial sector.

3.1.4 Big data and Data Analytics

Figure 9 shows that on average in EU27 14% of the enterprises with 10 or more workers analyse big data internally from any source. Malta and the Netherlands are the countries in which more enterprises engage in data analytics (30% and 27% respectively), whereas Romania and Bulgaria are the countries with fewer enterprises adopting this technique (5% and 6% respectively). It should also be noted that nearly 60% of the large enterprises in Denmark or Belgium use data analytics.

Figure 9 Distribution of Big data analysis, by country and firm size



Source: Authors' elaboration based on Eurostat data 2020 [isoc_eb_bd].

To show some of the purposes data analytics can be used for in enterprises, we draw on another source of data, namely the European Company Survey (ECS) described in box 2.

The ECS 2019 provides data on the presence of data analytics in establishments in the EU27 and the United Kingdom (UK), considering the specific purpose for which this technology is employed. The ECS 2019 survey distinguished between uses of data analytics for the improvement of production and service delivery processes and/or for monitoring employee performance (Eurofound and Cedefop, 2020).

Box 2 : The European Company Survey (ECS)

The ECS has been carried out regularly since its inception in 2004–2005 as the European Establishment Survey on Working Time and Work–Life Balance (ESWT). The second survey, under the new title European Company Survey, was completed in 2009, the third in 2013 and the fourth in 2019 in collaboration with Eurofound's sister agency Cedefop.

The ECS is a questionnaire-based representative sample survey of business establishments with at least 10 employees. Interviews take place with the manager responsible for human resources in the establishment and when possible with an employee representative.

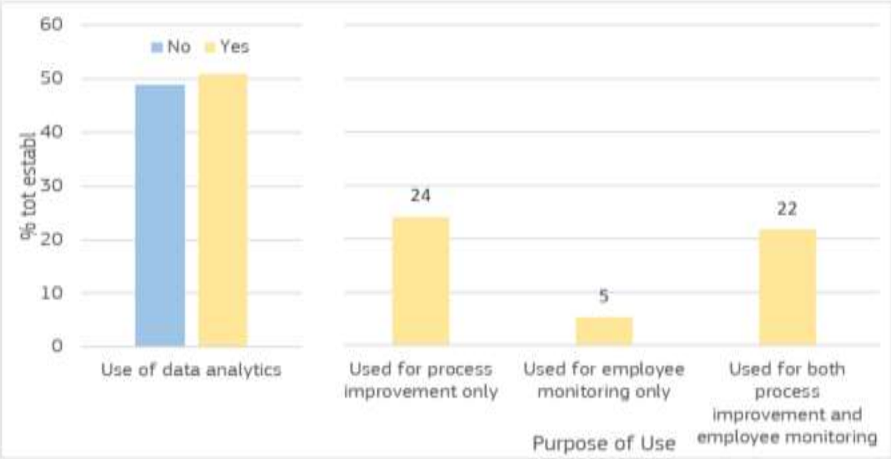
The fourth edition of the ECS was carried out in 21,869 establishments across the 27 EU Member States and the United Kingdom. The target population was establishments with 10 or more employees in economic sectors engaged in 'market activities', according to the statistical classification of economic activities in the European Community (NACE Rev. 2). The survey however does not cover establishments operating in agriculture, forestry and fishing (A), activities of the household (T) and activities of extraterritorial organisations and bodies (U).

First of all, it should be noted that the ECS survey finds that just over half of establishments use data analytics (51%). The discrepancy with the ICT survey reported above probably relates to the more general understanding of data analytics in the ECS survey where the relevant question makes no reference to use of 'big data'. Of the larger share of establishments identified as using data analytics in the ECS sample, a relatively low proportion uses it only for employee monitoring purposes (5%), while 24% use it only for process improvement, and 22% for both purposes (Figure 10).

According to an analysis of the ECS data carried out by Eurofound and Cedefop, the use of data analytics is more likely in establishments that have adopted to a large extent customised robots and software, but not necessarily computers. By contrast, establishments that use computers extensively, but not robots or customised software, are less likely to use data analytics (Eurofound and Cedefop, 2020: 26).

Summing the percentages reported in Figure 10, in total 27% of the establishments in the EU27 and the UK adopt data analytics for workers monitoring purposes, either exclusively or in combination with process improvement purposes.

Figure 10 Use and purpose of data analytics in establishments - EU27 and the UK, 2019



Source: Authors elaboration based on ECS 2019 management questionnaire

3.1.5 Wearable devices

To show the distribution of wearable devices by country and firm size, we draw from a different data source, the ESENER 3, described in box 3.

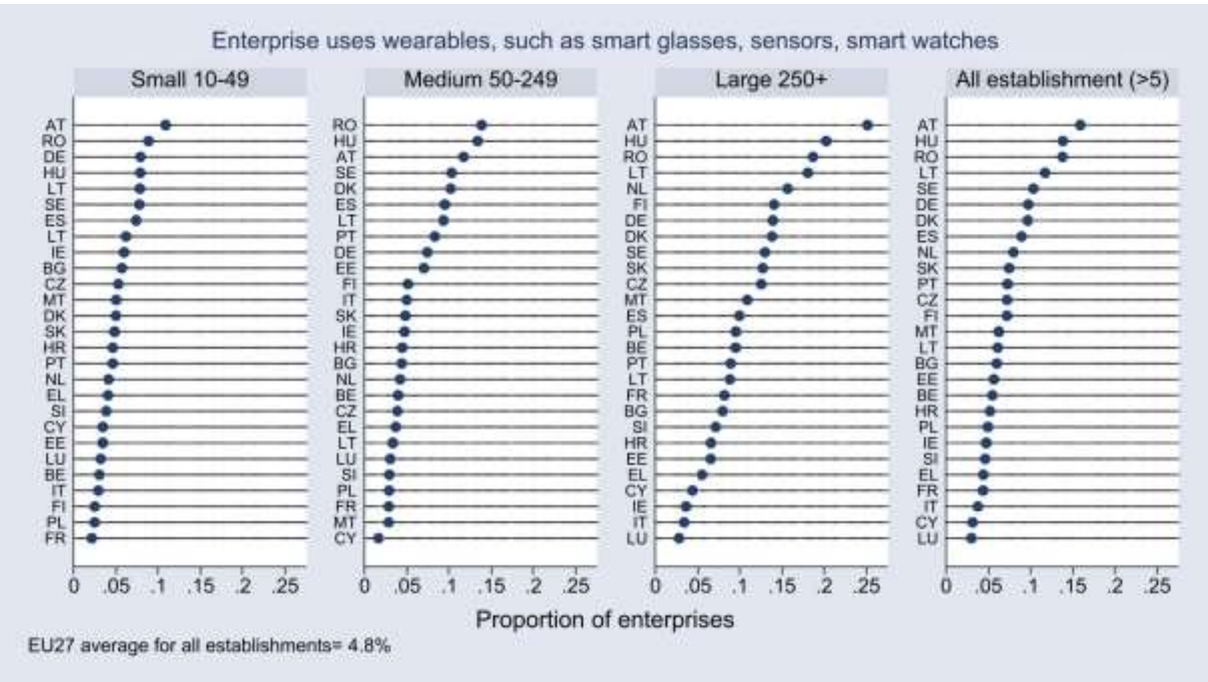
Box 3 : The European Survey of Enterprises on New and Emerging Risks (ESENER)

ESENER is a survey of establishments carried out every five years, since 2009, by EU-OSHA. The third ESENER wave was in 2019. It surveyed a representative sample of 45,420 establishments with at least 5 employees in all economic sectors from 33 European countries (i.e. EU27, United Kingdom, Iceland, North Macedonia, Norway, Serbia and Switzerland. The survey is answered by the person "who knows best about health and safety in the establishment", that can be the owner, managing director or manager, health and safety officer, an employee or a representative, 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 in the workplace, how these risks are managed, drivers and barriers for their management and workers' participation in OSH management.

The questionnaire underpinning the third ESENER wave included also some questions on the use of digital technologies and systems that would enable data-driven monitoring. In particular, ESENER contains information on whether the enterprise uses any of the following: 1) Personal computers at fix workplaces; 2) Laptops, tablets, smartphones or other mobile computer devices; 3) robots that interact with workers; 4) Machines, systems or computer determining the content or pace of work; 5) Machines, systems or computer monitoring workers' performance; and 6) wearable devices such as smart watches, data glasses or other embedded sensors.

