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European Trade Union Institute

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Abstract

This working paper examines the impact on job quality of new digital technologies at work. It applies the multidimensional framework of the ETUI Job Quality Index to an analysis of the 27 EU Member States and data from the 2021 European Working Conditions Telephone Survey. The effects of digitalisation are conceptualised on the basis of two theoretical approaches: one considers the impact of computerised systems and algorithmic management on task allocation, working time and work intensity; the other looks at digitalisation at work in terms of job demands and resources. The analysis examines how the use of computerised systems at work and their influence on the content and organisation of work affect different dimensions of job quality and how this may differ across groups of workers.

1. Introduction

Digitalisation is one of the principal motors of change in today's labour markets in developed societies, as digital technologies increasingly pervade jobs across the spectrum of sectors and occupations. The European Company Survey, carried out by Eurofound in 2019, confirmed that digitalisation is not only pervasive but also accelerating. For example, 51 per cent of establishments were using data analytics to improve processes, monitor employees or both; 54 per cent had purchased software specifically designed or customised to their needs in the past three years; and similarly, more than half of surveyed establishments were continuing to increase their use of data analytics (results cited in Berg et al. 2023). The Covid-19 pandemic gave additional impetus to these changes, ushering in the use of information and communication technologies (ICTs) in a variety of work settings (Cabrita and Eiffe 2023; Countouris et al. 2023).

Digitalisation affects labour markets and jobs more directly through changes in the employment relationship and work organisation, including the duration, place and nature of work, but also in a less direct manner through shifting power dynamics, as well as product and service innovation and development, leading to a structural shifts in the occupational structure, with some jobs disappearing and new ones emerging (Rubery and Grimshaw 2001; Weil 2019). Much research and controversy to date has focused on the potential of digital technologies to automate away human labour (Frey and Osborne 2013), which may lead to mass unemployment but also to potentially worker-friendly reductions in working hours (see discussion in Piasna 2023a). Other research strands have emphasised the relationship between technological change and workers' skills, with potential effects experienced differently depending on occupational class, level of education or experience. This may lead to polarisation in terms of relative demand, productivity and thus earnings between skilled and unskilled labour (Autor et al. 2003; Frank et al. 2019). While this literature is instructive with regard to the economic impact of technological change and its translation into the world of work, it does not extend our understanding of the impact of digitalisation on the qualitative aspects of work and employment and of how workers experience these conditions. The effects of technological change on job quality have admittedly generated spirited debate, but much of the speculation concerning impact still lacks empirical underpinnings.

This working paper aims to contribute to the literature on the impact of digitalisation on job quality by testing some of the main hypothesised effects with new empirical evidence. The analysis uses a multidimensional index of job quality, which allows us to disentangle the impact of technology on different aspects of

work and to identify possible trade-offs and synergies. The focus is on digital technologies that influence what workers do at work, rather than on tools that may help them to perform certain tasks more comfortably. The basic approach is to include a relatively wide range of technologies that impact work but without rendering the analysis too exclusionary by focusing only on some types of jobs. The effects of digitalisation are conceptualised on the basis of two theoretical approaches: the impact of computerised systems and algorithmic management on working time, task allocation and work intensity; and the effects of digitalisation at work in terms of job demands and resources. The results are based on data for the 27 EU Member States collected in 2021.

2. Framework for an analysis of the job quality outcomes of digitalisation

Adoption of digital technologies in the workplace takes many different forms, so a common set of outcomes for all workers is unlikely. Rather, the impact of digitalisation depends on the type of technology used and its purpose, where and for whom it is applied, but also how its use is managed and regulated. In this paper, the focus is on the use of computerised systems at work – that is, programmable and/or connected devices – and contexts in which such computers influence what workers do at work. While still broad, and in principle applicable to most, if not all, occupational classes, this approach to digitalisation aims to map its impact by comparing workers in similar jobs and institutional settings who are exposed to such digital technology to those who are not.¹

2.1 Transformation of work's rhythms and temporalities

Digitalisation can be a means to increase efficiency in task allocation and workers' performance. This may be achieved by providing them with access to resources, such as information or tools, so that they can perform their tasks more quickly (Green 2006; Adams-Prassl 2019), but also through timing and allocating tasks more efficiently. This has important implications for the way in which working time is structured and organised, and thus for the rhythms of work, which are some of the key dimensions of job quality.

In general, digital technologies allow for new ways of measuring, standardising, decomposing and quantifying labour (Altenried 2020). Work activities can be divided into small time intervals, which are then allocated in real-time to precisely match the timing of task performance with staffing levels (Lambert et al. 2019). While the idea itself is not new, digital technology with augmented computational capacities makes such matching of workloads to workers not only feasible but also cost effective on a large scale. Time allocated to perform each task can additionally be squeezed, limiting any breaks, downtime or auxiliary activities, thus further increasing efficiency, but also the intensity of work (Green et al. 2022).

It has been claimed that such an application of computerised systems will change the way working time is organised and structured in the work process, thus

1. The issue of the endogeneity of technology adoption is not directly tested in this paper. For a related discussion see, for example, Antón et al. (2023).

transforming existing time regimes (Piasna 2023a). What was once a relatively well delineated and continuous working day can be transformed into a patchwork of ever-shorter units of paid working time, scheduled in irregular and discontinuous patterns, according to business needs or fluctuating demand. Such units may be interspersed with unpaid or non-working periods insofar as companies are able to exclude activities that they deem low value added from the remit of paid labour (Standing 2023). Workers experience this as ‘atomised’ and ‘punctuated’ time (Piasna 2023a). The prime example of such deployment of digital technologies in the work process is the platform economy and its use of algorithmic management (Kellogg et al. 2020), but it can also be applied in traditional employment settings to time, allocate and monitor workforces of any size (see examples in Moore and Hayes 2017; Delfanti 2021). Workers then experience working hours as less predictable and the rhythm of work as more hectic (Scheele et al. 2023).

