European Parliament

Digitalisation and changes in the world of work

Literature Review

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Abstract

The aim of this study is to provide the Members of the committee on Employment and Social Affairs (EMPL) with an updated review of findings from research on the impact of digitalisation in the workplace.

This document was provided by the Policy Department for Economic, Scientific and Quality of Life Policies at the request of the Committee on Employment and Social Affairs.

CONTENTS

LIST OF BOXES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AI	Artifical Intelligence
AR	Augmented Reality
Cedefop	European Center for the teh Development of Vocational Training
ICT	Information and Communication Technologies
Cedefop	Committee of the Regions
DESI	Digital Society and Economy Index
EESC	European Economic and Social Committee
EMPL	Employment and Social Affairs
EP	European Parliament
ETUC	European Trade Union Confederation
ETUI	European Trade Union Institute
EU	European Union
Eurofound	European Foundation for the Improvement of Living and Working Conditions
IoT	Internet of Things
OECD	Organisation for Economic Coordination and Devolpment
OSHA	Occupational Security and Health Agency
SME	Small- and Medium-Sized Enterprise
STEM	Science, technology, engeneering and mathmematics
STOA	Scientific Foresight Unit of the Parliamentary's Research Service
UK	United Kingdom
UNI Europa	European Services Workers Union
VR	Virtual Reality

EXECUTIVE SUMMARY

Background

Digitalisation in the workplace covers a variety of digital technologies and fast-developing applications, ranging from digital communication and information tools (ICT) to robots and artificial intelligence (AI). These technologies all shape work to very different degrees, from platform work to the gig economy to algorithmic management and digital surveillance. The Covid-19 pandemic has brought with it an explosion in demand for remote and platform work and has accelerated the digital transformation of many regular workplaces in the European Union. Assessments of the benefits and downsides of the impact of digital technologies vary greatly. Hopes contrast with fears and the discussion about possible consequences on employment (demand for work) and working conditions (job quality) is quite polarised.

Aim

To decide on appropriate policies and measures that are mindful of the need to mitigate possible harms of digitalisation for workers, politicians should ensure that their decisions are based on sound evidence. Sound empirical research is all the more important given that dominant, discursive expectations on the impact of workplace digitalisation are not always based on empirical evidence. The aim of this review study is to provide the Members of the EMPL committee with an updated overview of findings from research on the consequences of digital technologies that are already having an impact in the workplace. The literature review presents recent empirical (quantitative) impact studies and supplement these with qualitative research findings from relevant case studies.

Key Findings

Although European countries show weaknesses in the use of digital technologies compared to the United States or China, there is a broad range of fast developing digital technologies already playing or likely to play a significant role in shaping the future of work. Indicators and new company surveys show that Covid-19 has been "the great accelerator" not only for remote and platform work but also for the adoption of digital business models and processes in regular work settings. Research on exploring the challenges facing firms and their workers in transitioning to digital technology during the pandemic, however, is only just emerging.

A major concern about the acceleration of advanced technologies is that it has widened the digital gap, known as the 'digital divide', between groups of workers. Indicators from the Commission's digital scoreboard (DESI) show that the digital divide has at least not worsened during the first year of the pandemic. The existing digital gender gap is closing in internet user skills but remains significant in specialist digital skill. However, the digital gender divide refers mainly to digital skills but does not say anything about how digital technologies impacts on the working lives of women. Findings from empirical research on the impact of digitalisation on the gender-pay gap, for example, provide contradictory results. Overall, there is so far no conclusive evidence on whether the digital transformation has the potential to reduce or even worsen gender inequalities.

An important lesson from recent empirical studies is that with the adoption of digital technologies at the establishment level, existing jobs will not be lost on a large scale. Study findings, however, agree in that the impact of workplace digitalisation is uneven among workers with different skills levels. Increased investment in digitalisation is generally associated with increased employment of high-skilled workers and reduced employment of low-skilled workers. Re-and upskilling might, however, not always be the silver bullet for individual workers with physical or mental limitations.

Research identified also other group of workers for whom re-training programmes are insufficiently targeted, e.g. well-paid routine workers displaced in the manufacturing industry.

The evidence on causal effects of digital transformation on working conditions or health outcomes remains sparse. There is only a small number of studies using large-scale administrative and survey data addressing empirically the direct effects of digital transformation on physical and mental health. The study findings suggest that an increase in ICT or robot intensity could indeed relieve workers of physically demanding tasks but that they may also have a negative impact on job insecurity and self-rated mental health. Business case studies also find that key technologies decrease physical risks and suggest that where worker or worker representatives were involved, technology adoption led to generally positive outcomes for the company workforce.

Recent debates revolve mainly around the risks of AI-enabled algorithmic management in the workplace. Despite the many fears that algorithmic management tools engender, there is still scarce evidence on the associated occupational safety and health risks arising from digital surveillance, performance pressure and job insecurity. New EU initiatives to regulate AI-enabled algorithms at work such as the Commission's proposals for an AI act or the directive on platform work are very controversial among stakeholders and (legal) experts. However, the extent to which these technologies raise ethical dilemmas largely depend on how they are designed and implemented in the workplace. To involve workers and unions in the introduction and use of AI systems at work seems therefore a sound proposal. Algorithmic management should thus not only be a topic for regulation at EU and national level but also for collective bargaining and worker involvement at all levels, including co-determination in day to day industrial relations.

INTRODUCTION

Digitalisation in the workplace covers a variety of digital technologies and fast-developing applications, ranging from digital communication and information tools (ICT) to the combination of robots and Artificial Intelligence (AI). These technologies all shape work to very different degrees, from platform work to the gig economy to algorithmic management and digital surveillance.

The digital revolution requires establishments to change their ways of operating, moving away from labour-intensive to more technology-intensive types of work organisation. These might go together with replacing humans by machines and changes in the content of jobs and skills, working conditions and work relations. The Covid-19 pandemic has brought with it an explosion in demand for remote and platform work and has accelerated the digital transformation of many regular workplaces in the European Union. More recently, *artificial intelligence* (AI) considered not only as an automation technology but also as a general-purpose technology, has become a central topic in the political debates on the risks of comprehensive digitalisation of the world of work. Debates revolve around AI's ability to self-improve and to expand the set of tasks that can be automated, including highly skilled ones. In particular, concerns have been raised about AI-based algorithmic management applications, which are used not only in the platform economy but increasingly also in the traditional economy. Algorithms might take over the tasks of the employer-from hiring (job interview) to firing (automated termination) also in regular work settings.

Assessments of benefits and downsides of the impact of digital technologies vary greatly. Hopes contrast with fears and the discussion about possible consequences on employment (demand for work) and working conditions (job quality) is quite polarised. On the one hand, it is argued that digital technologies could improve working conditions by replacing repetitive, heavy, labour-intensive or dangerous tasks, as well as by reducing the workload. It could also help to improve skills, raise the quality of work and create new, higher value-added employment, leaving more time for stimulating tasks and career development. On the other hand, there are fears that the adoption of AI applications will give rise to new risks such as opaque decision-making, discrimination, or intrusion into people's private lives raising crucial ethical questions. Ultimately, it could affect workers' mental health (EU-OSHA 2021). In the view of the European Trade Union Institute, AI systems in the context of employment "are intrusive and have negative impacts on workers" (ETUI 2022a) and legal experts assume that 'improving working conditions through AI applications might be the exception' (STOA 2022).

However, dominant, discursive expectations are not always based on sound empirical evidence. There are tensions between expectations and the empirical reality of AI. Scholars criticise that "grey literature" is used at the national and international level as a relevant orientation for action. Giering (2022) mentions in this context the example of the Commission's "White paper on AI". In many policy documents, the use and consequences of AI-based systems seem indeed to be more anticipated than evidence based. A likely reason for existing research gaps is the scarcity of (micro-) datasets that provide measures of the use of advanced technologies at firm level and the accompanying workers' outcomes (Genz 2022)[1].

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[1] More recently, research has developed new concepts to look at specific forms of digitalised workplaces in different work environments and new firm-level datasets have been set up .The IAB/ZEW dataset, for example, allows to study the labour market consequences of the latest digital technologies, incl. AI and smart factories, across all German industries. Combining establishment-level survey with extensive data from the Social Security makes it possible to investigate how the quality of existing jobs changes in dependence of individual, job and workplace characteristics changes.

In this review, we focus on findings based on datasets, which allow to analyse how advanced technologies in the workplace shape job quality. Findings from quantitative research are supplemented by relevant case studies to answer the following questions:

(1) How technological change influences the quantity of employment?;

(2) How digitalisation affects gender inequality in the labour market?;

(3) How the use of digital technologies, including artificial intelligence affects the quality of work?; and

(4) What are the risks connected to the use of AI as a management tool?

To answer the first two questions, we review the empirical literature quantifying the impact of digitalisation (automation in general, robots, ICT) on employment (volume of work) focusing on studies analysing the substitution potential of job tasks and its consequences for skills development. The substitutability potential in female dominated occupations is also used to discuss the question of an increase or decrease in gender inequality in the labour market.

To provide some insights to answer the third question, use is made of relevant research based on linked employer/employee datasets, which empirically investigate the impact of different technologies on working conditions, in particular on physical and mental health. The findings from quantitative research are complemented by business case studies exploring the consequences of introducing key technologies in establishments of different sizes and operating in different sectors. To address the fourth question, there are no data-driven studies on the impact of algorithmic management on working conditions. We therefore present a framework for studying the impact of algorithmic management in platform work and regular work settings, which might provide guidance for further research on the topic.

The paper is **structured** as follows:

- In the first chapter, we give an overview of the state of play with regard to the use of digital technologies in workplaces across EU Member States and address the accelerated spread of digital technologies during the Covid-19 pandemic. Based on indicators developed by the Commission (DESI) we present data on the "digital divide" caused by Covid-19;

- In chapter 2, we present study findings on the employment impact of digitalisation, focusing on the substitutability potential of jobs and tasks and discuss the consequences for skills development. In chapter 3 we provide insights into the implications of digitalisation for gender (in-)equality;

- In chapter 4, we review studies addressing the impact of different digital technologies on workers' physical and mental health and put a special focus on expectations about AI-enabled algorithmic management on workers' well-being; and

- In chapter 5, we present the Commission's main legal options for regulating the use of AI-enabled algorithmic management systems and review assessments by stakeholders and legal experts on the two main EU legal initiatives. Chapter 6 concludes.

1. HOW DIGITALISED ARE WORKPLACES?

KEY FINDINGS

Although European countries show weaknesses in the use of digital technologies compared to the United States or China, there is a broad range of fast developing digital technologies already playing or likely to play a significant role in shaping the future of work in Europe. Covid-19 is considered the "the great accelerator" not only for remote work and platform work but also for the adoption of digital business models and processes in regular work settings. A new ETUI survey, however, shows that only 1.1 per cent of the working age population in Europe can be classified as 'main platform workers' and there are only a few new company surveys that provide evidence that Covid-19 has accelerated technology adoption at the company level.

The most recent figures from the Commission's digital scoreboard indicate that the digital divide has at least not worsened during the pandemic. What has worsened, however, are the consequences for those who did not previously use internet and digital services. Significant gaps remain between the genders in specialist digital skills, and among SMEs and large companies in the use of advanced but also basic digital technologies. Only about 20% of all enterprises (with more than 10 employees in non-financial sectors) across the EU-27 provided professional training to their personnel to develop/upgrade their ICT skills in 2020.