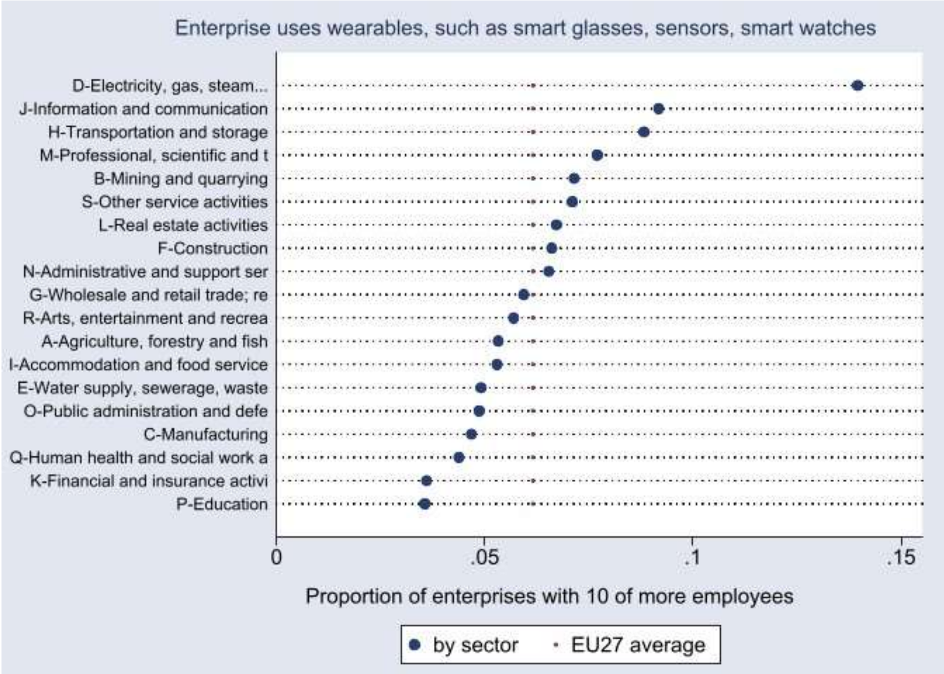
Wearable devices are still fairly uncommon in the EU27, with on average less than 5% of the enterprises with 5 or more employee using them for work (5.7% if we consider enterprises with 10 or more employees, like in the ICT survey). Estimates in Figure 11 also show that, predictably, the technology is more frequently adopted in larger establishments and in countries such as Austria, which also ranked first for the use of IoT. Interestingly, Romania is also one of the top adopters, even though it always ranked last for the adoption of technologies such as the IoT, AI or Data analytics. One possible reason is that, in the ESENER dataset, 50% of the enterprises with more than 10 workers belong to sectors such as manufacturing, wholesale and repair trade, and construction, which have an above average adoption of wearables, even though they are not the top sectors (see Figure 12).

Figure 11 Distribution of wearable devices, by country and firm size



Source: Authors' elaboration based on ESENER 3 data

Figure 12 Distribution of wearable devices, by industrial sector

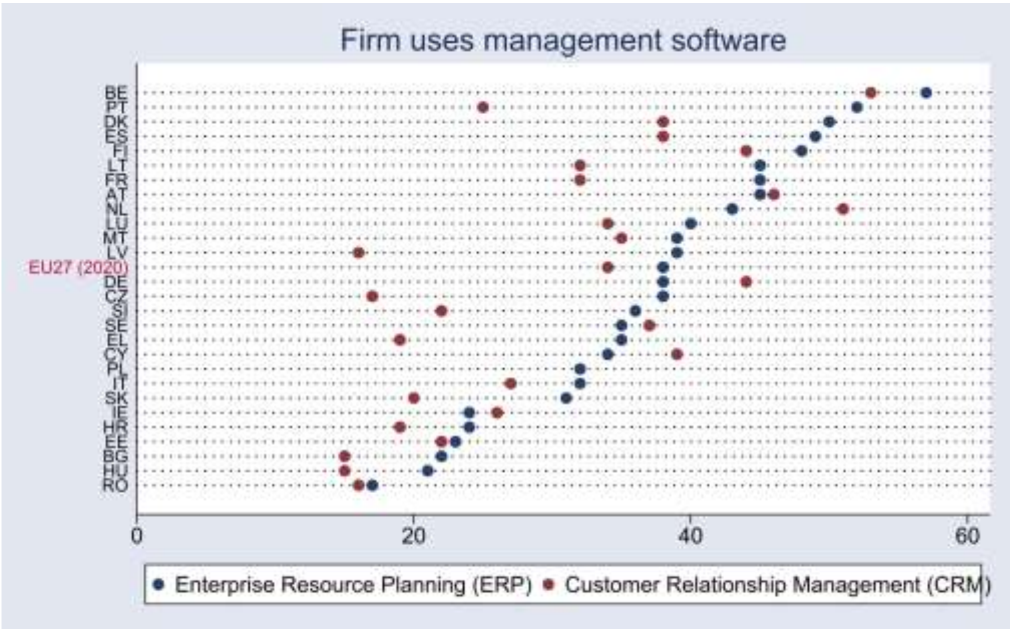


Source: Authors' elaboration based on ESENER 3 data

3.1.6 Management software applications and other enabling technologies

In 2021, 38% of EU enterprises used Enterprise Resource Planning (ERP) software, whereas Customer Relationship Management (CRM) software is found in 35% of enterprises across the EU. Belgium leads the ranking for both technologies, with over 57% and 53% of its enterprises using ERP and CRM respectively, while Hungary and Romania have the lowest levels of adoption.

Figure 13 Distribution of management software applications, by country



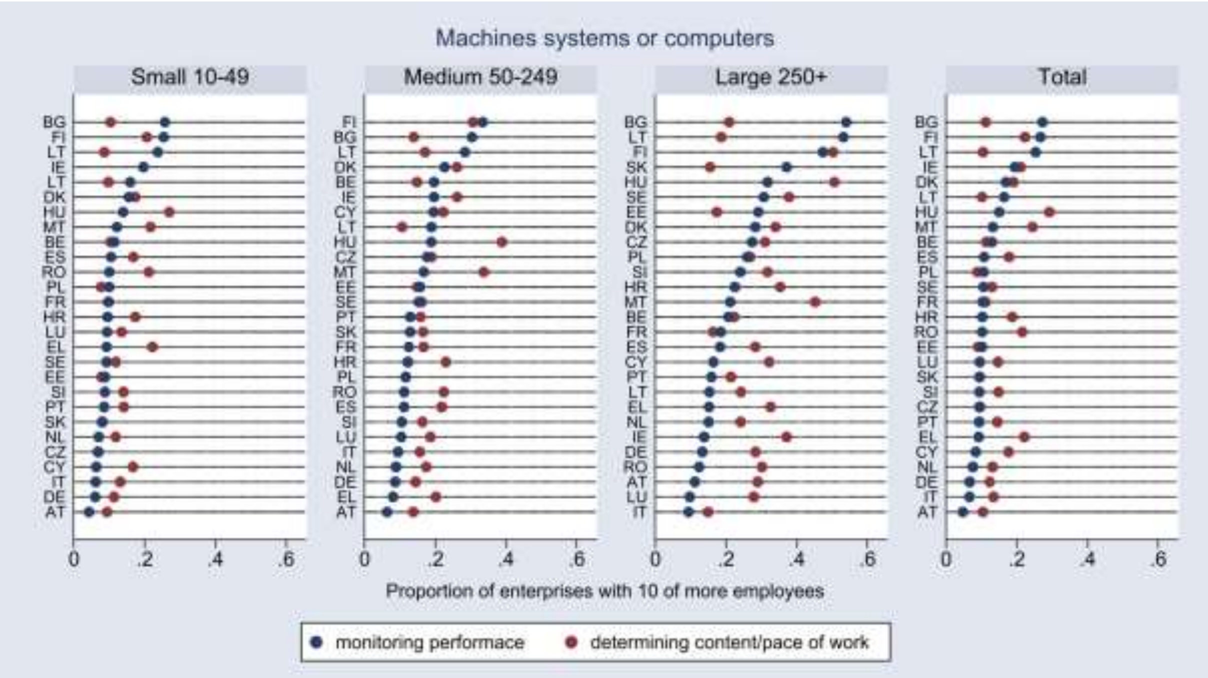
Source: Authors' elaboration based on Eurostat 2021 data; table [isoc_eb_iip].

With the rise of the IoT and AI, CRM and ERP software, and management software applications in general, are increasingly sophisticated. On the one hand, these software applications are enriched by the large amount of data collected from a wider range of interconnected devices that work often automatically. On the other, they are empowered by advanced techniques for data elaboration, including AI.

The ESENER dataset contains information on whether an establishment uses machines, systems or computers either determining the content or pace of work, or for monitoring workers' performance (or both). The questionnaire does not specify what these machines or systems may be, but only that they can be used to carry out or assist with the performance of some managerial functions, such as controlling (monitoring) or directing (determining content or pace of work).

Estimates in Figure 14 show that the proportion of enterprises that use devices to monitor performance ranges between 5% in Austria and 24% in Bulgaria, with a much higher proportion of large enterprises doing so; the proportion of enterprises using digital devices to set the content or pace of work ranges from approximately 10% in Austria to about a quarter of the Hungarian enterprises surveyed in the ESENER 2019. Again, the use of these devices is substantially higher in large enterprises (more than 50% in Bulgaria), suggesting that a potentially large number of employees may be affected by it.