This way of achieving time efficiencies in digitalised work settings is contingent on ensuring the availability of workers to access, procure and perform these small and scattered units of paid activity. Workers thus come under mounting pressure to make themselves more available. This is what is referred to in the literature as ‘incessant availability’ (Piasna 2023a), required of workers to ‘bridge the gaps’ in atomised and punctuated time. As a result, the performance of many tasks encroaches on workers’ private time – extending beyond their contractual hours in the case of regular employees – and blurs the boundary between paid work and private time, with expected negative consequences for work–life balance (Piasna 2023a).

Working with digital technologies facilitates this extended availability not only through automated management, but also through the portability of work devices, such as laptops, mobile phones or tablets, from the workplace to private spaces of life, and the associated difficulty of disconnecting from work. This has been identified in the recent literature as a risk linked in particular to remote working (Arabadjieva and Franklin 2023) and the platform economy (Schor 2020; Pulignano et al. 2021), but workers in other types of work who use portable connected devices may also be susceptible.

Extension of working hours under such conditions can be further augmented by individualisation of the employment relationship and working time patterns, for example, among freelancers or workers in self-directed work. Workers exposed to digital technologies at work were found to frame their autonomy in terms of pressure to work even more and saw themselves as being pulled towards self-exploitation. The literature refers to this as the ‘autonomy paradox’ (Mazmanian et al. 2013; Ivanova et al. 2018).

Overall, then, digitalisation can be expected to increase the unpredictability of working time, in many cases breaking with the pattern of a standard continuous working day, while the closer matching of work tasks to workers may be experienced by them as work intensification. A pressure to extend availability to work beyond standard hours is expected to lead generally to longer working hours and in particular to a spillover of work into individuals’ private time and space, potentially with detrimental effects for work–life balance. Processes such

as work intensification or spillover of paid work into private time are not new and have been linked to a variety of contemporary developments, notably deregulation and flexibilisation of the labour and economic markets (for example, Green 2006; Rubery et al. 2016; Isidorsson and Kubisa 2019). But these outcomes, as already discussed, are also expected to be related to the use of certain technologies in the work process. The empirical analysis that follows approaches this by testing how job quality differs among otherwise similar workers, alongside changes in digital technology's impact on their work.

2.2 Job demands and resources

Digitalisation of work has the potential to provide workers with new resources but also to expose them to specific risks and demands beyond the work intensification discussed above. The outcome is likely to be a shift in the balance of power between workers, managers and employing organisations. One important area with regard to empowering workers is upskilling as technological advances increase skill requirements, not only to work with new technologies but also to develop and produce them (Gallie 2007; ILO 2021). Higher skilled work in general tends to be more autonomous, and the proportion of creative jobs and the emphasis on innovation are likely to increase. An increase in the use of digital technology could then be expected to lead to structural shifts in the workforce towards more autonomous and higher skilled work (Hancock et al. 2023).

On the other hand, digital technologies provide employers with more ways of supervising, surveilling and controlling the workforce, which might have negative effects on worker autonomy (De Stefano 2018; Parent-Rochelleau and Parker 2022). In the context of the platform economy, for instance, digitally-mediated work carried out within the framework of precarious employment arrangements and algorithmic management was found to substantially constrain workers' autonomy in deciding when and for how long they work or what tasks they accept (Piasna and Drahokoupil 2021; Shanahan and Smith 2021). The impact of digitalisation on worker autonomy might then be shaped by the quality of employment arrangements, with a possible polarisation between more secure workers who are more likely to reap the benefits of computer use and a cumulative disadvantage among more precarious workers, whose insecure jobs will also be characterised by constraints on autonomy and limited discretion (Paugam and Zhou 2007).

Where education levels fail to catch up with the demand for highly skilled labour, skilled workers' bargaining power tends to increase, which can result in higher wages and better career prospects. A positive effect on wages would also be in line with a generally positive effect of digitalisation on companies' productivity and profitability (Muñoz de Bustillo et al. 2022), assuming workers have a sufficiently strong position to negotiate better pay, individually or collectively (Tahlin 2007; Berg et al. 2023). While the impact of digitalisation on wage levels has been well researched, less is known about the impact on more qualitative dimensions of income, such as the predictability or stability of earnings.

Moreover, a change in the task content of jobs related to digitalisation has the potential to eliminate tedious, monotonous or dangerous work (Jetha et al. 2023). We might then expect demands on workers in terms of certain physical risk factors to be reduced. At the same time, working with digital devices breeds new challenges in terms of psychological demands, psychosocial and ergonomic risks (Wixted et al. 2018). Therefore, while some types of physical risk factors can be expected to decline, others could gain in importance, such as strain related to prolonged work with personal computers or physical demands imposed by automated machinery. Such trade-offs may explain why some previous studies found no overall effect of digitalisation on physical work risks (Antón et al. 2023), and highlight a need for a more disaggregated analysis that distinguishes between specific risks.

Finally, an important resource for workers irrespective of particular work settings is access to channels of collective voice and representation (Hyman and Gumbrell-McCormick 2020), which has been shown to have positive outcomes in terms of job quality, especially for more vulnerable workers (Piasna et al. 2013; Kirov 2015). Indeed, we might expect that the digitalisation of workplaces in consultation with workers would be more likely to result in worker-friendly and job quality-enhancing outcomes. It is less clear, however, how access to worker interest representation may be affected by digitalisation. It may have negative effects as a result of decentralisation and fragmentation of business activities (Weil 2019), but there may also be reverse causation with a greater propensity to introduce new technologies in companies in which these processes can be negotiated and thus meet with less worker resistance (Mengay 2020). The relationship between access to worker representation and digitalisation thus remains an open empirical question.