1.1. Diversity of digital technologies

There are various impact pathways through which digitalisation affects work and employment. Eurofound distinguishes between **a) automation of work** (i.e. the replacement of human labour with machine input), **b) digitisation of processes**, i.e. the conversion of information from a physical to a digital format through AI-related technologies, cloud computing and Big Data, and **c) coordination by platforms**.

The broad range of fast-developing digital technologies makes it impossible to map the consequences of all the existing digital applications. This is particularly the case for Artificial intelligence (AI). There is **no single definition of AI**, which makes the operationalisation of the term in research difficult. In some studies, AI is understood as *one* automation technology allowing the automation of increasingly complex tasks and in others it is seen as *general-purpose technology*, i.e. a progressive form of general automation to be incorporated into businesses both through hardware (e.g. autonomous robots) and software applications (e.g. solutions for speech, text or image recognition). AI today, however, refers above all to various kinds of machine learning, i.e. the ability of an AI system to improve automatically through experience by algorithms that independently develop complex models for processing through predictive and behavioural analytics ("people analytics"). AI algorithms are trained using large datasets so that they can identify patterns, make predictions, recommend actions, and figure out what to do in unfamiliar situations, learning from new data and thus improving over time. AI systems are designed to operate with varying levels of autonomy" (OECD 2020). Box 1 provides some examples of what type of workplace technologies are included in policy documents.

Box 1: Diversity of technologies and digital tools used in policy documents

The European Union survey on ICT usage and eCommerce in Enterprises, which builds the basis for the Commission's Digital Society and Economy Index (DESI) includes the following technologies:

- Electronic information sharing (EPR-=enterprise resource planning);
- Social media;
- Big data;
- Cloud computing services;
- AI; and
- ICT for environmental sustainability

The European Agency for Safety and Health (EU-OSHA) focuses in its project (2020-2023) on OSH challenges and opportunities of digitalisation on the following technologies:

- Advanced robotics and artificial intelligence;
- Worker management through artificial intelligence;
- Digital platform work;
- Smart digital systems; and
- Remote work

Eurofound (2022a) includes in its report on 'Ethics in the digital workplace' the following technologies:

- Internet of things and wearables;
- Advanced Robotics;
- Artificial intelligence;
- Algorithmic work management;
- People analytics;
- Pre-hiring screening and recruitment; and
- Emotional AI

The Scientific Foresight Unit (STOA) of the European Parliamentary Research Service refers in its 2022 study mainly to the following AI applications and digital tools for human resource management:

- Recruitment (e.g. applicant tracking systems);
- Performance management (e.g. use of 'big data' for staff appraisal and professional development);
- Task distribution, management and evaluation (e.g. through automated decision-making)
- Retention, rewards and promotion (e.g. use of predictive attrition programmes); and
- Disciplinary procedures (e.g. through sweeping 'surveillance loops')

Source: Authors' compilation.

1.2.   Extent of digital technologies used at the workplace

Since 2014, the Commission's Digital Economy and Society Index (DESI) measures more broadly developments in the digital economy and society based on data collected directly by national authorities and by Eurostat. DESI covers data for 33 indicators in four principal policy areas: human capital (digital skills), connectivity, integration of digital technology in businesses and e-commerce and digital public services. These dimensions reflect those laid down in the 2030 Digital Compass, which serves as a guide for the digital transformation in the European Union by 2030.

The "Integration of digital technology" area is made up of three sub-dimensions: digital intensity, take-up of selected technologies by enterprises and e-commerce; SMEs with at least a basic level of digital intensity and take-up of big data, cloud computing and AI. The last DESI 2022 report presents data for 2021 that show that all EU Member States have made progress in the area of digitisation of businesses. However, only a fraction of enterprises used *advanced digital technologies* (14% big data, 25% AI and 26% cloud computing). There is a substantial gap between large companies and SMEs, not only in the use of advanced technologies, but also in basic digital solutions, such as having an enterprise resource planning (ERP) software package and engaging in e-commerce. The Ipsos survey on the uptake of AI estimates that 42% of enterprises in the EU27 use at least one AI technology when a wider set of technologies and systems are taken into account. While 38.5% of large companies already use advanced cloud services, and 32.7 % said they use "Big data analytics" only 17 percent of SMEs use cloud services and only 12 percent use big data analytics.

Differences are substantial also across EU Member States (24% of enterprises in Denmark and only 1% in Romania use e.g. AI technologies) but also across *economic sectors* (25% of enterprises in the information and communication sector and only 5% in transport and storage sector use AI technologies). In terms of e-commerce, only 17.5 percent of SMEs sold products or services online in 2019, a very small increase of 1.4 percentage points compared to 2016. In contrast, 39 percent of large enterprises used online sales in 2019.

The Eurostat database on ICT usage in enterprises (an integral part of DESI) further shows that 29% of enterprises in the EU employing more than 10 people use the Internet of Things (IoT), while only 5% use 3D printing. When it comes to the use of robots, 7% of EU27 enterprises use industrial or service robots, with the extremes being Denmark (13% of enterprises) and Ireland (2%). Less data is available on other technologies. According to the World Economic Forum (WEF) in a survey conducted among multinational companies and other large enterprises, 58% of companies were likely to adopt Virtual Reality (VR)/Augmented Reality (AR) technologies between 2018 and 2022 (Eurofound 2021a).
Providing training to workers, including on digital skills has been identified as being crucial to keep pace with transformative changes in the workplace. Figure 1 shows that in 2020, **20% of all enterprises**, (excluding the financial sector) with 10 or more employees and self-employed persons across the EU-27 **provided professional training to their personnel to develop/upgrade their ICT skills**.

Figure 1: Enterprises provided training to their personnel to develop their ICT skills, in % of enterprises, 2020
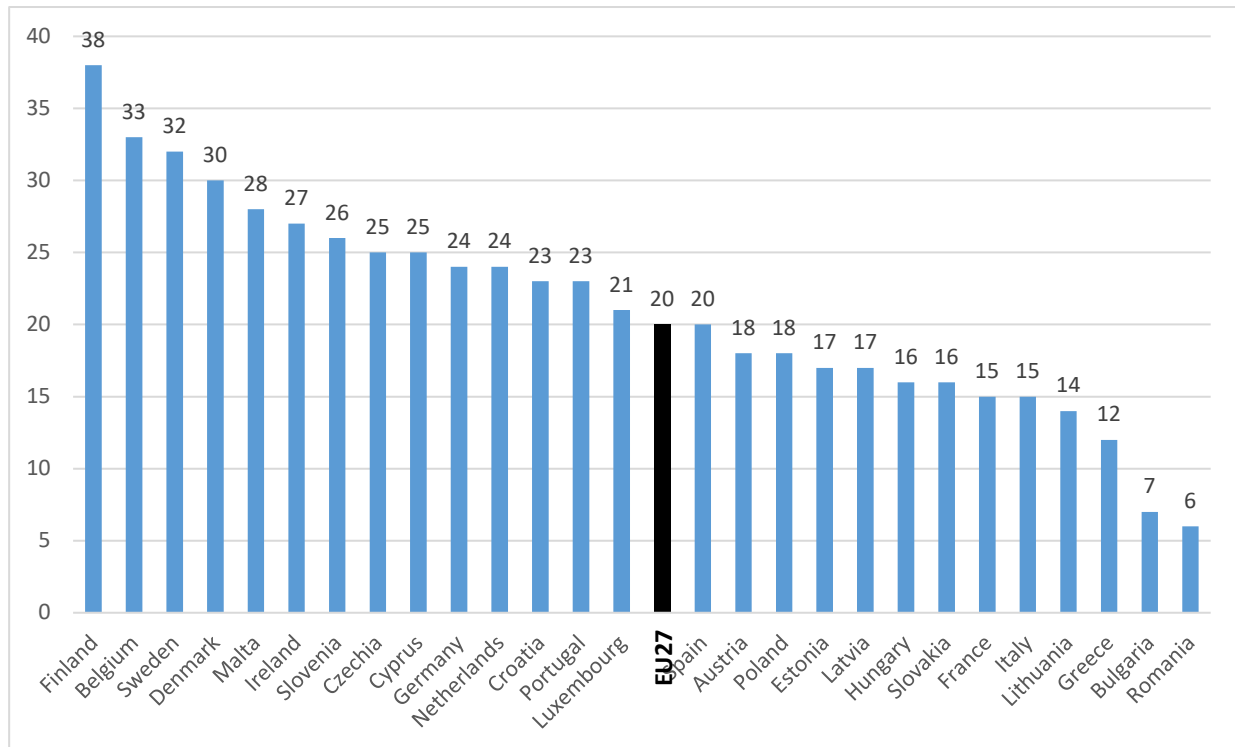
Source: Eurostat.

No data is available to distinguish between digital skills training in SMEs and large companies. In general, there is a considerable digital gap among SMEs and large companies. This digital gap has increased inequalities among people, places and firms, and there are concerns that the benefits of the digital transformation could accrue to early adopters, further broadening these inequalities. Enabling SME digitalisation has become a top policy priority in EU and OECD countries (OECD 2021).

On the supply side, the digital skills ("human capital") dimension of the DESI scoreboard assesses both internet user skills of citizens and advanced skills of specialists. Additionally, the "Women in Digital (WiD)" scoreboard has been set up to assess women's inclusion in digital jobs, careers and entrepreneurship. The 2021 Women in Digital Scoreboard shows that **a significant gender gap remains in specialist digital skills**, though the gap is closing in internet user skills. Only 19% of ICT specialists and about one third of science, technology, engineering and mathematics (STEM) graduates are female. There is no progress, as these figures have been stable over the last few years. The gender gap is less pronounced with regard to basic skills (54% of females vs. 58% of males on EU average) and "above basic digital skills" (29% females vs. 33% of males) as shown in Figure 2.

Figure 2: Individuals who have "basic or above basic digital" skills in % of individuals (male and female) aged 16-74 (2019)
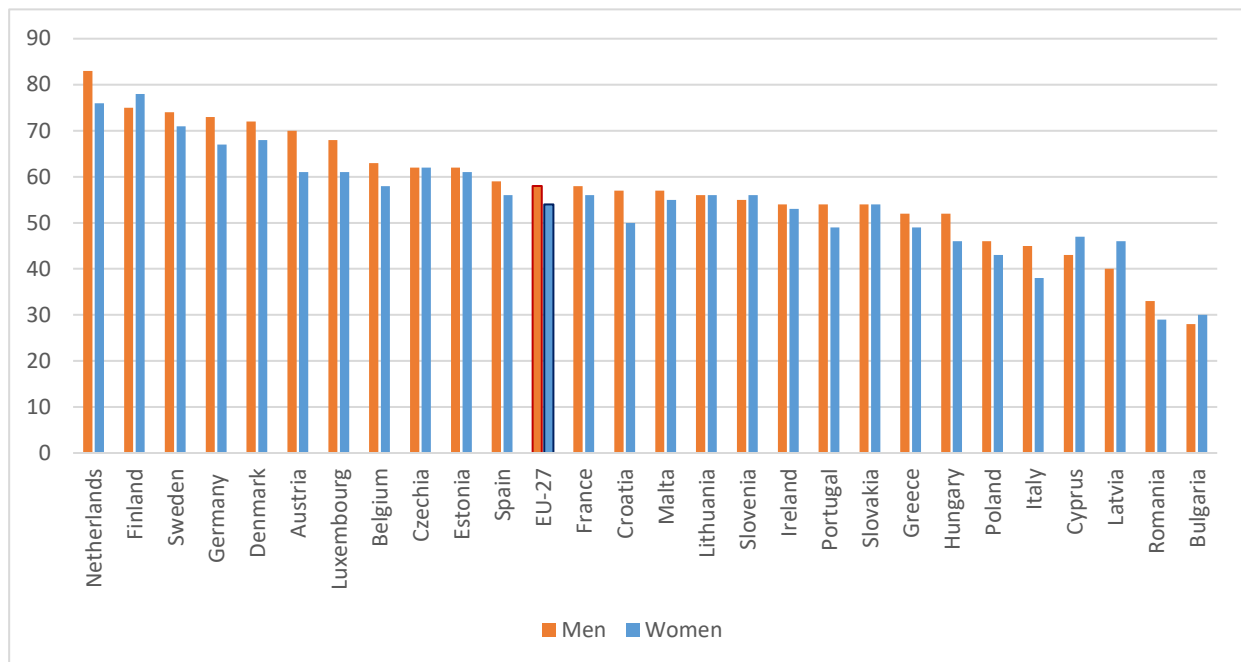
Source: Eurostat.