Figure 14 Distribution of other data-driven management enabling technologies, by country and firm size



Source: Authors' elaboration based on ESENER 3 data

4 Data analytics and work organisation: insights from the ECS

The adoption and use of digitisation technologies in companies is mostly driven by the need to increase productivity (and profitability) and reduce costs (Eurofound 2021). Data analytics, a technology enabling data-driven management, is no exception to this. Modern theories on the value of information depart from information theory (Blackwell 1953) and information-processing view of organisations (Galbraith 1974) suggest that the availability of more accurate information can enable more informed decision making and lead to higher firm performance (Brynjolfsson, Hitt and Kim 2011). Much of the available research has found a positive relationship between the use of data analytics and firm performance resulting from better informed decisions (Davenport and Harris 2006, Loveman 2003, Brynjolfsson, Hitt and Kim 2011, LaValle, et al. 2011, Ferraris, et al. 2019, Brynjolfsson, Jin and McElheran 2021). Empirical research drawing from German firm-level data also found that big data analytics is a determinant of innovative performance in terms of product innovation (Niebel, Rasel and Viete 2019).

Recent research - using survey data of over 30,000 American manufacturing establishments – has however found that productivity gains from the use of predictive analytics occur only in the presence of a significant accumulation of IT capital, educated workers, or so-called high flow-efficiency production systems (Brynjolfsson, Jin and McElheran 2021). Other empirical research exploring the impact of data analytics on firm performance found high level of complementarities between IT implementation, performance pay schemes, and HR analytics practices used to monitor employee performance and suggested that firm productivity is higher when these practices are implemented together, rather than separately (Aral, Brynjolfsson and Wu 2020).

As already mentioned in chapter 2, work organisation refers to 'how work is planned, organised and managed within companies via production processes, job design, task allocation, rules, procedures, communication, responsibilities, management and supervisory styles, work scheduling, work pace, career development, decision-making processes, interpersonal and interdepartmental relationships' (Eurofound, 2017).

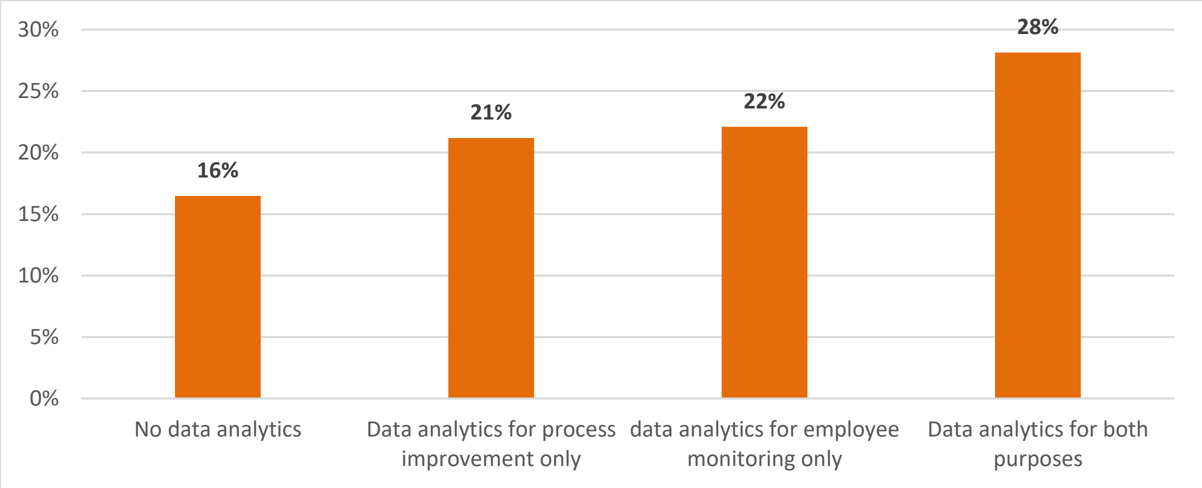
This chapter illustrates the relationship between one of the enabling technologies of data-driven management, namely data analytics, and aspects of work organisation, such as: autonomy and job complexity, variable pay schemes, or training provision, well as aspect of the business model (outsourcing and collaboration), establishment performance and workplace wellbeing. The reported estimates are merely descriptive and do not represent causal relationships. The data source used for this chapter in the 2019 European Company Survey (ECS), described in box 2.

4.1 Job complexity and autonomy

To assess the level of autonomy that workers have within the workplace, the survey asked managers about the proportion of the employees in their establishment who organise their tasks and their time autonomously or whose pace of work is determined by machines or computers.

Figure 15 summarises the proportion of establishments in which the pace of work is determined by machines or computers by the use of data analytics. The estimates show a positive correlation between use of data analytics and establishments where the pace of work for a large share of employees (at least 40%) is determined by machines or computers. This suggests that the use of data analytics is more likely in establishments where work processes are significantly digitised or automated, for example in advanced manufacturing. The positive correlation is more pronounced for use of data analytics for both employee monitoring and process improvement, which suggests that employee monitoring is as much a by-product of technological processes of production as of performance monitoring.

Figure 15 Pace of work significantly determined by machines or computers and use of data analytics, EU27 and the UK



Source: ECS 2019 management questionnaire
*Note: *For at least 40% of employees.*

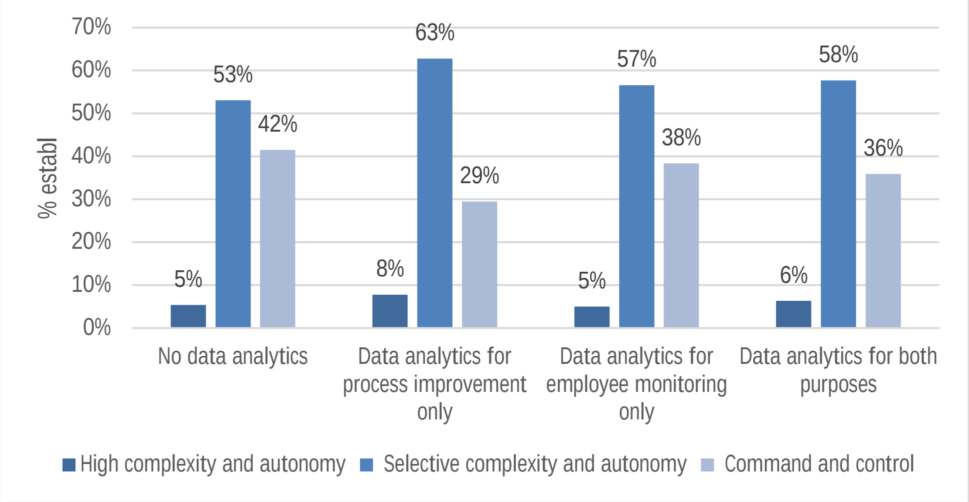
Latent class analysis from previous analysis of the ECS data (Eurofound and Cedefop, 2020) also identified three types of establishments based on the complexity of employees' jobs and the degree of autonomy they can exercise. These three types were: 'high complexity and autonomy', 'selective complexity and autonomy', and lastly 'command and control'.

The 'high complexity and autonomy' type is the least common, accounting for 6% of establishments in the EU27 and the UK. This type has many of the features of so-called high-performance workplaces, which are characterised for example by high degree of autonomy and complex problem solving on the part of individual employees as well as the presence of self-directed teams. Establishments using data analytics only for process improvement tend to be more represented in this group compared to establishments using data analytics for employee monitoring only and those not using data analytics at all.

The 'selective complexity and autonomy' type is more prevalent, representing 57% of establishments. This type exhibits some of the characteristics of the 'high complexity and autonomy' type, for example managers create the conditions for employees to work independently, but workers have typically lower degree of autonomy and exposure to complex problem-solving compared to the first type. This is the type of establishment most frequently associated with use of data analytics particularly for process improvement only (63% vs. 53% with no data analytics in place).

The 'command and control' type, which accounts for 37% of establishments, is characterised by more Tayloristic work arrangements, for example limited autonomy and less complex problem solving, lower incidence of teamwork, and greater management oversight on tasks performed. Use of data analytics is relatively less observed in this group of establishments (Figure 16). This lower prevalence of data analytics use in the 'control and command' category may be due to the fact that this establishment type is characterised by limited levels of computer use and digitalisation more generally, which can be considered a requirement for application of data analytic techniques (Eurofound and Cedefop, 2020).