3. European Job Quality Index

Job quality is assessed using the European Job Quality Index (JQI), which has been developed by ETUI researchers to measure and compare job quality across EU countries (for details on the index construction see Leschke et al. 2008; Piasna 2017). Workers and their well-being are at the centre of the index, which focuses on aspects of jobs that have been demonstrated to be conducive to health and safety, work–life balance and psychological and economic well-being (Quinlan et al. 2001; Burchell et al. 2002; Benach and Muntaner 2007; Muñoz de Bustillo et al. 2011).

The JQI encompasses a broad range of work and employment characteristics, summarising them in terms of six dimensions: (i) income quality; (ii) forms of employment and job security; (iii) working time and work–life balance; (iv) working conditions; (v) skills and career development; and (vi) collective interest representation and voice. Each of these dimensions then contributes equally to the overall JQI. These six main dimensions, in turn, comprise a large number of individual indicators derived from the European Working Conditions Survey (EWCS; in 2021 the EWCTS), the EU Labour Force Survey (LFS) and the database on the Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts (ICTWSS).

The focus in the present working paper is on individual level relationships between technology use at work and various job quality outcomes. For this reason, the analysis departs from the standard presentation of the European Job Quality Index aggregated at the country or sectoral level, and uses only individual-level data from one dataset, the EWCTS. This required some modification of the index by omitting or adjusting items based on other data sources. Table A1 in the Appendix explains where such adjustments to the full JQI have been introduced.

Table 1 presents the job quality index as used in this paper by listing all the dimensions of the JQI and the survey items used to calculate them. All dimensions are expressed on a 0–100 scale: this corresponds either to a percentage (that is, the share of workers reporting a certain work characteristic), or to a score derived from categorical response options. To make the interpretation of results more intuitive, the names used for the dimensions and sub-dimensions of job quality suggest whether this is a positive or a negative work feature – for instance, a higher score on the ‘Work intensity’ dimension indicates more intense work and hence lower job quality (it thus departs somewhat from a practice in job quality studies of coding higher values as indicating better job quality for all dimensions). As the dimension ‘Job security’ is derived from a question about how insecure people

feel about their job, the scores on that question have been reverse coded, so that interpretation of the results is more straightforward and also aligns with its name.

The analysis includes 27 EU countries and data collected in 2021. The full sample includes 58,403 respondents, who are employed adults aged 16 and over. However, some sections of the EWCTS were modularised, meaning they were not put to all respondents, but to a sub-sample, possibly to save costs and to keep the questionnaire reasonably short for a telephone survey. As a result, the use of ICT at work is analysed based on 58,378 respondents (this question was asked of all in the full sample), while the question about the influence of computerised systems on work on 29,035 respondents (this question was included in only one of the modules). As the sub-sample was designed to be a simple random sample of the full sample – in other words, not systematically different from the rest of the respondents – and their selection was not related to any of their characteristics, the estimates from the modularised questions are not expected to have any systematic bias. The main weakness is the smaller size of the sub-samples, which increases the standard errors. The analysis uses the post-stratification and cross-national weights provided in the EWCTS dataset (for more information about the survey methodology, see Eurofound 2023).

Table 1 **Dimensions of the European Job Quality Index and their components as used in the analysis**

Sub-indices	Indicators
JQI.1. Income quality	Income predictability: 'Can you tell in advance how much you are going to earn in the next 3 months?'
JQI.2. Forms of employment and job security	Job security: 'I might lose my job in the next six months' (reverse coded)
JQI.3. Working time and work-life balance	Long weekly hours: share of workers working more than 48 hours a week Work-life balance: extent to which working hours fit with family or social commitments outside work
JQI.4. Working conditions	Work intensity: frequency of working at a very high speed, to tight deadlines, and in one's free time to meet work demands Work at short notice: frequency of being requested to come into work at short notice Work autonomy: being able to choose/change order of tasks, methods of work, speed of work; being able to take an hour or two off for personal reasons Physical work risks: frequency of exposure at work to noise; handling chemical substances; infectious materials; tiring or painful positions; lifting or moving people; carrying or moving heavy loads Repetitive hand movements: frequency of exposure to repetitive hand or arm movements at work
JQI.5. Skills and career development	Prospects: 'My job offers good prospects for career advancement'
JQI.6. Collective interest representation*	Employee representation: presence of a trade union or works council in the company/organisation; presence of a health and safety delegate; holding regular meetings with employees

Note: * this sub-dimension is only available for employees and in a module together with the influence of computer systems, rendering n=25,398 observations with non-missing values.

A detailed explanation of the construction of the full JQI is provided in Piasna (2023b).

4. Digital technologies at work: mapping the gaps between EU workers

Digitalisation, in the sense of the extent to which digital technologies have penetrated a workplace, is measured by two indicators in the following analysis. The first is ‘the use of ICT at work’ and serves as contextual information in the descriptive part of the analysis. It is based on whether and how often respondents work with information and communication technology (ICT) in their main paid job (which may include a computer, laptop, tablet or smartphone). Responses are given on a five-point scale, ranging from ‘never’ (assigned a value of 0 in the analysis) to ‘always’ (100). The second indicator is the ‘influence of computerised systems on work’, which is the focus of the analysis and derived from the question about the extent to which a computerised system influences what respondents do in their work, but without providing respondents with any further specification or examples. The degree of influence is rated on a four-point scale (‘not at all’, ‘not much’, ‘to some extent’, ‘to a large extent’), with a fifth option to the effect that this does not apply to the respondent’s work situation.² All five responses are included in the analysis.