1.3.   Acceleration of digitalisation during the COVID-19 pandemic

Much of the world moved online when the Covid-19 pandemic hit. Covid-19 is considered as "*the great accelerator*" not only for remote work and platform work but also for the adoption of digital business models and processes in regular work settings (Amankwah-Amoaha et al., 2021). The pandemic has also boosted digital delivery of government services. Box 2 provides an illustrative example of the acceleration of digitalisation of operations and services in Public Employment Services (PES).

Box 2: Harnessing digitalisation in Public Employment Services

Spurred on by the Covid-19 pandemic, Public Employment Services (PES) across the EU and the OECD are accelerating their digitalisation journey, adopting digital – including AI – tools across all aspects of operations and services. These advancements are wide-ranging and seek to improve the effectiveness and efficiency of the PES in connecting people with jobs. Many of these changes consisted of investments in IT infrastructure to enable PES to deal with the increased client numbers and to enable service continuity in face of restrictions to in-person service provision. Changes to the delivery models of training and job-search support and counselling were particularly common across countries at this time.

More efforts that are recent focus on improving and modernising existing infrastructure (e.g. enhancing jobseeker profiling and job matching tools). However, countries are also engaging in efforts to digitalise other processes/services and adopt Artificial Intelligence (AI) tools or other advanced analytics. The OECD (2022) notes that the adoption of AI in PES activities provides many benefits, including better use of data and in a timelier manner. However, limitations exist, including risks posed by poor quality data and the inability of these tools to consider intangible information on a client's situation beyond what exists in the input data.

Source: OECD 2022.

1.3.1. Acceleration of digitalisation in regular work settings

Evidence that Covid-19 has accelerated technology adoption at the company level is not only provided by the corresponding DESI indicator "(integration of digital technology in businesses and e-commerce") but also by **new company surveys.** An example of the extent to which companies' investments in digital technologies have increased during the Covid-19 pandemic is given by Bellmann et al. (2021), and based on a large German company survey. The study examines whether and which companies have invested in different types of digital technologies, how these investments are connected to working from home, and how investments are influenced by the economic situation of companies during the pandemic. The authors also discuss further training activities provided and planned by employers and how those are related to their investments in digital technologies. The results show that about **50% of all companies in Germany have invested in some form of digital technology** since the beginning of the Corona crisis and 30% of all companies see the pandemic as an accelerator of digitalisation. Investments are particularly pronounced in large companies, while small and medium-sized companies invest less frequently and are more likely to face financial or logistical barriers. Hardware is the most common type of digital investment, while investment in communication software has been accelerated the most by the pandemic. Investments in digital technologies have been accompanied by an increase in IT training. In companies that are upgrading due to the pandemic, the need for further training in communication and cooperation skills and data protection is particularly high.

In the UK, a survey of businesses on technology adoption in response to Covid-19 was conducted in collaboration with the Confederation of British Industry in June 2020 and July 2021 (CEP-CBI survey). The results show that while remote working technologies were a prominent feature (particularly during the early days of the pandemic), there was also widespread adoption of online marketing technologies, cloud, data analytics and cyber security technologies, often in combination. **75% of firms have adopted digital technologies, 55% new digital capabilities and nearly 70% new management practices**. Over 60% engaged in product innovation.

Adoption of digital technologies and management practices occurred early on (March-June 2020) at many firms, although a large share of firms continued to innovate beyond the initial lockdowns. In contrast, the share of firms adopting new digital capabilities was constant, while product innovation increased. Smaller firms and those that were less digitised pre-pandemic tend to have adopted less and, along some dimensions, report differential impacts of technology adoption on firms and their workers. Smaller firms were also less likely to report an increase in resilience and worker productivity as a result of new technologies. These findings suggest that gaps between more and less digitised firms might widen in the future.

A post-pandemic increase in digitalisation and automation even in low-wage sector businesses might arise from the need to tackle immediate labour shortages. Automation has been rather low in retail or logistics, mainly due to cost reasons, but current staff shortages might push forward, for example, the loading of luggage by robots, passport control and boarding through facial recognition checks in the aviation sector or by "seeing cashiers" in self-service restaurants and automated delivery centres and warehouses (Handelsblatt, 01.07.2022).

1.3.2. The surge of remote[2] and platform work

Covid-19 triggered a surge in **remote working**, with about 40–50% of the workforce in advanced economies working from home at the height of the pandemic (Davis et al. 2021). Remote and especially telework entailing the use of information and communication technologies (ICT) and digital devices increased dramatically during the first lockdowns in spring 2020 but declined afterwards and since then never returned to the same level. In March 2021, when tight restrictions had been re-imposed in many parts of Europe, Eurofound's Living, Working and Covid-19 e-survey recorded a fall of 10 percentage points in the proportion of workers working exclusively from home compared with summer 2020. Eurofound's recent e-survey results show that teleworking numbers have stayed consistent (18% in 2021 and 2022) and that over 60% of people would prefer to work from home at least several times per month (Eurofound 2022b).

Although Covid-19 accelerated the efforts to automate "non-teleworkable" tasks to compensate for the unavailability of human workers (Amankwah-Amoah et al., 2021), estimates suggest that just about 37% of EU employees work in occupations that are teleworkable, which had large and unequal impacts on workers. An important determinant of this inequality is workers' ability to carry out their tasks from home, which varies both across and within occupations and industries. **There are fears that teleworkability in the Covid-19 crisis might give rise to a new digital divide** (Eurofound, 2020).

Adrjan et al. 2022 undertook an online survey in 25 countries among managers and employees in the first half of 2021 to investigate how teleworking impacts productivity and well-being of workers. Around 60% of managers think that workers work more and more productively in a teleworking environment – a result that aligns with findings from other studies. Workers value the advantages of teleworking even more strongly. Almost 90% of employees cite less commuting as the most important upside of this working arrangement. Finally, 85% of employees indicate that they can work better on tasks that require more concentration as an additional benefit of teleworking. On the downsides, more than 80% of them consider lack of social interactions and the fusing of private and professional life as the major downsides of teleworking.

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[2] We use remote work, also known as "work from anywhere," as umbrella term for ICT based mobile work including teleworking (work performed by employees outside a default place of work, normally the employer's premises) and "Working from home" as one specific sub-category of remote working where work is carried out from the worker's home.

The authors conclude that public policies have a key role to play in ensuring that teleworking has a positive impact on productivity and wellbeing. Overall, both **employees and employers seem to be mostly satisfied with their experience of telework and home-office during the Covid-19 crisis**.

Notwithstanding these positive views on the impacts of telework practices on productivity, there are surveys contradicting this assessment. Findings based on academic and scientific research carried out in the Member States and collected by Eurofound's national correspondents, Eurofound (2022c) highlights various disadvantages linked to telework. Main identified disadvantages include limited communication and social contacts with colleagues and superiors, feelings of isolation, disconnection and detachment with the organization, perception of decreased career advancement opportunities, difficulties to effectively monitor work or, finally, difficulties in ensuring healthy and safe working conditions in homes poorly prepared for telework, amongst others.

A review of evidence on an increase in monitoring and control practices for teleworkers during the pandemic by Eurofound (2022c) shows **no clear-cut results on an increase in the use of monitoring and control practices on teleworkers** during the pandemic. When misuse has been reported, they include a combination of traditional methods (e.g. micro-management and excessive supervision, calls, messages and e-meetings) with new ones (e.g. specific monitoring software and surveillance tools).

By way of contrast, there is empirical evidence across European countries suggesting that workers in telework during the Covid-19 pandemic period worked a longer number of (unusual) hours (Eurofound 2022c). Being able to disconnect and maintain normal working hours contributes to employees' well-being and performance, as well as the success of the companies they work for. In recognition of this, the '**right to disconnect**' has emerged as a legal means of protecting employees' right to switch off – literally and figuratively – at the end of a working day. In an (upcoming) report on the implementation of regulations on telework in EU countries, Eurofound (2022d) concludes that having the right to disconnect in national legislation might not be sufficient to prevent the spread of an always-on work culture. Evidence shows that even in countries that have a right to disconnect regulation, not all companies have adopted a policy related to this right.

Most **platform work** is done remotely. The pandemic accelerated the expansion of all kinds of platform work. The unprecedented demand for home deliveries under lockdown from early 2020 fuelled the further expansion of food delivery platforms and even ride-hailing reported a bounce back after restrictions were relaxed. In online labour markets, an initial drop in demand was followed by stable recovery. Furthermore, the shift to remote work in the pandemic may have given an impetus to companies to re-evaluate their working methods, possibly leading to more outsourcing to online labour platforms. The combined effects of the spread of mobile devices, decentralised information networks and big data analytics have enabled the emergence of digital platforms that mediate the provision of work. Although systematic data on the effects of the Covid-19 crisis remain scarce, a 2021 panel survey suggests that a large majority of platform workers in the European Union (EU) report either working more hours or re-starting working on platforms because of the pandemic (Barcevičius et al. 2021: 46). Hence, a model of *remote platform work* might be adopted across wider segments of the traditional economy in the near future (ETUI 2022b:51).

Research has shown a diversity of experience among platform workers with some – typically those relying on platform work as an additional source of income – benefiting from autonomy and flexibility. At the same time, platform work is also associated with difficult working conditions, health and safety risks and inadequate levels of income for those that rely on it as a source of living. Platform workers usually lack formal labour protection and are easily exploited by their employers.

Criticism of a growing "digital precariat" refers, among other things, to the accusation of pseudo-self-employment, to the control of crowd workers by algorithms and to a "delocalisation" of work, as digital platforms enable a new form of global division of labour. However, Kässi et al. (2021), point out that this debate lacks hard data. Since a large share of this activity happens under the radar of national statistical agencies, policymakers and researchers have limited possibilities for assessing the extent and impact of digital labour markets on workers.

To fill the gap of representative comparative evidence on the extent of platform work and the characteristics of the workers that engage in, new surveys and the combination of different data sources have produced more reliable estimates for the number of online workers. Kässi et al. (2021) estimate that there are globally 163 million registered workers on online labour platforms (platform mediated remote work), and 8.6% of them have ever worked through a platform. These figures confirm that online work is growing rapidly but that only a small minority have completed any projects, which suggests that digital platform work is a viable way to make a living only for a small minority of registered workers. The figures, however, do not include platform-mediated place-based work, i.e. the local gig economy of ride hailing and delivery services, remote work for overseas clients, and business process outsourcing.