Figure 16 Use of data analytics by establishment type – job complexity and autonomy, EU27 and the UK (%)



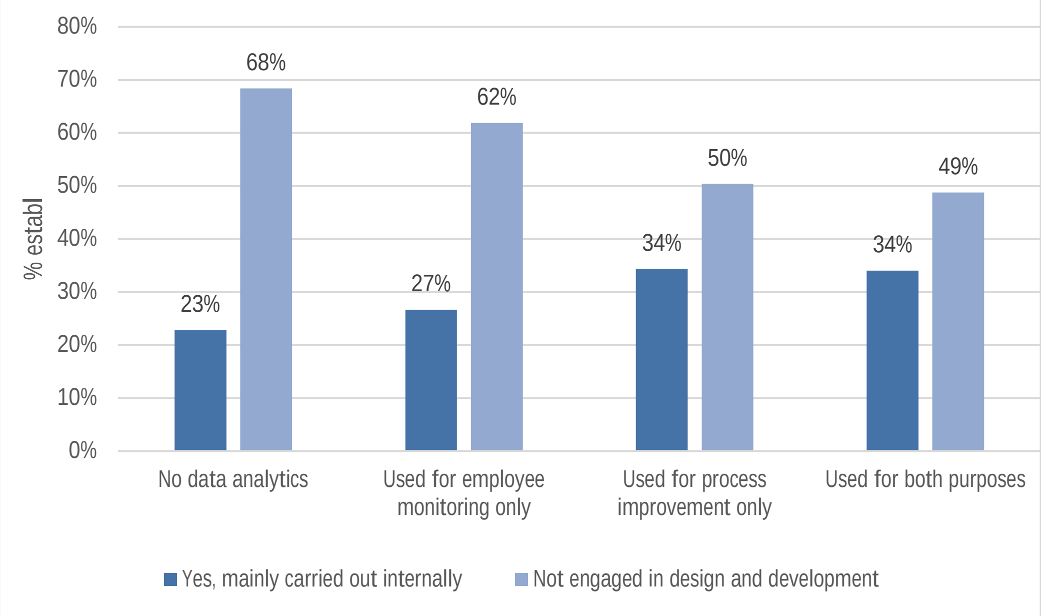
Source: ECS 2019 management questionnaire

4.2 Outsourcing and collaboration

Data-driven forms of management – including those enabled by data analytics – could affect firms' business models, for instance by boosting outsourcing or contracting out, as well as collaboration among firms. No clear correlation was however found between data analytics usage and outsourcing or contracting out of key activities in the surveyed establishments. Estimates shows that innovative establishments – which use data analytics – are more likely to engage in the design and development of new products or services and carry out such activities internally. This may have to do with the size of these establishments, with large ones more likely to have the capacity to do so. This correlation is more prominent for establishments using data analytics for process improvement, either exclusively or together with employee performance monitoring.

Furthermore, the survey identifies whether establishments engage in relationships with other establishments, either for production or design and development of goods and services. In this respect, the data shows that establishments with no data analytics are less likely to engage in design and development of new products or services. Engagement in such activities carried out internally is more prevalent in establishments with data analytics (Figure 17).

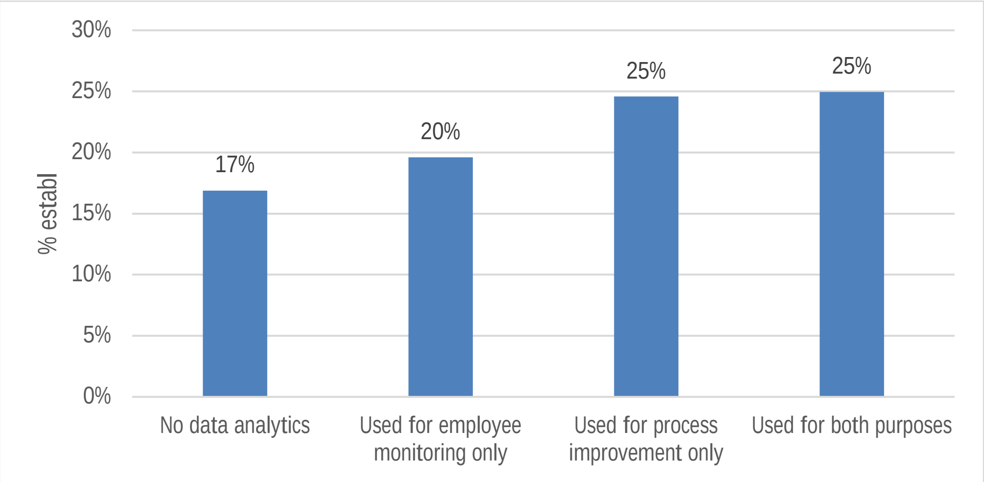
Figure 17 Share of establishments engaging in design and development of new products or services by use of data analytics, EU27 and the UK (%)



Source: ECS 2019 management questionnaire

The use of data analytics is also more observed in establishments that collaborate with other establishments (Figure 18).

Figure 18 Collaboration with other establishments by use of data analytics, EU27 and the UK (%)



Source: ECS 2019 management questionnaire

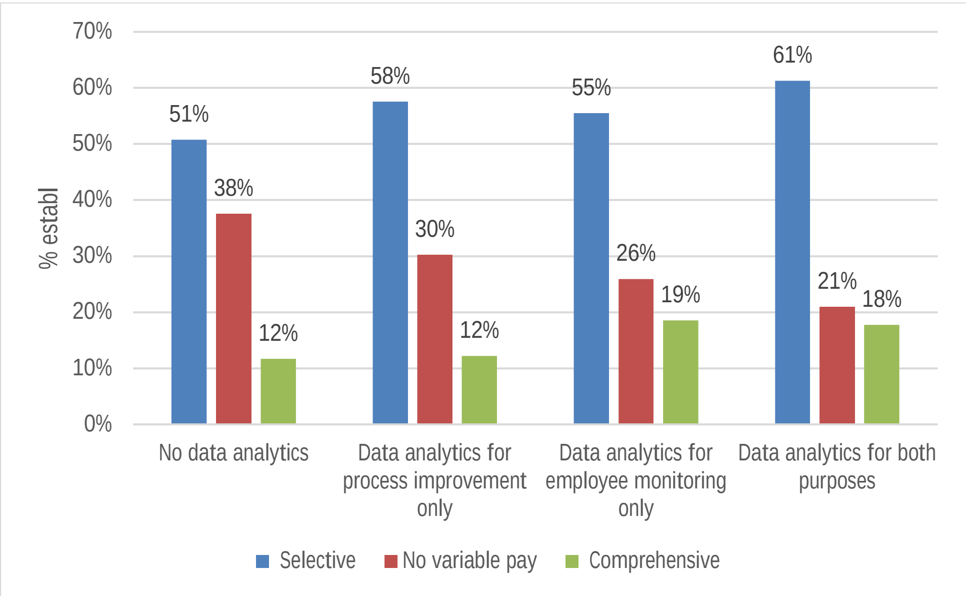
4.3 Variable pay schemes

'Variable pay' refers to additional compensation beyond the basic pay and may vary in amount. If properly designed, variable pay schemes can serve as effective tools to stimulate and reward extra effort, attract talent and enhance staff engagement and commitment to the organisation.

The ECS 2019 survey investigates practices that affect the performance of employees, as well remuneration and monetary incentives, including use of four forms of variable pay schemes. These were 'payment by results', 'individual performance-related pay', group performance-related pay' and 'profit-sharing schemes'. On the basis of these four forms of variable pay, latent class analysis identified three types of establishments (Eurofound and Cedefop, 2020). In establishments with a comprehensive approach to variable pay, all four forms of variable pay are likely to be used and applied to a large proportion of employees. This type represents only 13% of establishments. The comprehensive approach to variable pay is relatively more common in the case of establishments using data analytics for employee monitoring (19%) and data analytics for both employee monitoring and process improvement (18%).

The most pronounced correlation is however found in the establishment type with a selective approach to variable pay, which accounts for 55% of establishments. These establishments are likely to use at least some forms of variable pay, which apply to a minority of employees. Establishments using data analytics are more likely to fall into this group, particularly if the technology is used for both employee monitoring and process improvement. By contrast, establishments with no use of data analytics are more likely to belong to the establishment type with no variable pay - found in 32% of establishments.