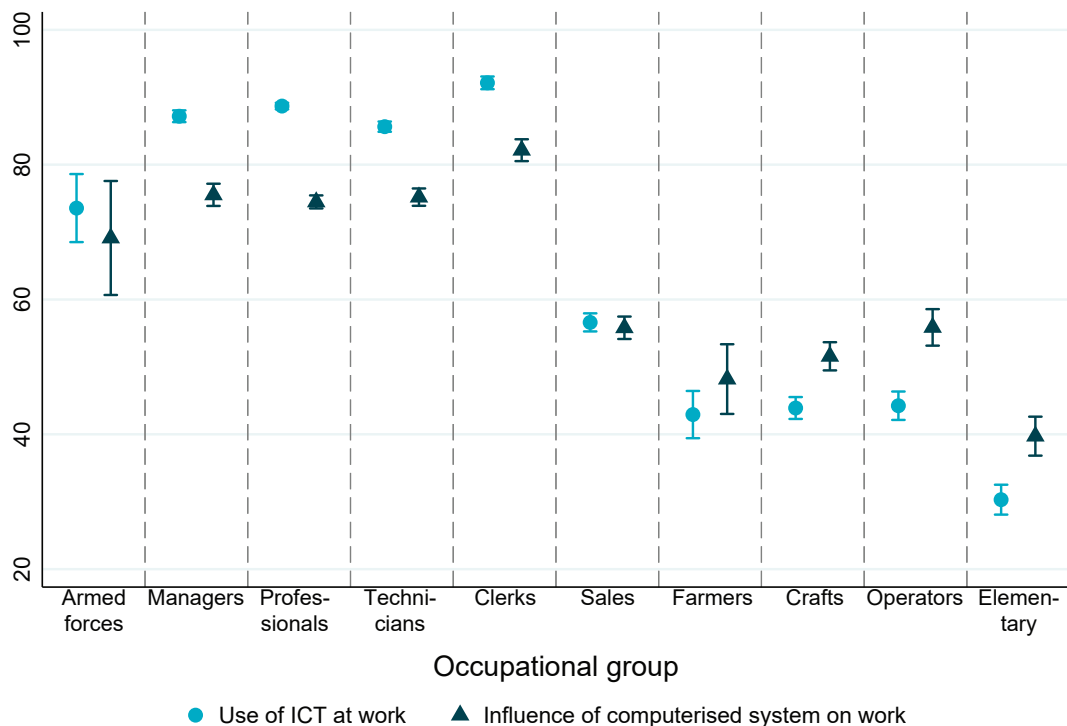
The influence of digital technologies on the work process is thus captured by a rather general question, which was admittedly open to interpretation by respondents, who were not provided with prompts or a list of applicable technologies. While this does not allow specific conclusions to be drawn concerning what type of digital technology has an impact on job quality, it does have the advantage of being inclusive and thus potentially capturing many different forms of technology that control or otherwise influence the work process. They can be expected to differ across workplaces and job types, which makes asking more detailed questions problematic, although it also avoids the bias towards conventional computers, whether a PC or a laptop. Accordingly, the digital technologies reported by workers in the EWCTS may encompass surveillance technologies, tracking devices, AI solutions that assign or perform some tasks, productivity-enhancing digital tools

2. Conceptually, it is difficult to distinguish between responses ‘This doesn’t apply to my work situation’ and ‘Not at all’, as we could assume no influence of computerised systems in both these situations. An additional analysis was carried out to test for any meaningful difference between workers who gave these two responses. Overall, few such differences exist and these responses tend to go hand in hand in similar groups of workers. Among the few observed differences, a response ‘does not apply’ was given somewhat more often than ‘not at all’ by workers in elementary occupations, those working in public administration and for households as employers. The opposite pattern emerged for workers in retail. In the descriptive part of the analysis, comparing the intensity in use of digital technologies at work for different groups of workers, the response ‘does not apply’ is assigned a value 0, while ‘not at all’ value 25, assuming there may indeed be some difference in exposure to technology between these responses, with remaining responses having values 50, 75 and 100. In the inferential analysis, all response options are included separately as categories.

or a technology that determines the speed of an assembly line. The key common denominator of these digital technologies is that they affect work performance as perceived by the workers themselves.

The degree of workplace penetration of digital technologies is largely a function of the type of work performed. While in most cases office work by white-collar workers might be expected to involve working with a personal computer, other types of connected devices or industrial computers are common in a wide range of workplaces. Figure 1 shows the penetration and influence of digital technologies at work by broad occupational groups. The most obvious division is between clerical and manual occupations. Furthermore, it is less related to skill levels once individual characteristics such as age, gender or employment status are taken into account. The extent of ICT use is highest among clerks or administrators, closely followed by professionals, managers and technicians and associate professionals. The lowest usage by far is in elementary occupations. The extent of the impact of computerised systems on work is closely related to the frequency of ICT use, with clerical occupations generally at the forefront. In lower-skilled manual occupations, however, digital technologies have a relatively greater impact on the organisation and content of work compared with their use. This is particularly the case for elementary occupations and operators and assemblers. This may suggest that these workers are disproportionately exposed to the controlling aspect of technology, such as algorithmic management and the allocation and pacing of work tasks.