The European Trade Institute (ETUI) set up an "Internet and Platform Work Survey" in 2018 to map the extent to which the internet, and in particular online platforms, websites or mobile applications, are used as a tool to generate income, including platforms' intermediary role in matching workers with clients. A second ETUI Internet and Platform Work Survey (ETUI IPWS), conducted in 14 MS in spring 2021, distinguishes between internet work and platform work: the former capturing a broader concept of digitally mediated labour; the latter measuring in a very restrictive way based on both a descriptive definition of the type of work and the names of platforms provided by respondents. The survey also provide data on the prevalence and profile of platform work in Europe. In contrast to the study prepared for the Commission (Barcevičius et al., 2021), the ETUI survey uses a sampling frame to ensure equal probability of being selected for different groups of the general population, and to identify their characteristics, in a way that is generalizable to the working age population. According to the ETUI IPWS estimates, 17 per cent of the working age population did some internet work in the past year, 4.3 per cent did platform work and **1.1 per cent of the working age population in Europe can be classified as** '**main platform workers**'; that is, working 20 hours or more per week or earning more than 50 per cent of their income through platforms. Based on these results, the authors estimate that there were about 47.5 million internet workers, 12 million platform workers and 3 million main platform workers in the EU27 in 2021(ETUI IPWS 2022:52). This survey also revealed that platform workers are somewhat younger but are far from constituting a student workforce. They are better educated than those who have never done internet work and this is particularly the case for higher skill professional workers who perform creative freelance work. The survey results indicate that in general there is a wide variation in the occupational and sectoral profiles of all types of internet and platform work. Income from internet and platform work is very low and, for the vast majority of workers, this type of work provides only a very small share of their total income. Only around 5-10 % of internet and platform workers make sizeable earnings, particularly through the renting of accommodation, remote freelance work and transport work (ETUI IPWS 2022:53).

1.4.   Evolution of the digital divide during the pandemic

A major concern about the acceleration of advanced technologies is that it has widened the digital gap known as 'digital divide'. The concept of the digital divide is not univocal. Gender, income, educational attainment and disabilities are the main components influencing digital disparities. The main concern regarding the digital divide is that it increases social inequality and that vulnerable groups are becoming even more marginalised.

There is a generalised perception that the pandemic has resulted in an increase in digital divides. A closer look at different levels of the problem provides, however, a more nuanced picture. The Commission's digital scoreboard indicates that the digital divide in Europe has been substantially reduced before the onset of the crisis and available figures for 2020 show that indicators such as ICT specialists and female ICT specialists **have at least not worsened**. Other indicators such as "lack of access to internet and digital services" or "lack of digital skills" have not changed, either. What has worsened, however, are the consequences, in particular the outcomes obtained from the use of internet and digital services. It is not that there are more people without internet access but the gap has widened between those who have used the internet efficiently and productively in their daily lives (learning, teleworking, online banking, E-shopping, etc.) and those who have not. Nor are there more people without e-skills, but those who did not have them before have not benefited equally from their access to the internet (iClaves-ESADE, 2021).

At EU-level, special attention is given to the digital gender divide. The Women in Digital (WiD) Scoreboard is part of the Commission's Digital Economy and Society Index (DESI), and assesses Member States' performance in the areas of internet use, internet user skills, specialist skills and employment based on 12 indicators. The 2021 Women in Digital Scoreboard shows that although the figures for female ICT specialists have not worsened, **a significant gender gap remains in specialist digital skills**, though the gap is closing in internet user skills. While only 19% of ICT specialists and about one third of science, technology, engineering and mathematics graduates are female, 85% of females used the internet regularly in 2020 compared with 87% of males. A 4-percentage-point difference can be observed in the digital skills indicators: 54% of females have at least basic digital skills (58% of males), 29% above basic digital skills (33% of males) and 56% at least basic software skills (60% of males) as of 2019. However, female ICT specialist figures have been stable over the last years meaning that no progress has been recorded. To improve women's digital inclusion there are mainly two indicators most relevant according to a study by Damiani and Rodríguez-Modroñ (2022): STEM graduates and the unadjusted pay gap.

However, digital gender divide refers mainly to digital skills but does not say anything about **how digital technologies impacts on the working lives of women**. Findings of current research on the impact of digitalisation on existing gender inequalities are discussed separately in chapter 3.

2. IMPACT OF DIGITALISATION ON EMPLOYMENT AND SKILLS DEVELOPMENT

KEY FINDINGS

An important lesson from recent empirical studies is that existing jobs will not be lost on a large scale with the adoption of digital technologies at the establishment level. One of the reasons new technology does not produce more acute changes in employment is the diversity of tasks within jobs (and the diversity of jobs within occupations), which are not all equally susceptible to technological substitution.

Depending on the type of technology, there is evidence even of improved employment stability, or higher wage growth, and increased cumulative earnings in response to digital technology adoption. Study findings, however, agree in that the impact of workplace digitalisation is uneven among workers with different skills level. Increased investment in digitalisation is generally associated with increased employment of high-skilled workers and reduced employment of low-skilled workers.

More in-company training is needed, so that staff can adapt to new requirements. At the same time, policymakers have to take steps to prepare the workforce for the future. Re-and upskilling might, however, not always be the silver bullet for individual workers with physical or mental limitations. Studies have identified also other groups of workers for whom re-training programmes are insufficiently targeted, e.g. well-paid routine workers displaced in the manufacturing industry.

Big data and AI methods might provide better insights into future skills demand through "real data" skills intelligence tools compared to conventional methods such as skills and jobs surveys or skills forecasts.

2.1. Findings from quantitative research

Numerous observers believe recent developments in robotics and AI may cause an unprecedented wave of automation-related job losses. In this view, the new technology is fundamentally different from earlier waves of computing technology because it improves at an accelerating rate and substitutes for a much wider range of occupations. The widely cited study by Frey and Osborne (2013) estimates that 47% of US jobs at high risk of becoming automated in the near future. While the fear of technology-driven unemployment has been fuelled by such striking numbers, more recent studies stress that the main challenge of digitalisation will not be the number but the structure of jobs (task composition of jobs), raising the question of what kind of jobs we will have in the future and are workers able to fill these jobs. Part of the reason new technology does not produce sharper changes in employment is the **diversity of jobs within occupations and the diversity of tasks within jobs**, not all of which are equally susceptible to technological substitution. Automation of some tasks, such as document review within legal occupations, may result in more time spent on other, perhaps new, tasks without necessarily a reduction in the number of jobs. When technology substitutes for some tasks within an occupation, it is possible that workers will be shifted to other, sometimes new, tasks, rather than simply losing their jobs. The extent to which technology augments organisational capacities rather than simply saving labour is an empirical question that tends to be overlooked in discussions of automation, perhaps because it represents continuity rather than a break with existing practices. A study based on U.S. Bureau of Labour Statistics data examining growth trends in specific occupations that are most favourable to automation found little support for widespread job losses.

The author of the US study (Handel 2022) concludes that 'it is entirely possible that robotics and AI are simply another in a long line of waves of innovation whose effects on employment will unfold at rates comparable to those in the past'.

The finding that new technologies do so far not necessarily produce massive "technological unemployment" is in line with **economic theory**, which suggests that several compensating mechanisms can counterbalance the initial labour-saving impact of new technologies (Acemoglu and Restrepo 2019). First, technological change can increase the demand for labour by creating new jobs that are directly associated with the new technology. Second, technology-induced increases in productivity release production resources that can raise the demand for labour in other tasks within the same firm or industry. Thirdly, technology can raise the demand for labour through increased consumer demand. This occurs when new technologies boost productivity growth and, in turn, lead to lower production costs and consumer prices. New technologies can further raise the marginal product of labour and capital, resulting in both higher wages and returns to capital. The two latter effects contribute to a rise in real income. If demand is sufficiently elastic and positively responds to increases in income and decreases in prices, technologies can stimulate a demand-induced expansion of output (Bessen 2019). In principle, empirical results support these theoretical considerations on employment and productivity effects of digitalisation. However, it is important to **carefully distinguish the effects of different types and generations of technology**.

In the past, various studies examined **robot adoption in manufacturing**. They find varying results. Using novel panel data on robot adoption in seventeen countries from 1993 to 2007 (Graetz and Michaels, 2018) find that increased robot use contributed approximately 0.36 percentage points to annual labour productivity growth. Evidence on employment of robot adoption is mixed and seems to depend on the county context. In the US, robot adoption has reduced *total employment*. Acemoglou and Restrepo, 2017 found that one additional robot reduces aggregate employment by three to six jobs. This was not the case in Germany, where the decline in manufacturing employment between 1994 and 2014 was counterbalanced by an increase in employment in the service sector (Dauth et al., 2021). The authors used linked employer-employee data which trace employment biographies and earnings profiles of roughly one million manufacturing workers with varying exposure to robots (and some other technology and trade shocks) to shed light on the question of how individual workers were affected by and responded to the rise of robots over time. The worker-level analysis delivered a surprising insight. The authors find that more robot-exposed workers in fact have a substantially higher probability of keeping a job at their original workplace. That is, robot exposure increased job stability for workers, although some of them end up performing different tasks in their firm than before robot exposure.

To examine how workers adjust to firms' investments in new digital technologies, including artificial intelligence, augmented reality (AR), or 3D printing Genz et al. (2021) linked survey information on firms' technology adoption to administrative social security data. The authors find evidence for improved employment stability but also for higher wage growth, and increased cumulative earnings in response to digital technology adoption, depending on the type of technology. Beneficial developments seem to be driven by technologies used by service providers rather than manufacturers. However, the adjustments do not occur equally across worker groups: IT-related expert jobs with non-routine analytic tasks benefit most from technological upgrading, coinciding with highly complex job requirements, but not necessarily with more academic skills. In a study based on Swedish employer-employee data, Yakymovych (2022) finds sizeable on-the-job earnings gains for high-skilled workers, especially in scientific and management positions when introducing robots in manufacturing.

In contrast, low-skilled and especially medium-skilled manufacturing workers, suffer from lower wages and cumulative earnings losses caused by robots.

Substantial heterogeneities in the employment effects across skill groups, occupational tasks performed, and gender is also documented by Genz and Schnabel (2021). Employment reactions to digitalisation are most pronounced for both low- and high-skilled workers, for workers with non-routine tasks, and for female workers. Results underline the importance of tackling the impending digital divide among different groups of workers. The **uneven impact of workplace digitalisation on workers with different skills level** is supported by evidence derived from unique Swiss firm-level microdata. Increased investment in digitalisation is associated with increased employment of high-skilled workers and reduced employment of low-skilled workers, with an overall positive net effect on employment (Balsmeier and Woerter, 2019). The main effects are almost entirely driven by firms that employ *machine-based* digital technologies, e.g. robots, 3D printing or the IoT but not by *non-machine*-based digital technologies such as ERP (enterprise resource planning), e-commerce or cooperation support systems. Battisti et al. (2021) study the extent of complementarity/substitutability between robots and workers at different skill levels. The authors find evidence of polarizing effects, according to which middle-skilled workers, typically employed in intermediate routine and/or codifiable tasks, are the most vulnerable to robotisation.

There are only a few quantitative studies examining the consequences of **AI technologies and AI applications** in the workplace. They all find no clear evidence on possible positive employment effects of these new technologies. Acemoglu et al. (2022) study the impact of artificial intelligence (AI) on labour markets using establishment-level data on the near universe of online vacancies in the United States from 2010 to 2018. In the US, there is rapid growth in AI-related vacancies that is driven by establishments whose workers engage in tasks compatible with AI's current capabilities. As these establishments adopt AI, they simultaneously reduce hiring in non-AI positions and change the skill requirements of remaining postings. While visible at the establishment level, the aggregate impacts of AI-labour substitution on employment and wage growth in more exposed occupations and industries is currently too small to be detectable.