Figure 19 Use of data analytics by establishment type – variable pay, EU27 and the UK (%)



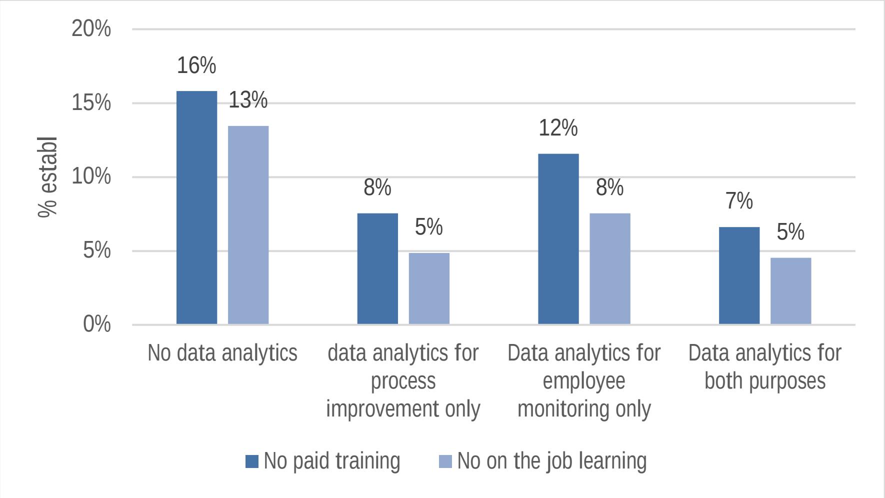
Source: ECS 2019 management questionnaire

4.4 Training provision

Previous analysis of the ECS 2019 data suggests that the higher the level of digitalisation of an establishment, the greater the use of data analytics for both process improvement and employee monitoring (Eurofound and Cedefop, 2020). As AI and IoT technologies generate vast amounts of data and data analytics techniques become more sophisticated, establishments will require new skills for their data operations and analysis. This skills gaps may be filled through training and skill development. With regard to skills development activities, the ECS 2019 asked managers about two types of training: training sessions delivered to employees during paid working time and on-the-job learning. Previous analysis of the ECS data shows that training during working time and on-the-job learning was provided to a limited proportion of workers (less than 20%) respectively in 34% and 28% of establishments (Eurofound and Cedefop, 2020).

Looking at the provision of such training in establishments by use of data analytics, estimates shows that the lack of provision of paid training and on the on-the-job learning is associated with no use of data analytics in the establishment (Figure 20). Of all establishments, those using data analytics for process improvement, either exclusively or together with employee monitoring purposes, are more likely to provide either form of training to their employees. Where data analytics is used for employee monitoring only, the share of establishments not offering these training possibilities is higher, though not as high as in the firms not using data analytics at all.

Figure 20 Establishments with no employees availing of paid training or on the job learning, EU27 and the UK (%)



<u>Source</u>: ECS 2019 management questionnaire

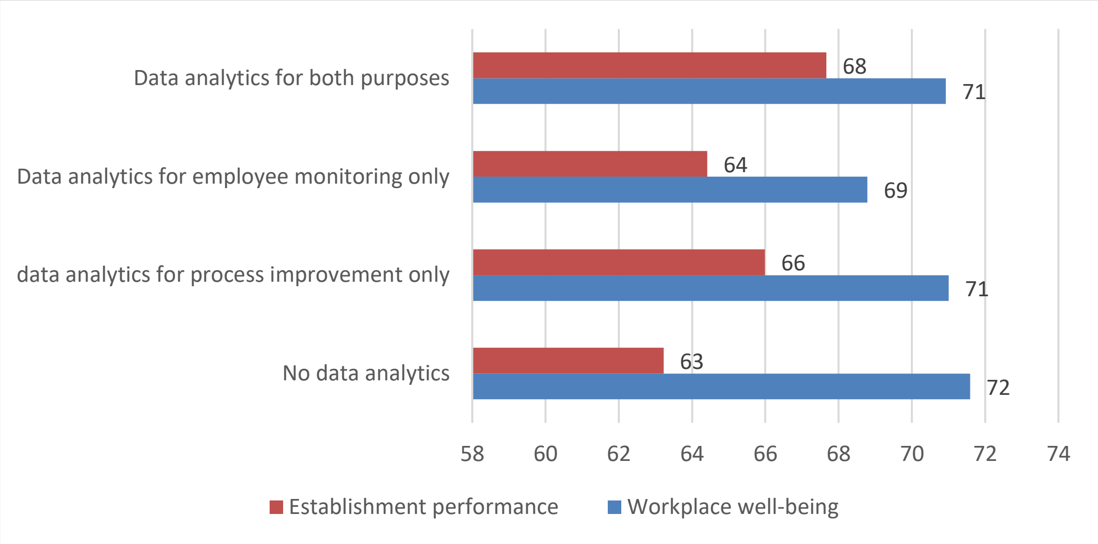
4.5 Establishment performance and workplace wellbeing

Possible changes on work organisations and workplace practices can reflect on business performance and workers' well-being. Prior analysis of the ECS data used two composite indicators scaled 0–100 to monitor outcomes at establishment level in relation to workplace well-being, on the one hand, and establishment performance, on the other (Eurofound and Cedefop, 2020). Four questions were used to indirectly measure workplace well-being: one captured the quality of the relationship between management and employees and the other three questions concerned challenges in terms of human resources (such as low motivation, absenteeism and staff retention). Establishment performance was measured in relation to the following four variables: the profitability of the establishments, the profit expectation, the change in production volume and the expected change in employment.

Using these two indicators, the analysis shows that establishments using data analytics for both employee monitoring and process improvement score higher on establishment performance. By differentiating between the two types of data analytics, the score of establishment performance is higher in establishments using such technologies for process improvement only and marginally higher in the case of those using the technology for employee monitoring only.

The use of data analytics exclusively for employee monitoring is associated on the other hand with somewhat lower workplace wellbeing, in comparison to not using data analytics at all. The use of data analytics for process improvement seem to make almost no difference on the score on workplace well-being, in comparison to the establishments with no data analytics.

Figure 21 Use of data analytics and workplace outcomes, EU27 and the UK (%)



Source: ECS 2019 management questionnaire

5 Wearables and other digital devices enabling data-driven management: impacts on Occupational Safety and Health

Data-driven forms of management, and in particular algorithmic management as defined in Chapter 2, can affect the mental (but also physical) health of workers. This chapter explores the association between digital technologies that enable data-driven forms of management and Occupational Safety and Health (OSH) as measured by the presence of psychosocial risks in European workplaces. In addition, it assesses the potential mitigating role of OSH preventive measures in managing risks related to digitisation and reducing the potentially negative effects of data-driven management technologies.

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 OSH, nowadays. The EU-OSHA defines psychosocial risks as "those aspects of the design, organisation and management of work, and its social and environmental context, which can cause psychological, social or physical harm" (Brun and Milczarek 2007)In practical terms, 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. From an employer's perspective, they are an issue as they lead to absenteeism, lower productivity and financial losses ((Leka and Cox 2008).

The empirical analysis presented in this chapter draws on a unique set of data, the EU-OSHA ESENER 3 (described in box 3). Such data allow to identify a set of digital technologies and systems enabling data-driven management of workers, as well as the presence of psychosocial risks and mitigating measures at the workplace level in a representative sample of European establishments.

In line with the literature summarized in chapter 2, the underlying hypothesis is that the use of selected technologies may be associated with increased psychosocial risks by boosting job demands and decreasing workers' autonomy. However, OSH measures in the workplace can be of help to manage and mitigate such increased risks, so they are also considered in the empirical analysis, in the following section.

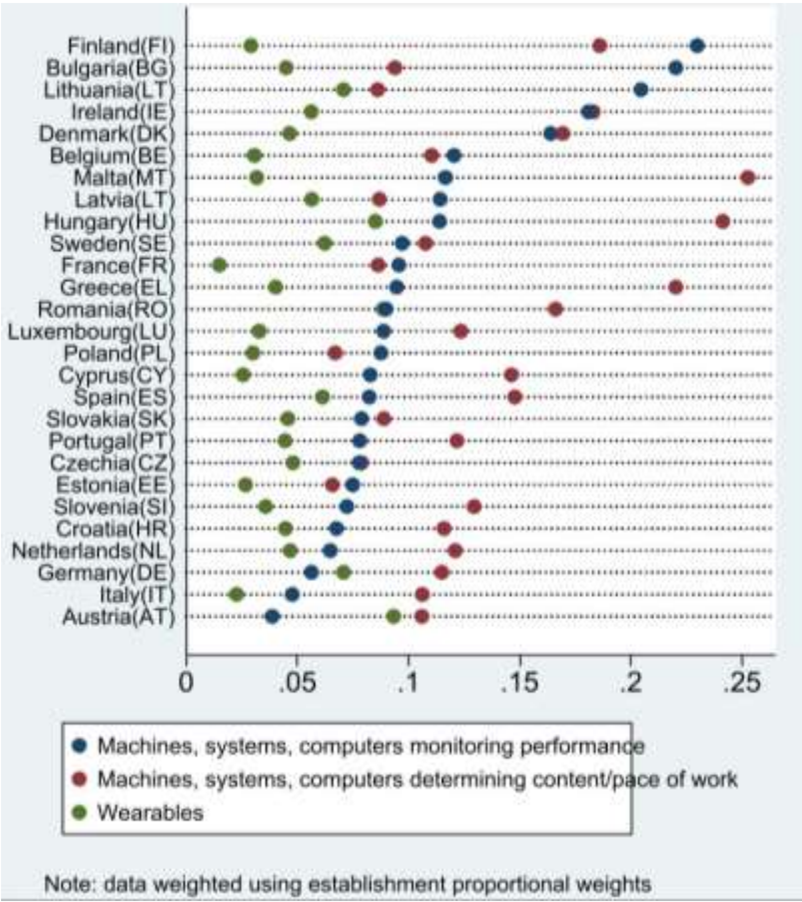
5.1 Enterprises adopting data-driven management enabling technologies

The digital technologies and systems that can enable data-driven management included in the ESENER dataset are:

- 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).
- 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.
- Wearable devices, such as smart watches, data glasses or other (embedded) sensors (allowing for data gathering and feed into the other systems).