Figure 1 Working with digital technologies, by occupational group, EU27

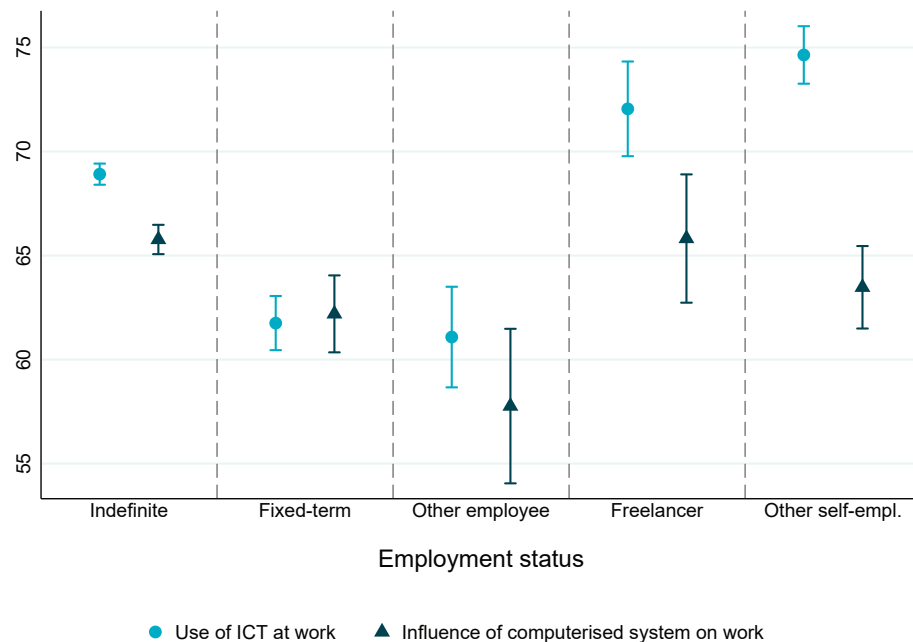


Note: regression results, with 95% confidence intervals, controlling for gender, age, employment status, occupational group (1-digit ISCO) and country.

Figure 2 further illustrates the diffusion of digital technologies and their impact on work by focusing on differences related to employment status and contract type. Three groups of employees and two types of self-employed are distinguished. The former are divided into those with an indefinite employment contract, those with a fixed-term contract (including temporary agency workers and apprentices), and those with any other contractual arrangement (including no formal contract and with self-reported other arrangements). The self-employed are divided into ‘freelancers’ (thus a group who reported self-employed status and describing themselves as doing freelance work, as being subcontractors or being paid a salary by an agency) and ‘other self-employed’ (thus a group of all remaining self-employed). This categorisation does not follow a simple distinction between solo self-employed and employers, and instead relies on more nuanced information available in the EWCTS referring to workers’ degree of dependence and vulnerability.

In general, employees are less likely to work with computers than the self-employed, even after controlling for differences in job type and individual characteristics. Among employees, those with indefinite contracts are most likely to work with computers, while freelancers are slightly less likely to use computers at work than other self-employed persons. Despite a higher incidence of digital technologies among the self-employed, they report a relatively lower impact of technology on their work organisation, to an extent similar to that of employees on indefinite contracts.

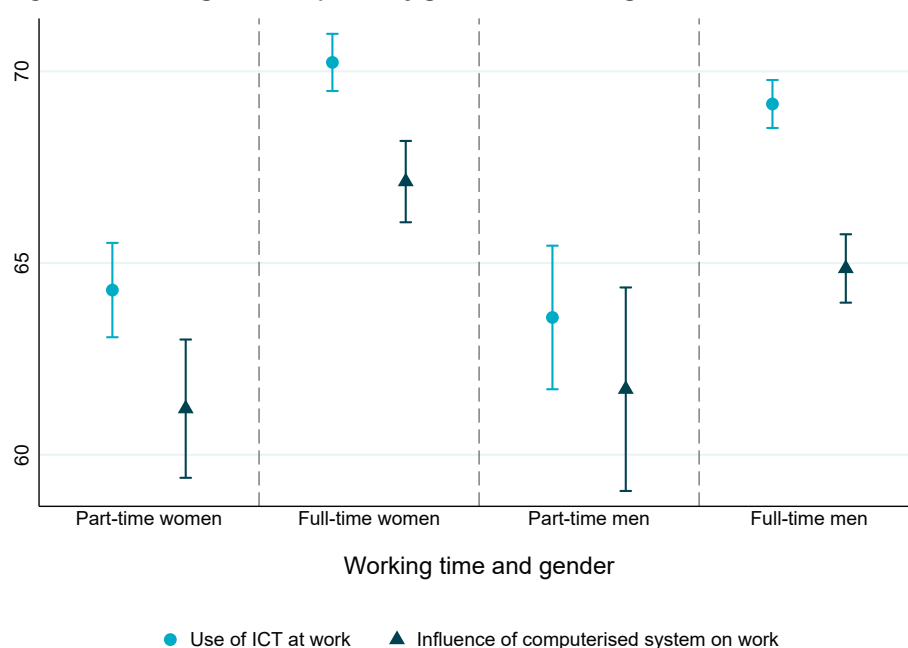
Figure 2 Working with digital technologies, by employment status, EU27



Note: regression results, with 95% confidence intervals, controlling for gender, age, employment status, detailed occupational group (2-digit ISCO) and country.

A similar gap is found between full-time and part-time workers (Figure 3), with part-time work characterised by a lower exposure to digital technologies than is the case for full-time workers. Notably, these differences between full-time and part-time workers persist even after controlling for detailed occupational group, employment status, and other individual characteristics. Interestingly, women in full-time jobs are more likely to work with computers and are relatively more subject to their influence on work organisation than men working full-time. There are no such gender differences, however, among part-time workers.