Similarly, Damioli et al (2022) find no evidence about the possible positive employment effect of AI technologies, considered as product innovations in the supply sectors. The positive employment impact of AI is larger and more significant when compared to the job creation effect of other innovation activities. However, the labour-friendly employment effect of patenting in AI technologies is small in magnitude (the estimated elasticity being equal to 3–4%) and is unlikely to be able to compensate for the possible labour-saving impact in the downstream user industries.

Adopting the "AI occupational impact measure" developed by Felten, Raj and Seamans, an indicator measuring the degree to which occupations rely on abilities in which AI has made the most progress, Georgieff and Hyee (2022) extend the measure to 23 OECD countries and find no clear relationship between AI exposure and employment growth, either. However, in occupations where computer use is high, greater exposure to AI is linked to higher employment growth. A negative relationship exists between AI exposure and growth in average hours worked among occupations where computer use is low. One possible explanation is that partial automation by AI increases productivity directly as well as by shifting the task composition of occupations toward higher value-added tasks. This increase in labour productivity and output counteracts the direct displacement effect of automation through AI for workers with good digital skills, who may find it easier to use AI effectively and shift to non-automatable, higher-value added tasks within their occupations. The opposite could be true for workers with poor digital skills, who may not be able to interact efficiently with AI and thus reap all potential benefits of the technology.

2.2. Consequences for skills development and (re-)training policies

Research suggests that career changes, switching occupations, and moving across multiple employers and even across industries will increasingly become important for workers to remain employed. An important lesson from the studies examined is that existing jobs will not be lost on a large scale but that the adoption of digital technologies at the establishment level might change the task content of jobs. Hence, it is mainly up to the employer to provide in-company training so that staff can adapt to new requirements.

The studies reviewed, however, underline also the importance of tackling the impending digital divide among different groups of workers and of addressing the uneven impact on workers with different skills level. To avoid rising inequality and to meet the shift in demand both within and between occupations and sectors, authors such as Arntz et al. (2019) call for more general supply side adjustments as the effects of labour-replacing technological on the most exposed individuals can be severe and difficult to ameliorate. The nuanced impact of firms' adoption of new technologies that split unevenly across different occupations and worker types requires policymakers to take steps to prepare the workforce for the future, including encouraging enrolment in STEM (science, technology, engineering, and mathematics) subjects, promoting lifelong learning, facilitating occupational retraining, and generally working to reduce labour market frictions (Genz 2022).

While there seems to be a political consensus that promoting lifelong learning and facilitating occupational training by employers and governments is important to shape the working world of tomorrow, re-and upskilling might not always be the silver bullet for individual workers who have lost or are going to lose their job as labour-saving technologies are introduced. The following examples demonstrate that more specific and differentiated solutions tailored to particular workplace contexts and worker groups are necessary.

Balsmeier and Woerter (2019) suggest that as long as medium- and low-skilled workers can be trained to learn new skills, the promotion of such professional training programs could be very helpful for the individuals affected and the economy alike. Nonetheless, **generic solutions such as "lifelong learning" or up-and reskilling are adequate in theory but they are often hard to implement in practice**, for example, for cases where professional training and educational attainment programs are not feasible due to physical or mental limitations. The authors suggest to use collaborative artificial intelligences themselves to enable medium and low-skilled workers to focus on tasks where they have a comparative advantage over machines, e.g. any work that requires personal emotional interaction. This would increase the individual productivity of medium and low-skilled workers.

Another group for whom re-training programmes are insufficiently targeted are well-paid routine workers displaced in the manufacturing industry. Policies to make this group of displaced workers more flexible in terms of their job search and to retrain them so that they can shift out of declining occupations and industries do not seem to work, as the study Yakymovych (2022) shows. Due to a loss of occupation- and industry-specific human capital, displaced routine-workers who have lost their jobs in mass displacement events, suffer penalties in terms of earnings and unemployment, which persist in the medium to long term. Routine workers are unable to find jobs similar to those they had before becoming displaced. Even switching to a non-routine occupation did not reduce routine workers' losses.

For experts and policymakers, one of the main challenges is identifying the most significant impact of the latest technologies on the workforce and preparing individuals to obtain skills required in a world of work with digital technologies, keeping their skills up to date and remaining employable in the long

run. Direct evidence on the impact of firm-level technological change on skill demand is, however, still scarce, and somewhat inconclusive[3].

Ideally, education and training systems offer flexible solutions that facilitate skill upgrading within short time periods to meet current industry needs quickly. Forecasts on skills need are, however, fraught with uncertainties. While, for example, the first Cedefop European skills and jobs survey in 2014 still found that two in five EU jobs face a high probability of substantial transformation, the average employment decline in the group of occupations deemed to be "fully automatable" by earlier studies has only been -2%. One reason might be that occupations identified as "high-risk" due to corona exposure and social distancing have been found to correlate weakly with those facing higher automation risk (CEDEFOP 2020). Based on data from conventional sources (skills and job surveys, skills forecasts), Cedefop estimates the share of EU adults whose skills may become outdated by technological change at 16%. At the same time, Cedefop highlights that conventional methods are limited and that big data and AI methods provide better insights into skills demands through 'real data' skills intelligence tools, which 'gives policy-makers the means to separate noise from signal and supports employers and citizens in making decisions in line with the new realities in the world of work'. Cedefop (2021a) provides a practical guide for analysts and policy-makers on available skills anticipation methods based on such skills intelligence tools. Direct evidence on the impact of firm-level technological change on skill demand is still scarce, and somewhat inconclusive. For instance, Aghion et al. (2017) find that more R&D-intensive firms pay a lower college premium, while Bøler (2015) finds that higher R&D intensity is associated with an increase in the skill ratio.

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3   Lindner et al. (2022) exploit administrative data and a large survey measuring a broad class of firm-level technological changes from Hungary and Norway. They estimate that the aggregate college premium increases by 6.1% in Norway and by 13.8% in Hungary as a result of the skill bias in technological change. From these results they conclude that innovation is a key force behind the recent trends of inequality; in particular in countries far from the technological frontier.

# 3. IMPACT OF DIGITALISATION ON GENDER (IN-)EQUALITY

KEY FINDINGS

Overall, there is so far no conclusive evidence on whether the digital transformation has the potential to reduce or even worsen gender inequalities While the increasing use of digital technologies in "female" professions could improve horizontal segregation in the labour market, the effects on vertical segregation, i.e. the unequal distribution of the sexes to different occupational hierarchy levels, are not so obvious. Studies on the impact of digitalisation on the gender-pay gap provide so far contradictory results.

Many believe that the ongoing digital transformation will strengthen the position of women in the labour market. More flexible ways of working may make it easier to combine paid work with caring responsibilities which are still more often taken on by women; automation is also more likely to replace less skilled jobs, giving women an advantage since they now outperform men on most measures of educational attainment. Forecasts suggest that women are likely to be affected disproportionately by increased uptake of AI. The World Economic Forum in 2018 estimated that over 57 % of the workers who will be affected by labour market disruptions are likely to be women. One of the explanations is that women are more likely to be employed in jobs facing high risks of automation. For example, 97 % of cashiers are expected to lose their jobs due to automation in the next few years as a case study on Amazon Go suggested. However, automation has so far been most common in sectors like agriculture and manufacturing, where men dominate. But in the future, digitalisation is expected to spread across all sectors and most occupations, including those traditionally dominated by women, such as the retail trade or hospitality services. In addition, jobs are likely to grow the most in business services, health, education and social services – many of which have been traditionally female-dominated (OECD 2017).

These developments are shown, for example, by a granular analysis for Germany. Dengler and Matthes (2021) calculate a so-called substitutability potential, i. e. occupations highly vulnerable to substitution by computers or computer- controlled machines (robots, AI). Figure 1 shows the results for occupational segments for the year 2019. Potential of substitution refers to the technical feasibility of some job tasks being replaced by machine learning algorithms and is not the same as actual job loss. First, adoption of new technologies is often slow due to economic, legal and societal hurdles. Firms' decisions to automate depend on a combination of factors including the "business case" for adopting new technologies, their cost, diffusion hurdles, the relative supply and price of skill and labour, uncertainty in investment decisions and shifting social attitudes (Cedefop, 2021b). Second, history shows that workers have adapted to major changes during large technological revolutions by changing the tasks that they perform at work, thus avoiding mass technological unemployment.

Figure 3: Substitutability potential in occupational segments by gender in Germany (2019)
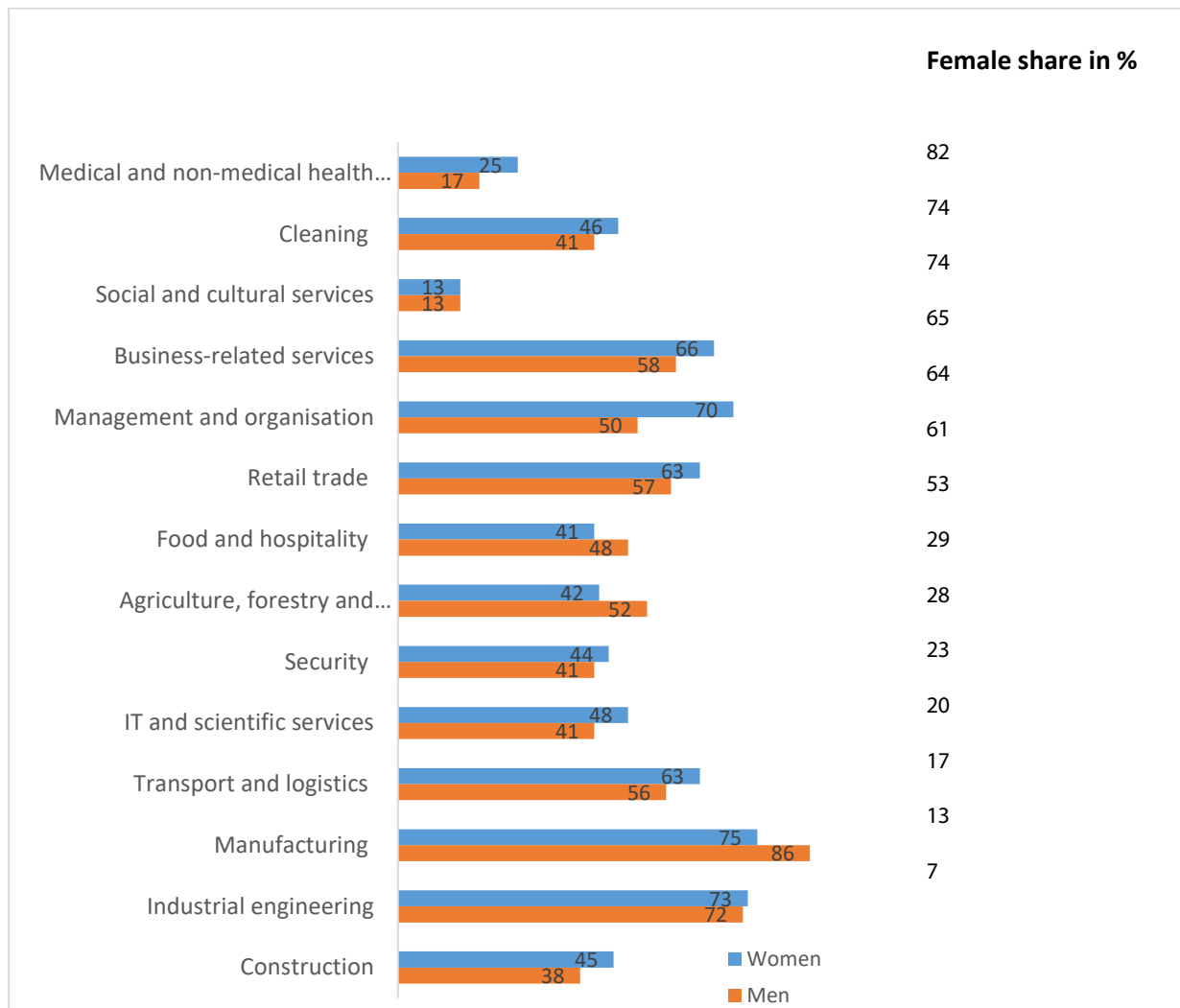
Source: IAB Forum, June 2022.