As illustrated in Chapter 3 and summarized in Figure 22, such managing technologies are relatively little widespread in European establishments overall, although substantial differences exist across countries, sectors and firms size.

Figure 22 Selected management technologies by country, EU 27]



Source: Authors' elaborations using ESENER 3

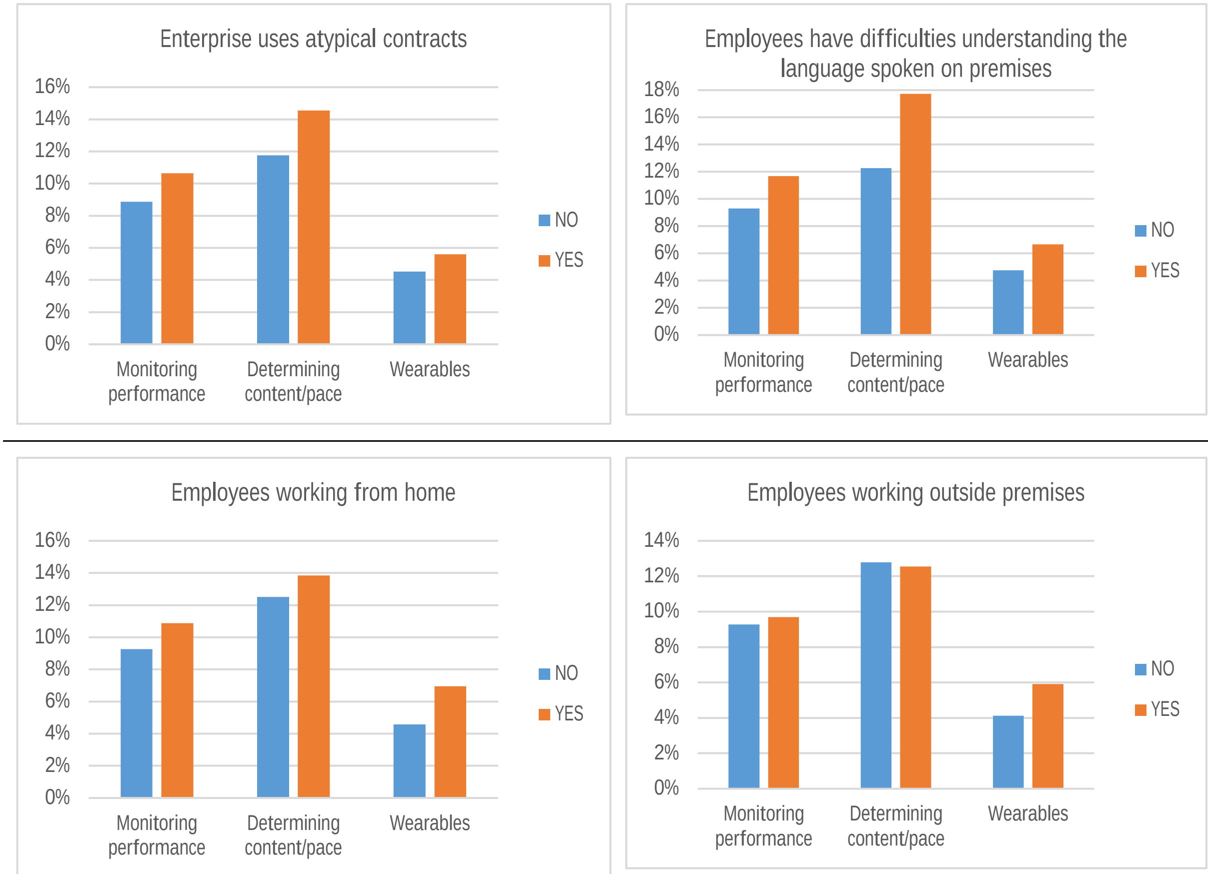
The ESENER 3 dataset allows for a more granular description of the distribution of technologies, by establishment characteristics. In particular, the survey provides information on whether the enterprise employs workers with atypical work contracts (subcontractors, temporary agency workers or volunteers), whether the enterprise employs people who have difficulties understanding the local language; and whether any of the employees work somewhere else outside the premises of the establishment (other than working from home). (Figure 23).

Estimates in Figure 23 show that the prevalence of all three digital technologies differs across different establishments. For instance, devices for monitoring performance are more likely to be found in establishments that use atypical work contracts (10.6% vs. 8.9%), have employees who can't understand the local language (11.7% vs. 9.3%), or that have employees who work from home (10.9% vs 9.3%). By contrast, having employees working outside the premises seems to make little difference.

Similarly, devices that determine content or pace of work are more likely to be found in establishments that use atypical work contracts (14.5%% vs. 11.7%), have employees who can't understand the local language (17.7% vs. 12.3%) or work from home (13.9% vs. 12.5%).

The prevalence of wearables follows a similar pattern, however in this case they are also more likely to be found in establishments where people work outside the premises (5.9% vs. 4.1%).

Figure 23 Distribution of digital technologies by selected establishment characteristics, EU 27]



Source: Authors' elaborations using ESENER 3; data are weighted using establishment weights.

What these findings suggests is that some data-driven management enabling technologies, for instance those for performance monitoring, may be related to lower trust, for instance to exert more control over employees working from home, or lower cohesion, as in the case of enterprises using management technologies to monitor the performance of subcontractors or agency workers. In other cases, the adoption of management technologies, and especially those enabling the setting of content or pace of work, may be sector-related: for instance, Urzí Brancati and Curtarelli (2021) show that management technologies are more prevalent in sectors such as transportation and storage, manufacturing, or mining and quarrying, which are also, arguably, more likely to employ foreign workers (so workers who have difficulties understanding the language spoken on premises) or workers on atypical contracts.

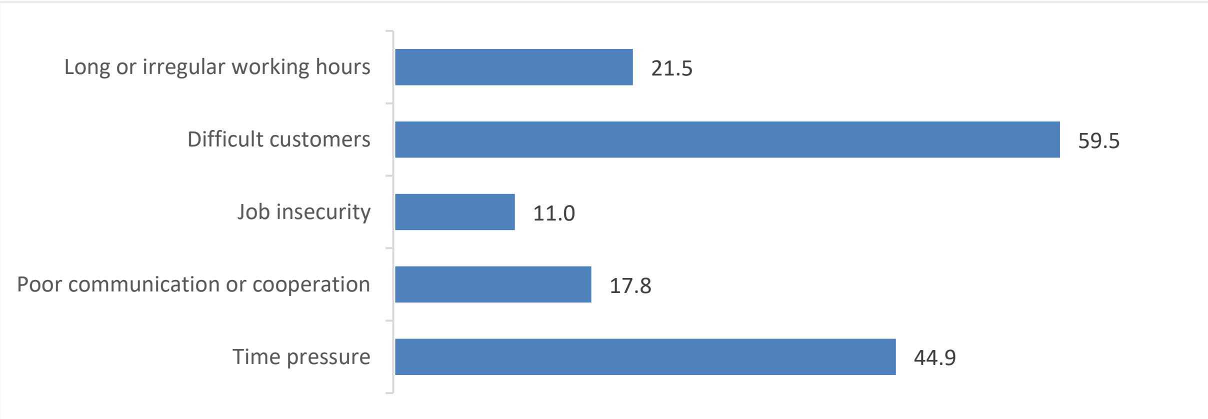
5.2 Psychosocial risks

Psychosocial risks refer to those aspects of the work environment that are likely to affect mental health. They are called "psycho-social" because they represent the influence of social factors on workers' psychological response. Recording the presence of psychosocial risks in the workplace is important because they result in work-related stress, and possibly depression, anxiety or sleeping disorders ([22]).

The ESENER dataset contains five variables related to the reported presence of psychosocial risks in the workplace, namely 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.. Note that the presence of a psychosocial risk is reported at the establishment level by the person interviewed, 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.

As shown in Figure 24, having to deal with difficult customers, patients or clients and time pressure are the most widespread psychosocial risks, as they are present in approximately 60% and 45% of the EU27 establishments, respectively. They are followed by the risk of long/irregular working hours (present in 21.5% of the establishments in the EU), poor communication of cooperation (17.8%) and fear of job loss (11%).