Figure 3 Working with computers by gender and working time, EU27



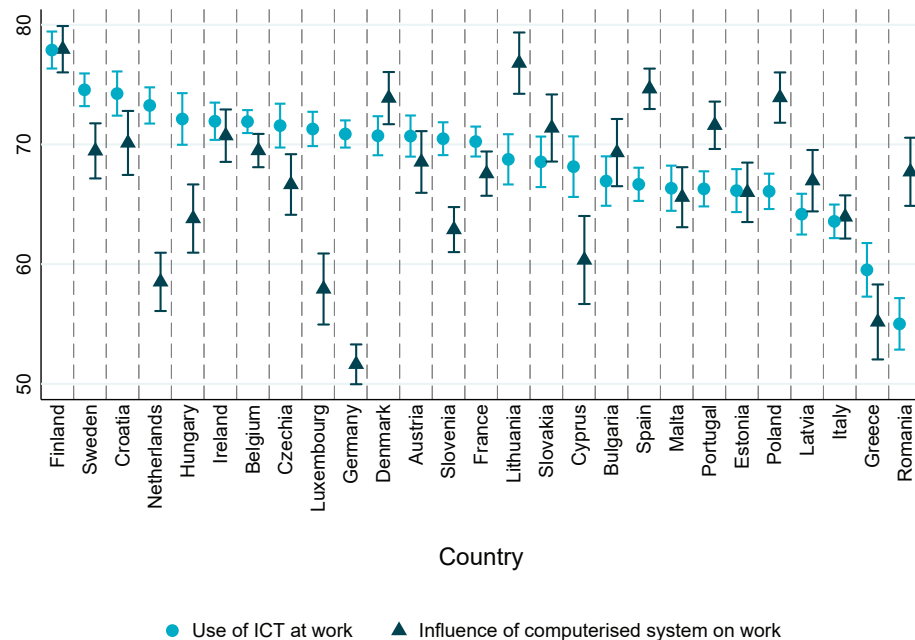
Note: regression results, with 95% confidence intervals, controlling for gender, part-time/full-time work, age, employment status, detailed occupational group (2-digit ISCO) and country.

Finally, there is a remarkable cross-national variation in the deployment of technology in the EU (Figure 4). Once structural differences between countries are taken into account, Romania and Greece stand out with a much lower use of digital technologies in the work context. Eastern, central and southern European countries generally have a lower diffusion of ICTs at work than other EU members, with the notable exceptions of Croatia, Hungary and Czechia, where the use of computers is more common. Finland leads in the use of digital technology, followed by Sweden.

Figure 4 also shows that the ways in which computers are integrated into the work process differs between countries and is not directly related to the extent of their use. For example, in Germany, Luxembourg and the Netherlands, ICTs are used at work relatively frequently but computerised systems exert little influence on workers. In Romania, on the other hand, the use of computers is less common, but the extent of their influence is disproportionately high. A similar pattern is found in some other eastern and southern European countries, such as Lithuania,

Spain, Poland and Portugal. These results are interesting and can be considered one manifestation of the mutually reinforcing characteristics of institutional structures, with some countries, notably in central and eastern, as well as southern Europe, showing traditionally less individual level control (Gallie and Zhou 2013). In contrast, control over the work process by digital technologies can be more contained in countries where individual control is anchored in broader industrial relations structures that are more strongly institutionalised, thus better protecting workers from various pressures, presumably including those stemming from increasing digitalisation. These results thus resonate with earlier findings that the ultimate effect of digitalisation on work depends on the institutional contexts in which technology is introduced (see also Kornelakis et al. 2022; Minardi et al. 2023).

Figure 4 Working with computers, by EU country



Note: regression results, with 95% confidence intervals, controlling for gender, age, employment status, detailed occupational group (2-digit ISCO) and country.

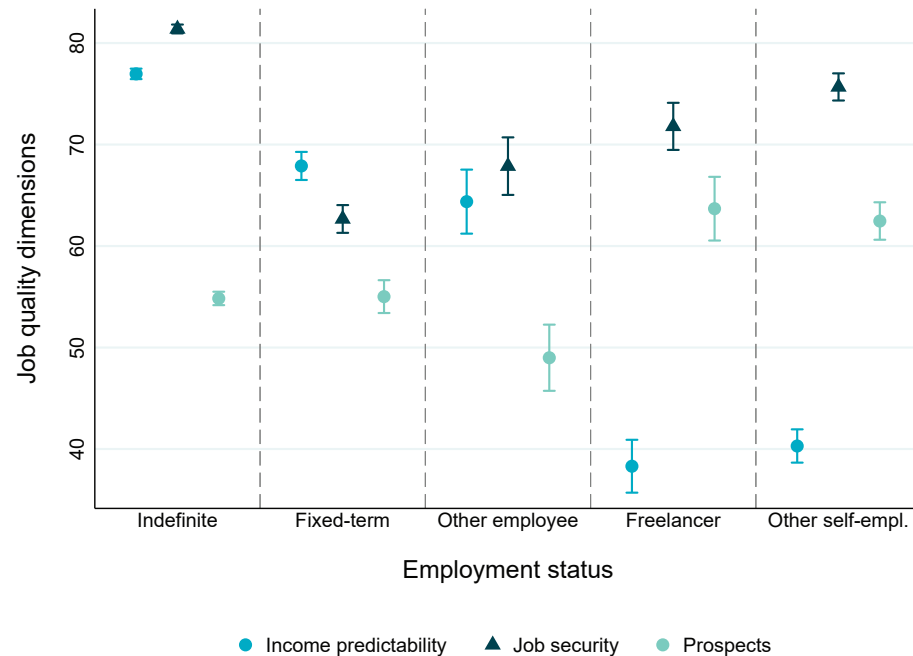
5. Impact of digitalisation on job quality

5.1 Trade-offs and inequalities in job quality: an overview

Before moving to the analysis of job quality differences related to the use and impact of digital technologies on work organisation, this section briefly presents how job quality dimensions used in the analysis differ among analysed workers. As already shown, substantial differences in the extent of digitalisation of work are linked to employment status. In this section, then, the mapping of job quality is carried out through this lens. The aim is to provide context for further analysis by showing how various good quality characteristics are bundled among workers with different vulnerabilities and exposure to technology.