Note: Female share in % refers to the share of women in total employment in the respective occupational group.

The analysis shows that on average, men still work more often than women do in occupations in which the share of potentially substitutable tasks is higher. In 2019, 40% of men work in occupations with high substitutability potential, but only 27 per cent of women. However, there are also occupational fields where female jobs are prone to digitalisation. In the "management and organisations" segment, for example, the share of women is comparatively high at 64%. The substitutability potential among women in this occupational segment is 70 compared to 50 for men, as women are disproportionately employed in commercial occupations that have a medium to high substitutability potential (e.g. office clerks). In contrast, men work more often as managers, directors, operations, project or group leaders, i.e. in occupations with a low substitutability potential.

Over time and across all occupational segments, women were more and more affected by digitalisation. Between 2013 and 2019, the substitutability potential among women increased twice as much as among men (10 vs.5 percentage points). The reason is that in female dominated occupations, digital technologies have been increasingly used. These are in particular mobile, collaborative robots and self-learning computer programmes. Changes in occupations are also accompanied by changes in the task profiles within occupations. The boundaries between classic male and female professions are becoming increasingly blurred.

For example, social aspects could play a stronger role in engineering professions. Conversely, digital technologies are increasingly being used in professions, which still predominantly employ women. This could make such professions more attractive for men in the future. Hence, there might be opportunities to overcome or at least improve the **horizontal segregation** on the labour market as there are many jobs that can be substituted by digital technologies and where either women or men are heavily outnumbered (Burkert et al., 2022).

On the other hand, the effects of digitalisation on **vertical segregation,** i.e. the unequal distribution of the sexes to different occupational hierarchy levels, are not so obvious. The possibility of flexible working can lead to a better reconciliation of care and gainful employment and thus open up career opportunities and the path to higher employment positions for women. The widespread work culture that is closely linked to physical presence in the company - a situation that strongly disadvantages employees with caring responsibilities - could lose importance due to the increasing establishment of new digital possibilities such as mobile (remote or tele-) work. Hence, the technical possibility of digital networking might be an opportunity to overcome the boundaries- depending on the field of work, organisation/culture and individual possibilities - between paid work and care.

Studies on the impact of digitalisation on the **gender-pay gap** provide contradictory results, so it is not yet possible to make reliable statements on the development of the gender pay gap in the digitalisation process. Analysing gender differences in working patterns and wages on platform work using Amazon Mechanical Turk as example, Abi Adams-Prassl (2020) find no gender difference in task selection nor experience on the platform. Nonetheless, women earn 20% less per hour on average. Half of this gap is explained by differences in the scheduling of work. Women have more fragmented work patterns with consequences for their task completion speed. A follow up survey shows that the wage gap is concentrated amongst women with young children, who also report that domestic responsibilities affect their ability to plan and complete work online.

Wage development depends very much on developments to be expected in terms of occupational fields and career opportunities, working hours and contractual framework conditions. There are, however, increasing indications that the gender pay gap could widen further, for example, because positive income developments are expected for ICT professions in particular, in which women are especially underrepresented. Although women meet or exceed men's skill levels in most categories, they significantly lag behind in STEM skills, which are an essential fuel for efficient twin transition. Against this background, it seems important to increase the proportion of women in ICT professions in order to tap into the increasing employment and income opportunities there. At the same time, the upgrading of personal services, especially social and health care professions, remains a key gender equality policy to reduce the gender-pay gap. Whether digitalisation will close or widen gender gaps in the labour market will, in the end depend to a large extent on policy (Pimminger and Bergmann 2020: 27).

4. ADOPTION OF DIFFERENT TECHNOLOGIES IN THE WORKPLACE AND ITS IMPACT ON WORKERS

> KEY FINDINGS
>
> There is only a small number of studies focusing on the direct impact of new technologies on working conditions or health outcomes. Using large-scale administrative and survey data empirically, a handful of studies address the direct effects of digital transformation on physical and mental health. Some find that digital technologies (ICT) could indeed relieve workers of physically demanding jobs but might have a negative impact on job insecurity. Other studies show that an increase in robot intensity negatively affects the self-rated mental health of workers. However, the evidence on causal effects of digital transformation on mental health remains sparse.
>
> Business case studies find a positive impact of key technologies on job quality (decrease of physical risks) and suggest that where employees were involved, technology adoption led to generally positive outcomes for workers.
>
> Recent debates revolve mainly around the risks of AI-enabled algorithmic management in the workplace. While there is still scarce evidence on the associated occupational safety and health risks arising from digital surveillance, performance pressure and job insecurity, there are many doubts of AI enabled algorithmic management at work- often based on single but prominent cases such as Amazon. Surveillance and privacy breaches, discrimination when selecting personnel through the screening of CVs by AI tools as well as the potential threat to fundamental human rights (i.e. the right to non-discrimination, human dignity and integrity) are among the main concerns voiced by EU agencies, stakeholders and (legal) experts.

4.1. Insights and business case studies

Before summarising the scarce empirical findings from quantitative research on the impact of different digital technologies on work exposure and health outcome, we present some insights on the adoption of key digital technologies based on business case studies. Case studies often provide valuable insights but due to their selectivity their results are less generalizable. Case studies research faces the important caveat that the impacts of this qualitative research method depend on the specific use cases and a variety of contextual factors. Nonetheless, case studies research is a widely used and accepted qualitative research method for examining issues arising from technology adoption (Choudrie and Dwivedi, 2005).

Between May 2020 and February 2021 Eurofound (2021a) coordinated 12 case studies revolving around three key technologies, which are crucial to the digitisation of business and work processes ((IoT, 3D printing, VR/AR). The use cases covered a mix of establishments of different sizes and operating in different sectors employing different applications of the technologies in focus. The emphasis of the case study research was not only on the impact of these technologies on work, but also on the motivations behind technology adoption, how digitisation evolves in the workplace and the extent of employee involvement. Main results are summarized in Box 3.

Box 3: Key findings from business case studies coordinated by Eurofound

- Though none of the three digitisation technologies (IoT, 3D printing, VR/AR) can be considered mainstream, IoT is the most established, providing a range of applications, particularly in manufacturing ;

- Elements underpinning the successful implementation of digitisation in the workplace include the adoption of an explicit digitisation strategy with a phased approach to implementation based on experimentation and piloting, early communication and employee involvement, the provision of upskilling, reskilling and training on an ongoing basis, and strategic partnerships and collaborations with other companies and relevant organisations;

- The approaches used tended to be top-down, with limited opportunities for employees to voice concerns and provide feedback based on their experiences;

- All digitisation technologies have extensive logging, reporting and monitoring capabilities. While these can be leveraged for the benefit of workers (for example, to reduce physical effort and hazardous situations), they can also pose challenges, particularly in relation to data protection and privacy;

- IoT raises most concerns, especially when the data collected are used when making important decisions about wages, contract renewals and even dismissals;

- The overall impact of the three technologies on job quality was positive (decrease of physical risks). However, performance slowed down and work intensity increased, particularly in the initial phase of deployment;

- IoT has most impact on the area of skills and autonomy at work. IoT adoption drove the upgrading of skills, particularly for managerial and engineering positions and less so for lower skilled and blue-collar workers; and

- 3D printing resulted in a skills shift, with greater emphasis on 3D design and planning skills and production workers being more reliant on 3D designers and planners.

Source: Eurofound 2021.

Other business case studies, carried out in the context of a study on "unionisation and the twin transition" commissioned by Parliament's EMPL committee find that **where employees were involved, technology adoption led to generally positive outcomes for workers**, including a shift to more complex and interesting tasks, upskilling, improved working conditions, or better work-life balance (Bendorz et al., 2022).

4.2. Impact of ICT on physical and mental health

By taking over physically demanding tasks or repetitive tasks, machines and robots might lessen the physical strain on employees. New technologies might also create a safer working environment due to automated monitoring methods based on real-time responses, particularly in hazardous workplace environments. Examining the relationship between digital transformation and physical health by using large-scale administrative and survey data from Germany and an innovative measure for the degree of digital transformation, namely the substitution potential, Dengler and Tisch (2020) analyse the relationship between the substitution potential of occupations and work exposure in gender-specific occupations. Men are generally at a higher risk of being substituted by computers or machines compared to women as men are more likely to work in physically demanding occupations.

The authors find that **digital technologies could indeed relieve men of physically demanding jobs**. They did not find any evidence that digital technologies have already caused employment to decline in occupations with physical work exposure.

Using pooled survey data, Dengler et al. (2022) estimate how an increased use of ICT in the workplace relates to **work-related mental and physical health** (complaints of back pain, neck pain and physical exhaustion, as well as psychosomatic complaints such as headaches and fatigue). They find that high ICT use at work is associated with better self-rated health and a significantly lower prevalence of back pain and physical exhaustion. At the same time, it is associated with a higher prevalence of headaches. After controlling for physical work exposures, the health-promoting effect of computer use is much smaller. This suggests that, particularly in the manufacturing sector, high computer use is associated with a less physically demanding work environment, which in turn relates to better physical health outcomes.

A growing body of literature indicates an association between digital transformation and mental workload and, in particular, a trend towards borderless work settings and different forms of work intensification (Korunka and Kubicek, 2017). Accordingly, Chesley (2014) showed that an increased use of ICT is related to increased stress and leisure work. Furthermore, job insecurity and fears of unemployment tend to increase when a job has a high potential of being performed by machines. While the association between digital transformation and mental workload is becoming better documented, the empirical evidence regarding the **causal effects of digital transformation on mental health remains sparse.**

Abeliansky and Beulmann (2019) present one of the rare studies that empirically addresses the direct effects of digital transformation on mental health. They find that an increase in robot intensity **negatively affects the self-rated mental health** of workers. This effect can be explained by increased job insecurity and the fear of a decline in an individual's economic situation, especially for those performing routine tasks and males. Moreover, the mental health of younger workers is the most vulnerable to an increase in automation. A further study by Dengler and Gundert (2021) shows that increased use of ICT has indeed a **negative impact on job insecurity**. Studying the relationship between digital transformation and subjective job insecurity based on a large-scale panel from Germany in the period between 2013 and 2016, the authors examine to what extent employees are afraid of losing their jobs to computerisation. The authors measure subjective job insecurity by three interrelated items: cognitive job insecurity, i.e. the individual assessment of job loss probability, labour market insecurity, i.e. the perceived availability of job alternatives, and affective job insecurity, i.e. the extent to which individuals are worried about a potential job loss. While the digital transformation has a negative impact on cognitive job insecurity, they did not find any effect on labour market and affective job insecurity.

Overall, the findings from the impact studies presented show that evidence of a causal relationship between the adoption and use of different types of technologies and working conditions (including health outcomes on workers) is still inconclusive.