Figure 24 – Establishments by type of psychosocial risk in the EU27 (%, 2019)

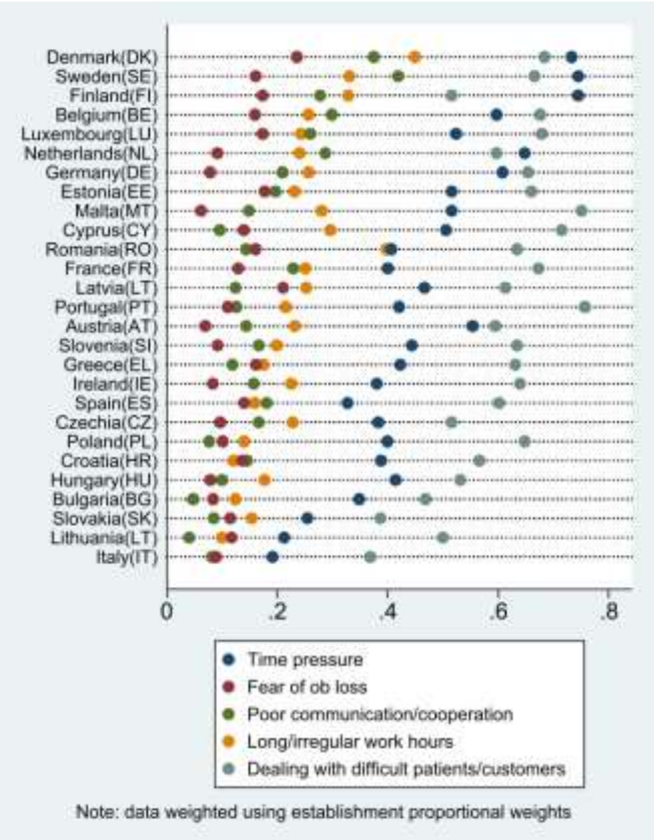


Source: Authors' elaboration on EU-OSHA ESENER-3 data.

([22]) https://www.etui.org/news/gig-economy-and-psychosocial-risk-interview-pierre-berastegui

The distribution of psychosocial risks by country presented in Figure 25 shows that generally when one risk is widespread in a country, the others tend to be reported more frequently than in other countries. For instance, 74% of the enterprises in Sweden report the presence of time pressure and 66% report having to deal with difficult patients, customers, etc., whereas in Italy only 19% of the enterprises report time pressure and about 36% report having to deal with difficult patients, customers, etc. While it is possible that this is due to the existence of 'healthier' enterprises, with lower psychosocial risks overall in certain countries, we should not discard the possibility that higher incidence might depend on reporting culture, or on having an OSH responsible on the premises, and therefore countries in which a higher proportion of establishments report the presence of psycho-social risks may be the ones in which such risks are simply more visible. Another possibility is that the higher incidence of psychosocial risks actually depends on more intensive use of technology, which is what the rest of this chapter is going to investigate.

Figure 25 Distribution of psychosocial risk by country, EU27



Source: Authors' elaborations using ESENER 3

The association between the technologies enabling data-driven workers' management and the psychosocial risks in the workplace is described in Table 1. The first row of table summarises the psychosocial risks composite index (calculated as sum of the five psychosocial risks shown in Figure 25) ([23]), whereas the following rows summarise the incidence of individual psychosocial risks and compare it in establishment which have introduced one of the management technologies under study, with those who didn't. Estimates are carries out on the sample of EU27 countries.

([23]) Psychosocial risks indicators are dichotomous variables equal to 1 if they were reported in the establishment and 0 otherwise. The cumulative index for workplace psychosocial risks (PR) is equal to the sum of all dichotomous psychosocial risk indicators at the establishment level (0-5).

The psychosocial risks index is nearly half a point lower in establishments that haven't adopted monitoring technologies, compared to those that have (i.e. 1.51 vs. 1.98). Similarly, the score on the psychosocial risks index is approximately a third of a point higher in establishments that have adopted technologies determining content/pace of work compared to those which did not (1.80 vs. 1.51); the same can be said for the last technology, since establishments using wearables report an average psychosocial risks of 1.91 vs. 1.53 of those that do not use such technology.

As per the prevalence of individual risks, it is consistently higher in establishments which use one of the enabling technologies: while approximately 44% of the establishments which do not use technology to monitor workers' performance report time pressure, the proportion rises to 57% among the establishments using such technology. The difference in incidence of time pressure is very similar for the other two technologies. Looking at the indicator "fear of job loss", its prevalence is nearly double in establishments that adopted technology to monitor performance compared to those that didn't (18.9% vs. 10.4%). The difference is slightly smaller with respect to the technology determining content or pace of work (15.6% vs. 10.5%) and substantially smaller, but still positive, considering wearables (12.4% vs. 11.0%). 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 (26.4%). By contrast, working long or irregular hours is reported more frequently in establishments that use wearable technologies (31.2%). Finally, focussing on the most widespread psychosocial risk (that is dealing with difficult customers, patients, pupils etc.), its prevalence is highest in establishments monitoring performance (67.4%) or using wearables (66.2%), while using technology to determine content or pace of work does not appear to be associated with this psychosocial risk.

Table 1 Prevalence of psychosocial risks in establishments by presence of different types of technology – EU27, 2019

	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	1.51	1.98	1.51	1.80	1.53	1.90
	% of establishments reporting a psychosocial risk					
Time pressure	44.0%	57.3%	43.8%	54.7%	44.4%	58.0%
Fear of job loss	10.4%	19.3%	10.5%	15.6%	11.0%	12.4%
Poor cooperation/ communication	17.2%	26.4%	17.1%	24.2%	17.7%	22.6%
Working long/irregular hours	20.9%	28.2%	20.9%	26.1%	21.0%	31.2%
Difficult clients	59.0%	67.4%	59.7%	60.1%	59.4%	66.2%

Source: Authors' elaborations using ESENER 3

Estimates in Table 1 are purely descriptive and do not account for potential confounding factors; however, they are in line with results from a regression analysis, not limited to EU27 but including all 33 countries in the ESENER dataset, which was carried out by Urzì Brancati and Curtarelli (2021). So we can conclude that the positive correlation between management technologies and psychosocial risks is present even ceteris paribus, that is, controlling for all factors such as establishment size and characteristics (such as those summarised in Figure 23), and sector fixed effects.

5.3 Workplace-level measures to prevent risks to worker´s safety and health

A number of workplace measures are aimed at preventing psychosocial risks as reported in ESENER data. The OSH measures that are likely to be introduced to prevent psychosocial risks in the workplace and are considered in the analysis 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. In addition to those, the analysis considers whether the establishment had in place an action plan to prevent work-related stress. ([24]) This OSH preventive measure is likely to consist of a document or other hard evidence detailing the actions specifically foreseen by the management to prevent work-related stress.

According to the ESENER data, a majority of establishments have put in place measures to prevent psychosocial risks. The OSH measure introduced in most establishments, regardless of whether they have introduced digital technologies enabling data-driven workers’ management, consists in allowing employees to take more decisions on how to do their job (67.7%), therefore increasing their autonomy and counteracting the potentially negative effect of digital technologies. Around 43% of the establishments have introduced measures allowing the reorganisation of work to reduce job demands and work pressure. Only 29.1% 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% and conflict resolution training by 34% of the establishments. Finally, approximately 33.5% of the establishments (with 20 or more employees) report having an action plan to prevent work related stress.

Measures to prevent psychosocial risks are relatively less commonly introduced in establishments using technologies enabling data-driven management of workers, as displayed in the table below. Among the establishments using digital technologies, the most frequently introduced measure is the action plan to prevent stress, followed by the intervention to modify working hours. Unsurprisingly much less common – while it is the most common option for the European establishments as a whole – is allowing employees to make more decisions about how to do their job, as data-driven workers’ management practices restrict workers’ autonomy and room for manoeuvre.

([24]) 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.