Figure 5 illustrates the trade-offs between income predictability, job security and prospects – none of the labour market segments are characterised by the best outcomes on all dimensions. Employees on indefinite contracts, as might be expected, feel most secure in their jobs and their incomes are largely predictable. Their prospects for career progression and development are average. Other employees report similar prospects, but their job security and predictability of earnings are significantly lower than for standard employees. The self-employed are the most optimistic about their prospects, more so than employees, with little difference between freelancers and other self-employed. Their job security is significantly lower than that of standard employees with indefinite contracts, but slightly higher than that of fixed-term and other employees. Freelancers feel less secure in their jobs compared with other self-employed. Self-employment, however, is associated with very low income predictability.

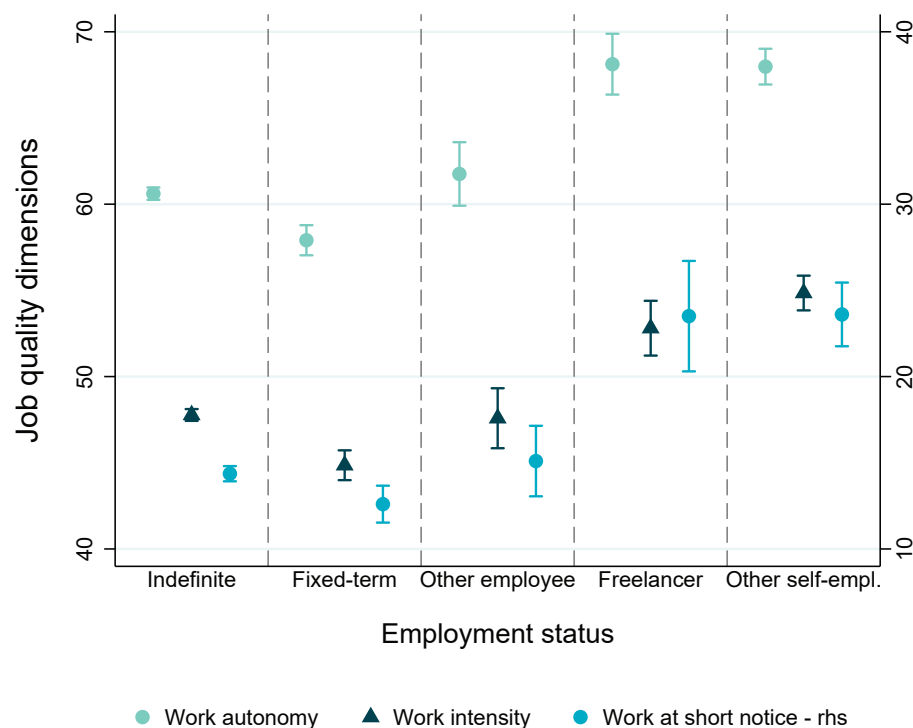
Figure 5 Patterns of job quality across a segmented workforce: income, job security and prospects, EU27



Note: regression results, with 95% confidence intervals, controlling for gender, age, employment status, detailed occupational group (2-digit ISCO) and country.

Another set of trade-offs in job quality is shown in Figure 6. The work intensity index as shown in the figure includes three measures: work at high speed, to tight deadlines and work in free time to meet work demands. Together with the need to work at short notice, it indicates more intense and less predictable work. As illustrated in the figure, work autonomy, work intensity and the need to perform work at short notice all move in parallel across employment statuses, meaning that more autonomy is associated with more intense and hectic work. This is particularly the case for freelancers and other self-employed, which might suggest that self-directed work leads to self-exploitation in some contexts, notably of low job and income security. Employees with fixed-term contracts, on the other hand, have the least autonomy but also a less intense pace of work.

Figure 6 Patterns of job quality across a segmented workforce: trade-offs between autonomy and work intensity, EU27



Note: regression results, with 95% confidence intervals, controlling for gender, age, employment status, detailed occupational group (2-digit ISCO) and country.

5.2 Punctuated working time and work intensification

The impact of digital technologies is analysed first in terms of temporalities and rhythms of work. While technologies and their applications are vast and diverse, several common threads have emerged from the literature. In particular, in work contexts where computerised systems influence the organisation of work, whether in a form of algorithmic management, or some degree of automation in task allocation, evaluation or scheduling, working time tends to be approached as composed of discreet units, rather than as a continuous day, week or month. This is because digital technologies make the management of such small units considerably easier and cost efficient. This allows a closer match of labour demand and supply, resulting in a punctuated working time.

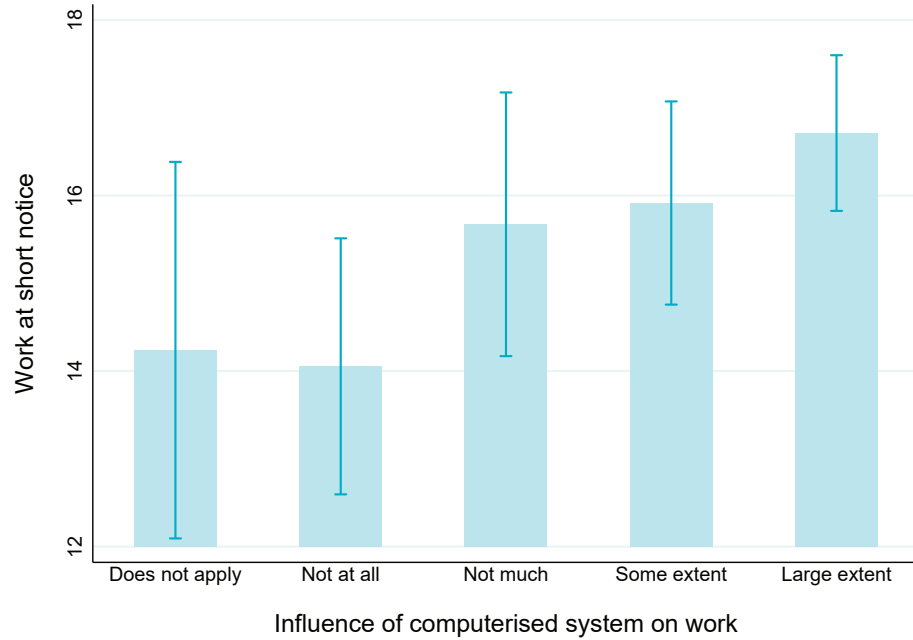
In the analysis, this change in working time logic is measured by the reported need to perform work at short notice. As shown in Figure 7, there is indeed a significant and positive relationship between the extent to which computers influence work and a higher frequency of working at short notice. A similar relationship exists between the use of ICTs at work and work at short notice, which is most common among those who often work with these digital technologies and least common