4.3.   Algorithmic management and workers' well-being

Recent political debates on the impact of digitalisation in the workplace revolve mainly around algorithmic management. Algorithmic management refers to the use of algorithms to allocate, monitor and evaluate work in platform and in regular work settings. The 'algorithmic boss' (Prassl 2019) makes decisions about workers and job candidates alike. What makes contemporary algorithms distinct from other workplace technologies used over time is the fact that the algorithm as a computational tool has

a new competence linked to the availability of big data sets that are used to train machines to learn. AI-based technologies allow for new, widespread, continuous and lower cost forms of worker monitoring and management based on the collection of large amounts of real-time data on workers. Complex computational systems are increasingly being used to monitor, score, manage, promote and even fire workers. These systems are often referred to as people analytics. Based on big data sets or other data accumulation and aggregation, digital tools are used to predict, measure, report and analyse employee and potential employee performance; design workplaces; manage workforce talent; and to carry out a wide range of workplace operations. On the assessment of drawbacks of AI entailed algorithmic management see Box 4.

Box 4: Risks of algorithmic management

People analytics operate at every step of the way in human resources, from recruitment and hiring practices using psychometric tests to digitalised interviews. The data collected are used to inform management and make automated or semi-automated decisions based on algorithms or more advanced forms of AI. This may allow employers to increase control over their workers and the workplace, incorporate rating systems or other metrics into performance evaluation, improve workers' performance and productivity, rationalise the organisation of work and production, reduce the cost of monitoring and surveillance, profile workers, influence their behaviours, and discipline them or improve HR management (STOA 2020).

At the same time this kind of micro-management of workers entails a variety of risks. Legal experts find that the functionality and utility of many forms of AI at work remain in doubt. For example, many of the AI tools currently deployed in recruitment remain untested. De Stefano et al. see genuine risks to the incorporation of AI at work (STOA 2022). According to the authors, among the most prominent risks are surveillance and privacy breaches and discrimination when selecting personnel through the screening of CVs by AI tools. AI technologies present also clear threats in the area of occupational safety and health (OSH).

The European Agency for Safety and Health (EU-OSHA) highlights the fact that the use of algorithms in platform work results in workers losing control over their jobs and leads to increased micromanagement, performance pressure, competitiveness, individualisation and social isolation. Workers may feel that their privacy is being invaded, which is a source of anxiety and stress. Workers may be unable to take breaks when they need to, which may cause accidents and health issues such as musculoskeletal disorders and cardiovascular diseases. In addition, unstable work schedules, such as the short-term schedules established automatically by algorithms, have a variety of negative impacts on workers, including increased work–family conflict and work stress, and income uncertainty.

The OECD (Lane et al., 2021) stresses that in regular work environments, the use of workers' data to reward or penalise them could lead to job insecurity and stress. The use of automated decision-making systems for personnel selection entails a risk of discrimination as AI has the potential to produce results that are inaccurate and/or biased and therefore lead to unfair and discriminatory decisions.

Eurofound (2022a) is concerned that algorithms are raising new ethical concern about workers' fundamental rights. The agency distinguishes between two kind of ethical concerns:
a) epistemic concerns about inconclusive, inscrutable and misguided evidence relate to the quality and accuracy of the data used to justify conclusions generated by algorithms,
b) normative concerns about unfair outcomes and transformative effects of algorithmically driven decisions.

Source: Authors' compilation.

In any case, the introduction of algorithms to perform the different functions of management implies a fundamental departure from traditional human management practices. Although still not mainstream, AI will probably become more prominent in regular workplace s (STOA 2022). The many fears and challenges but also possible benefits of algorithmic management are still mainly theoretical. The often cited 'evidence' on the detrimental impact for workers stems mainly from single case studies such as Amazon, the most prominent example cited in the literature, (see Box 5).

Box 5: Digital surveillance at Amazon

The Amazon business model worldwide is based on management and control of work through networking and artificial intelligence. Digital monitoring and control of workers are central to working at Amazon. Without the technological tools of scanners, apps and camera surveillance, workers cannot work in warehouses or delivery centres. At the same time, the devices permanently collect workers' data.

In this way, Amazon is always informed about where individual employees are at any given time, whether they are talking to colleagues, if and when they take a break or how much time they need for work. Anyone who does not comply with the performance targets, i.e. is not fast enough or takes breaks that are too long, will be warned and must expect to be dismissed.

All employees are under constant pressure to perform as the pace of their work is measured and their performance compared with others. The solo self-employed couriers are controlled by the predefined route in the "Flex" app. The "Mentor" app records working hours, driving behaviour and phone use.
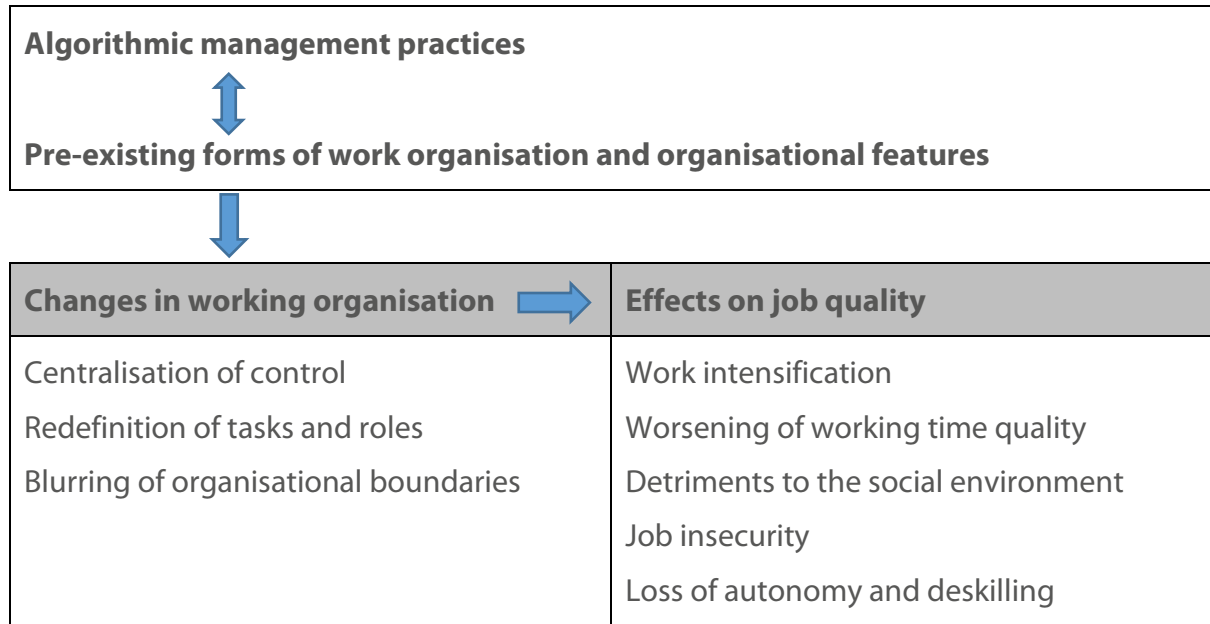
In this way, supervisors know in real time how quickly packages are being delivered. Even in countries where there is a works council at Amazon, such as in Germany, it has not been possible so far to conclude a collective agreement that legally safeguards and anchors pay and working conditions.

Source: https://www.boeckler.de/data/Impuls_2022_09_S5.pdf.

Hence, there is still scarce evidence on the associated occupational safety and health risks arising from digital surveillance, performance pressure and job insecurity. To study the merging phenomenon of algorithmic management and the implications for organisation and working conditions, the Commission's Joint Research Centre (JRC) presented recently a **conceptual framework** (Baiocco, S.et al. 2022). The authors stress that in regular workplaces these algorithms tend to assist rather than automate human decision making in most cases.

Baiocco, S.et al. 2022 identify elements of algorithmic management in different contexts regardless of the level of development and automation that it implies. The authors highlight that managerial algorithms should not be assumed to be positive or negative per se, and that their effects cannot be predicted ex-ante. The authors stress the need to further build empirical evidence and analyse the pivotal role of organisational choices and policies in determining the final outcomes for workers. In contrast to "pure" digital labour platforms, algorithmic management practices in regular workplaces have to be implemented over pre-existing structures and processes of work organisation, which can make algorithmic management less easy to identify. The likely (theoretical) impacts of algorithmic on several aspects of job quality are schematized in Figure 4.

Figure 4: Algorithmic management and its implications on working conditions and job quality in regular work settings

| **Algorithmic management practices** |
| **Pre-existing forms of work organisation and organisational features** |

Changes in working organisation	**Effects on job quality**
Centralisation of control	Work intensification
Redefinition of tasks and roles	Worsening of working time quality
Blurring of organisational boundaries	Detriments to the social environment
	Job insecurity
	Loss of autonomy and deskilling

Source: Baiocco, S.et al. 2022:21.

5. EU PROPOSALS TO REGULATE ALGORITHMIC MANAGEMENT

KEY FINDINGS

The question of how the alleged pervasive power of AI-enabled algorithmic monitoring should be addressed without holding up innovation is fiercely debated at EU level. What makes contemporary algorithms distinct from other workplace technologies used over time is the fact that the algorithm as a computational tool has a new competence linked to the availability of big data sets that are used to train machines to learn.

New initiatives to regulate AI-enabled algorithms at work are the Commission's AI Act proposal and the proposal for a directive on improving working conditions in platform work. Both legislative initiatives are very controversial among stakeholders and (legal) experts. Trade unions are of the view that the proposed AI regulation fails to address the workplace dimension, in particular the active participation of trade unions and workers' representatives. Employers' associations consider the proposed definition of "AI systems" too broad and likely to endanger innovation and lead to over-regulation. Employers' representatives have also a particularly critical view towards the proposed directive on platform work. They fear that the approach will harm the flexibility of platform work and ultimately the labour market and the economy. In contrast, legal experts advocate extending the scope of the AI proposal as several workplace aspects are not sufficiently addressed. They propose, for example, to reconsider the "high-risk criterion" proposal, as it does not cover the potentially significant harmful impact on health and safety. They also propose to support the right to disconnect to limit the invasion of workers' private lives by AI tools and to extend the scope of the legislative initiative on platform work.

To involve workers and unions in the introduction and use of AI systems at work seems a sound proposal given that the nature of the impacts of digital and automation technologies- including algorithmic management - depends greatly on its design and implementation. Involvement at all levels should thus be a topic for collective bargaining and worker co-determination in day- to-day industrial relations.

5.1. Assessments of EU legislative proposals

Stakeholders, EU authorities and legal experts alike agree that a lot of effort is required to implement AI successfully without producing excessive adverse effects to workers. In their view, the data collection and processing capabilities of digital technologies call for strong safeguards to preserve employees' data protection and privacy rights, redress options, and enable greater enforcement of existing provisions (see STOA 2022, social partners' framework agreement on digitalisation, the EESC report on 'A Guide to Artificial Intelligence at the Workplace'. Parliament's special and temporary AIDA (*Artificial Intelligence in the Digital Age*) committee urges in its final report (April 2022) the EU to act and swiftly put in place a favourable regulatory framework for AI able to provide for effective governance, balanced ethical standards and leeway for innovation while avoiding overregulation.

Among the main initiatives at EU-level to regulate AI are the **Commission's AI Act proposal and the proposal for a Directive on improving working conditions in platform work**. Both proposals address the issue of regulating algorithms at work.