Table 2 Measures adopted by EU27 establishments to prevent psychosocial risks (% - 2019)

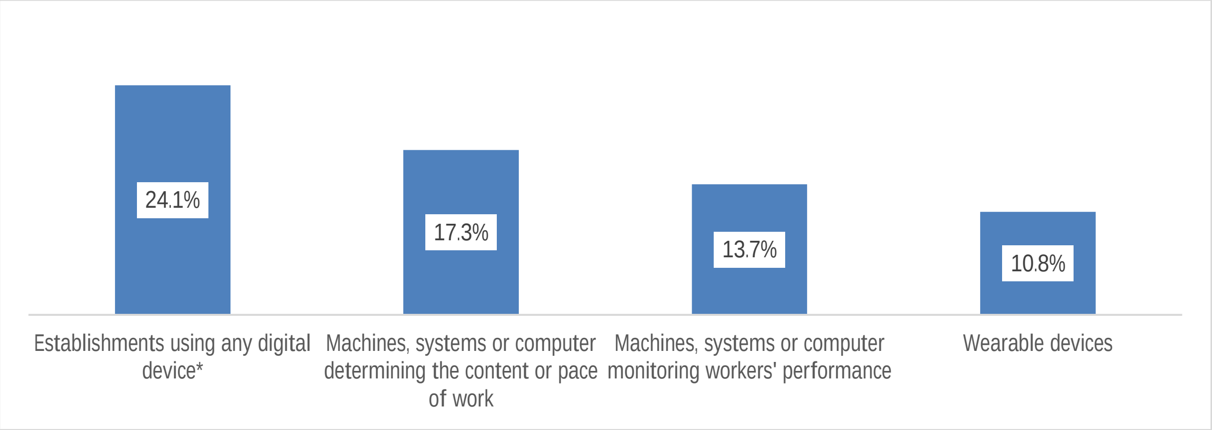
		Establishments using digital technologies		
	All establishments	Machines, systems or computer determining the content or pace of work	Machines, systems or computer monitoring workers' performance	Wearable devices
Reorganisation of work	43.3%	13.6%	9.6%	5.7%
Confidential counselling for employees	42.0%	13.2%	10.2%	5.6%
Training on conflict resolution	34.0%	13.8%	10.6%	6.2%
Intervention if long or irregular hours are worked	29.1%	15.0%	10.7%	6.7%
Allowing to take decisions on how to do the job	67.7%	12.0%	8.5%	5.2%
Action plan to prevent work-related stress	33.4%	17.3%	12.3%	7.5%

Source: Authors' elaboration on EU-OSHA ESENER-3 data.

In addition, a proportion of the establishments that adopted management technologies report having discussed the effects of such technologies on OSH with their workforce as a specific measure to raise awareness and prevent risks associated to the use of management technologies.

Around 24% of establishments that report using any of the digital technologies have internally discussed the effects of such technologies on OSH (see Figure 26). Such discussions are reported by about 11% of establishments that use wearable devices, such as smart watches and glasses, approximately by 14% of establishments using machine, systems, or computers monitoring worker performance, and by 17% of establishments using machine, systems, or computers to monitor content or pace of work.

Figure 26 Establishments in the EU27 which have discussed the possible health and safety impacts of impact of digital technologies by type of digital technologies used (%, 2019)



Source: Authors' elaboration on EU-OSHA ESENER-3 data.
** Including personal computers, laptops and other portable devices and robots interacting with workers, in addition to the technologies enabling data-driven management practices (Q310 of survey questionnaire).*

Overall, the topic most often discussed in establishments that use digital technologies is the need for continuous training to keep skills updated (by 77% of establishments that use any technologies). Discussions on prolonged sitting (65.5%) and increased flexibility for employees (63%) are reported by around two thirds of the establishments. Increased work intensity or time pressure and information overload, commonly reported in association with the use of data-driven workers' management practices, are discussed in about respectively 58% and 52% of the establishments using digital technologies. The issue of blurring boundaries between work and private life is discussed in 47% of establishments using digital technologies. Finally, the fear of job loss is the issue discussed by only 21.1% of establishments that use digital technologies (Figure 27).

Figure 27 Establishments in the EU27 which have discussed the possible health and safety impacts of impact of digital technologies by type of issue discussed (%, 2019)

Source: Authors' elaboration on EU-OSHA ESENER-3 data.

** Including personal computers, laptops and other portable devices and robots interacting with workers, in addition to the technologies enabling data-driven management practices (Q310 of survey questionnaire).*

Discussions on the impact of digital technologies on health and safety are more likely in establishments operating in economic sectors with higher digital intensity, such as information and communication, education, administrative and support service activities, and finance and real estate. Establishments in lower digital intensity sectors such as accommodation and food services, art, entertainment and recreation, and manufacturing are less likely to discuss the impact on health and safety of digital technologies.

On a final note, it is worth mentioning that workplace risk assessments are carried out by 75.3% of EU27 establishments, but establishments using technologies enabling data-driven forms of workers' management seem more keen in carrying out risk assessments: 80.3% of establishments using technologies to monitor content or pace of work, 80.5% of those using technologies to monitor workers' performance and 78.9% of establishments using wearables report regularly carrying out risk assessments.

The evidence presented above, complemented by the regression analyses on ESENER-3 data in Urzì Brancati and Curtarelli (2021), suggests that the presence of technologies enabling data-driven management of workers is associated with an increase in reported psychosocial risks in the workplace, especially when it comes to technologies monitoring performance. This is consistent with the Job Demand-Control (JDC) model on occupational stress, the combined low workers' control on their job (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) result in "high-strain" jobs, associated to increased psychosocial risks and potentially work-related stress and other health issues for the worker.

However, the descriptive analysis presented in this chapter suggests that only a minority (24%) of the establishment that have adopted any of the data-driven management enabling technology are aware of their potential negative impact on occupational health and safety (as measured by the presence of psychosocial risks). Indeed, this is in line with previous findings by Urzì Brancati and Curtarelli (2021) whose empirical analysis cannot confirm a mitigating role of OSH policies, except for having an action plan to reduce stress. In addition, the relatively small proportion of establishments that do discuss the risks of digitalisation seem to focus on the need for continuous training to keep skills updated. This suggests that the impact of such technologies on workers' wellbeing may be overlooked.

6 Conclusions

'The processing of personal data should be designed to serve mankind' (GDPR, pg. 2, (4)).

The EU digital strategy, together with the EU regulation on digital labour platforms, AI and data privacy (GDPR), aims, first and foremost, to expand the digital economy and make the EU a leader in a "society empowered by data to make better decisions – in business and the public sector". At the same time, the strategy recognises the importance of protecting citizens from the potential harm associated with emerging digital technologies. This report contributes to the policy debate by focusing on the potential for digital technologies to enable data-driven management of workers and the implications for occupational safety and health.

In particular, this report shows how data-driven and algorithmic management are not a marginal phenomenon limited to digital labour platforms, but are progressively spreading to traditional workplaces. Several technologies enabling data-driven management are widespread in the EU, especially in some member states and in large firms. Eurostat data show that the most widespread technologies enabling data-driven management are Enterprise Resource Planning (ERP) and Customer Relations management (CRM) software, present in more than a third of European enterprises with 10 or more employees. The Internet of Things is also fairly widespread, as it is present in approximately 29% of the EU27 enterprises; other technologies are relatively less common: for instance, data analytics is present in approximately 14% of the EU enterprises, AI in 8% while wearable devices in less than 6% of the enterprises with 10 or more employee. Such technologies can affect primarily the managerial functions of controlling, leading and directing, by facilitating worker monitoring, enabling the automatic allocation of tasks, setting the content or pace of work and so on. The number of workers subject to data-driven management is uncertain; however, the fact that large enterprises tend to adopt enabling technologies more often than the smaller ones implies a large number of workers may be affected. More detailed data at individual level, could help to assess the size of the phenomenon and to improve our understanding.

The descriptive analysis in this report showed that the use of technologies enabling data-driven management can have both positive and negative impacts for the employers and the workers.

The analysis presented in chapter 4 illustrated how establishments using data analytics for production improvement and employee performance monitoring have better outcomes in terms of establishment performance than those with no use of data analytics. In addition, the use of data analytics (particularly for process improvement) tends to be associated with features of so called 'high-performance work practices', for example, higher levels of training provision, performance-related pay, greater job complexity and worker autonomy. Possibly due to their large size, establishments with data analytics are also found to be more likely to engage in the design and development of new products or services than their counterparts with no use of data analytics. However, the technology is also associated with somewhat lower worker wellbeing, especially if used for employee monitoring.

Similarly, as displayed in the analysis presented in chapter 5, the use of digital technologies to monitor workers' performance or determine the content or pace of work is associated with a higher prevalence of reported psychosocial risks in the workplace, and in particular time pressure and long or irregular working hours.

The analysis highlighted that workplaces can introduce a number of measures to tackle the issue and prevent risks related to data-driven management on workers' wellbeing; for instance, prior to adopting a technology that can enable data-driven management, establishments can involve their workforce and discuss its possible impacts with them. Having an action plan to reduce stress in place would also help mitigate some of the negative effects on OSH. Nevertheless, the analysis displayed as well that establishments using the worker management enabling technologies are also those comparatively less inclined to have psychosocial risk preventive measures in place, which could indicate that they tend to have a limited awareness about the risks that the digital managing technologies can bring along. 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.

At the EU level, it should be recognised that workers in traditional workplaces may be subject to the same risks related to algorithmic and data-driven management as platform workers, and all establishments should carry out risk assessments that cover also the automated or semi-automated worker monitoring and decision-making systems and ensure that such systems do not in any manner put undue pressure, or otherwise put at risk the physical and mental health of workers.

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