The draft regulation on AI, presented by the Commission in April 2021 sets out a regulatory structure that bans some uses of AI considered to involve unacceptable risks, imposes conformity requirements on high-risk uses (for example, compulsory human oversight and proof of safety) and lightly regulates

less risky AI systems. The proposed Commission regulation classifies AI systems "used in employment, workers management and access to self-employment, notably for the recruitment and selection of persons, for making decisions on promotion and termination and for task allocation, monitoring or evaluation of persons in work-related contractual relationships" as high-risk. This means that, before being placed and used in the EU single market, such AI systems are subject to requirements such as an ex-ante conformity assessment with respect to risk management, transparency, oversight, and cybersecurity.

The directive on improving working conditions in platform work was presented by the Commission on 9 December 2020. The scope of the proposals includes platforms that organise work performed by individuals in the EU and one of its main aims is to ensure that platform workers obtain the correct legal status that corresponds to their work relationship with the platform. The second objective of the directive is increasing the transparency of algorithms used by the digital platforms by introducing the requirement of human monitoring. Finally, the last main objective of the proposed directive is to increase the transparency of platforms in general by making platforms declare work to national authorities and by asking them to make information available to users and national authorities.

Both legislative initiatives are very **controversially discussed among stakeholders and (legal) experts**. A number of criticisms have been raised with regard to both proposals; in particular the proposed AI act. In Eurofound's (2022a) view, the current AI proposal may not be optimal as it governs the relationship between those who develop the AI technologies and those who deploy them leaving the worker out of the equation, and with limited mechanisms for redress if any harm is caused to workers due to any misuse of the technology. The draft regulation has also been criticised for not addressing the key issue of liability – that is, who is responsible for the consequences of actions undertaken by pre-programmed intelligent systems, and for not providing redress mechanisms for those harmed by AI systems (ETUI 2022a). De Stefano and Taes (2021:11) criticise that there is no requirement for an external conformity assessment by a notified body, which allows companies the freedom to use such systems at their own discretion and entails power asymmetries that disadvantage the individuals affected by the use of AI systems.

The authors **(legal experts)** of a recent study commissioned by Parliament's Scientific Foresight Unit (STOA 2022) suggest to reinforce the AI act proposal and to draft an ad hoc directive on AI in employment, as several workplace aspects are not sufficiently addressed in the Commission proposal. They propose, for example, to reconsider the "high-risk criterion" proposal, as it does not cover the potentially significant harmful impact on health and safety. They also suggest to break the 'regulatory ceiling' by allowing Member States to impose additional requirements in areas such as employment, and involve workers, representatives and unions in the introduction and use of AI systems at work. They also propose to support the right to disconnect to limit the invasion of workers' private lives by AI tools and to extend the scope of the legislative initiative on platform work (STOA Option brief 2022). Algorithmic management in platform work should not be considered the norm, nor regulated to a lesser extent than national legislation concerning other workplace monitoring tools. They further propose that the legislative initiative should have a broader personal scope to ensure (bogus) self-employed platform workers have also legal coverage.

The key concern of the **European Services Workers Union** (UNI Europa) regarding the draft AI regulation is that the proposal fails to address the crucial role that social partners and collective bargaining play in the deployment and governance of AI systems in the workplace. They also criticise the fact that the approach is too narrow, as AI applications other than algorithmic management especially do not fall under its scope.

UNI Europa suggests to categorise all AI systems as high risk and to make them subject to an independent Third-Party impact assessment. Furthermore, the AI act should not undermine existing protections at national level (legislation, collective bargaining).

The main criticism of the **European Trade Union Confederation** (ETUC) is that the proposed AI regulation fails to address the workplace dimension, in particular the active participation of trade unions and workers' representatives. When it comes to the social protection of platform workers, ETUC believes that labour platforms developing their own schemes of private protection should be avoided. ETUC welcomed the fact that the directive will make algorithmic transparency compulsory for digital labour platforms, obliging them to show the functioning of their algorithm to workers and trade unions. Nevertheless, the proposed definition of algorithmic management is considered as too restrictive and could lead to companies using algorithmic management to fall outside the scope of the directive.

Innovation and over-regulation are some of the key concerns SMEs experts have with respect to the AI act proposal. The **Digital SME Alliance** finds that the definition of AI provided in the proposal is too broad and that regulating SMEs in areas that do not pose risks should be avoided. On the other hand, the Alliance criticises the fact that real and future risks of AI in terms of the overall risk for society and fundamental rights are not adequately addressed. BusinessEurope also considers the proposed definition of AI systems as too broad and recommends to focus on AI systems that display intelligent behaviour and act with some degree of autonomy. Classifying all AI systems used in the context of employment as high-risk will lead to legal uncertainty for businesses and to a slowdown of AI application used in human resources and would hinder the positive effects that they could have on the workplace and workforce.

Employers' representatives have a particular critical view towards the proposed directive on platform work. In its position paper of 23 February 2021, **BusinessEurope** defines the Commission proposal to regulate platform work as a "wrong policy orientation", being particularly critical of the issue of employment status. According to the organisation, the approach will harm the flexibility of platform work and ultimately the labour market and the economy. The rebuttable presumption of employment and the criteria to determine who is an employer are described as not balanced, as it would lead to a de-facto employee status for workers. BusinessEurope believes that a better approach would be to encourage Member States to adopt procedures aiming to determine the existence of the employment status based on the actual performance of work.

5.2. Employee involvement at all stages to adopt effective regulation

Business case studies show that the nature of the impacts of digitalisation and automation technologies depends greatly on the design and implementation of these technologies in the workplace. This means that digitalisation, including algorithmic management, should be a topic for collective bargaining and worker involvement at all levels, including co-determination in day-to-day industrial relations.

Business case studies (see chapter 4.1. above) have shown that strengthening workers' voice is indeed beneficial in shaping the digital transition in the workplace. Employee involvement through formal employee representation bodies and direct participation results in greater acceptance of technological change and employee buy-in, leading ultimately to a more effective approach to digitalisation (Eurofound 2021a). Other findings from the reviewed business case studies are that the involvement of worker representatives varied across the cases, ranging from no or little involvement, to establishing a framework for negotiations and analysis of the impacts of new technologies and sometimes even to initiating technology adoption efforts.

The conclusion emerging from these findings is that social dialogue at all levels has to be strengthened to ensure that employees reap the benefits of technological change and job quality is not compromised.

This is in line with claims from scholars, who argue that more worker representation is necessary to protect the data rights of workers (STOA 2020). Given that many workers do not know what data employers collect about them, what algorithmic management systems are used and if it is done appropriately, scholars stress the importance of workers being able to "negotiate the algorithm" when AI is used in performance management systems, a task which is more challenging when transparency is low (De Stefano 2019).

Beyond the safeguarding of data protection and privacy rights, a more far-reaching ethical approach addresses fundamental human rights, i.e. the rights to non-discrimination, human dignity and integrity, freedom of association and collective bargaining. To ensure the appropriate development of an *ethical approach* to digitalisation of work, Eurofound (2022a) finds that the involvement of social partners is crucial to safeguard the interests of all stakeholders at all levels, from the design and implementation of national strategies to the introduction and use of the technologies in the workplace (p. 36). Ethical issues have been addressed so far only in a handful of EU Member States. Trade union campaigns for responsible use of technologies are slowly emerging and to date few have issued ethical guidelines and checklists. To better understand AI applications, in particular the data and algorithmic surveillance that exists in different workplaces and how trade unions and work councils could protect workers in these sectors, trade unions are increasingly offering training for workers and workers' representatives (see, for example, ETUI 24/3/2022).

6. SUMMARY AND CONCLUSIONS

To decide on appropriate policies and measures that are mindful of the need to mitigate possible harms of workplace digitalisation for workers, politicians should ensure that their decisions are based on sound 'evidence'. Sound empirical research is all the more important given that the dominant, discursive expectations are not always based on empirical evidence. In this review we therefore focused on findings based on datasets, which make it possible to analyse how advanced technologies in the workplace shape job quantity and job quality. Findings from quantitative research are supplemented by relevant case studies.

In the past, much of the research on the impact of digitalisation on work and employment has focused on quantifying the potential job losses resulting from increased automation and digitisation. This has influenced the policy debate on the implications of the digital revolution for the future of work. While empirical research has recently put the fears of digital technology-driven massive unemployment in perspective, current developments in AI have stirred up new fears about job losses. However, to date there are no conclusive results on the impact of the latest generation of AI technology on employment and skills needs.

A major concern of politicians about the acceleration of advanced technologies is that it has widened the digital gap among people and firms. The 'digital divide' is deemed to increase social inequality. There is a generalised perception that the Covid-19 pandemic has resulted in an increase in digital divides. A closer look at different levels of the problem, however, provides a more nuanced picture. The most recent figures from the Commission's digital scoreboard indicate that the digital divide has at least not worsened during the pandemic. What has worsened are, however, the consequences for those who did not previously use internet and digital services.

EU indicators mapping the evolution of the digital gender divide indicate that the gender gap is closing in internet user skills but that a significant gender gap remains in specialist digital skills. However, the digital gender divide refers mainly to digital skills but does not say anything about how digital technologies impact the working lives of women. Evidence on whether the digital transformation has the potential to reduce or even worsen gender inequalities is still not conclusive. It is not yet possible to make reliable statements. There are indications that the horizontal occupational segregation might be overcome or at least improve. Vertical segregation (the unequal distribution of the sexes to different occupational hierarchy levels), however, might be more difficult to overcome. Studies on the consequences of digitalisation for the gender-pay gap provide at best contradictory results.

The review of impact studies on the use of advanced technologies at firm level and accompanying workers' outcomes in terms of physical and mental health has revealed that here is not much data on how advanced technologies in the workplace will shape job quality- whether for good or for ill, either. Nonetheless, the few available studies based on new micro-datasets have shown that depending on the type of digital technologies, the impact on working conditions differs. An increase in ICT or robot intensity is, for example, associated with a less physically demanding work environment, which in turn relates to better physical health outcomes. At the same time, they might have a negative impact in terms of job insecurity and the self-rated mental health of workers. More research and better datasets are needed to draw robust and causal relationships between the adoption and use of different types of technologies and working conditions (including health outcomes on workers).

The studies reviewed on the impact on employment concur that there are substantial heterogeneities in the employment effects across skill groups. Increased investment in digitalisation is generally associated with increased employment of high-skilled workers and reduced employment of low-and middle-skilled routine workers.

Re-and upskilling might, however, not always be the silver bullet for all groups of workers who have lost or are going to lose their job as labour-saving technologies are introduced. More specific and differentiated solutions tailored to worker groups, e.g. with physical or mental limitations or well-paid routine workers displaced in the manufacturing industry, are needed.

At present, debates at EU-level mainly revolve around the risks and challenges of algorithmic management in platform and regular work settings. AI enabled algorithmic management tools are seen as likely to replace managerial roles increasingly and to intensify organisational processes in workplaces. In this context, concerns have been voiced regarding employee well-being linked to the idea that AI-enabled algorithmic management tools may soon become pervasive in the workplace and threaten to undermine humans' place in it. Despite the many fears engendered by algorithmic management tools, there is still scarce evidence on the associated occupational safety and health risks arising from digital surveillance, performance pressure and job insecurity. The extent to which digital technologies raise ethical dilemmas largely depends on how they are designed and implemented in the workplace. Algorithmic management should, therefore, not only be a topic for regulation at EU and but also for collective bargaining and worker involvement at all levels, including co-determination in day to day industrial relations.

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The aim of this study is to provide the Members of the committee on Employment and Social Affairs (EMPL) with an updated review of findings from research on the impact of digitalisation in the workplace.

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