among those who never do (results not shown). It should be noted, however, that this increased tendency to work at short notice linked to the influence of digital technologies at work is found only when we compare similar workers in very similar jobs and who differ in their exposure to digital technologies at work. This is because, in general, jobs where digital technologies are used more often are also characterised by a lower frequency of working at short notice, which may be primarily related to the nature of the tasks they perform. To discern such confounding compositional effects, all analysis presented in this section is carried out controlling for individual characteristics, job and contract type, as well as country fixed effects. An additional disaggregation of the results by broad economic sector (not shown) reveals that digitalisation is linked to more frequent work at short notice, in particular in education, health care and financial services.

Approaching work as composed of fragmented time units that can be allocated and closely matched to tasks and peaks in workload is expected to result in work intensification. This assumption is tested by comparing levels of work intensity between workers impacted to a varying extent by technology, net of job-type related and individual differences between workers. Work intensity is measured here as work at high speed and to tight deadlines, thus excluding its third component used in JQI, which is work in free time to meet work demands. Although highly correlated with the former two, this third aspect of work intensity is analysed separately in the following section. Figure 8 shows that, as expected, work intensity increases alongside increasing interference of technology in the organisation of work. Workers exposed to a large extent to the influence of computerised systems on their work are most often working at a high speed and to tight deadlines. These effects are observed across all sectors, but are most pronounced in construction, manufacturing, health care and other services, while less manifest in transport.

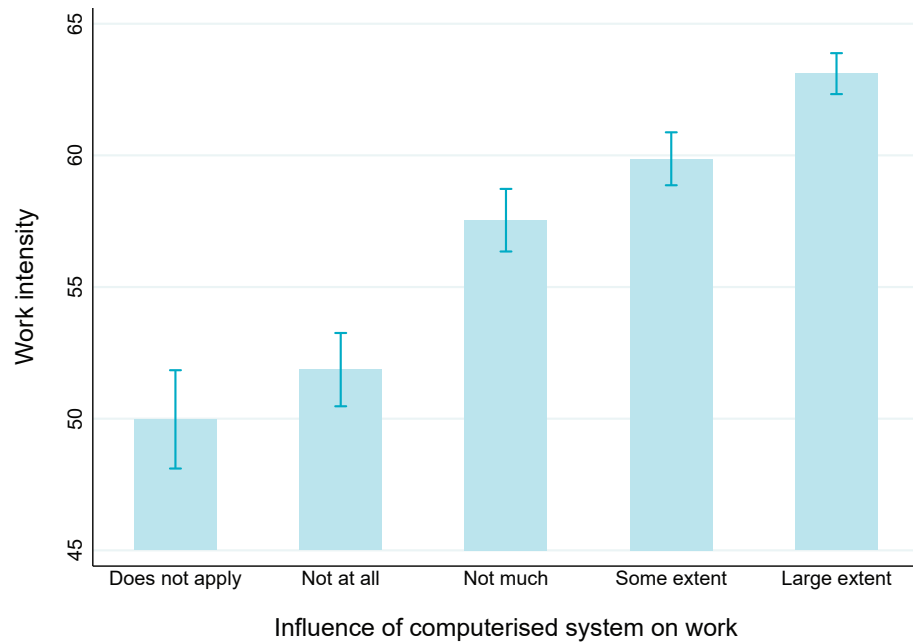
Overall, then, when computer systems influence what people do at work, working hours are more likely to be punctuated and work to be more intense. It is not just a question of whether or not computers affect work, but also of the extent of this impact, with a large extent of the impact associated with the most intense work and most frequent work at short notice. This then supports the claims put forward in the literature that digital technology can be used to achieve efficiency gains by more effectively matching work tasks to fragmented and punctuated units of time, leading to effort-biased technological change.

Figure 7 The influence of computers and work at short notice, EU27



Note: predicted scores from regression analysis, with 95% confidence intervals, controlling for gender, age, employment status, detailed occupational group (2-digit ISCO) and country.

Figure 8 The influence of computers and work intensity, EU27



Note: predicted scores from regression analysis, with 95% confidence intervals, controlling for gender, age, employment status, detailed occupational group (2-digit ISCO) and country. Work intensity only includes two items here: work at high speed and to tight deadlines.

5.3 'Incessant availability'

The paradoxical impact of digital technologies, as posited in the reviewed literature, is that they enable a more efficient allocation of work by closely matching tasks to workers, but at the same time their use pushes workers in various ways to extend their availability for work. In some work contexts, such as 'incessant availability' may be an overt business strategy, as in many forms of platform work, but it may also be a by-product of the way workers interact with technology. In some cases, it may be difficult to disconnect from work, which follows workers into their private time and spaces on a variety of portable devices.

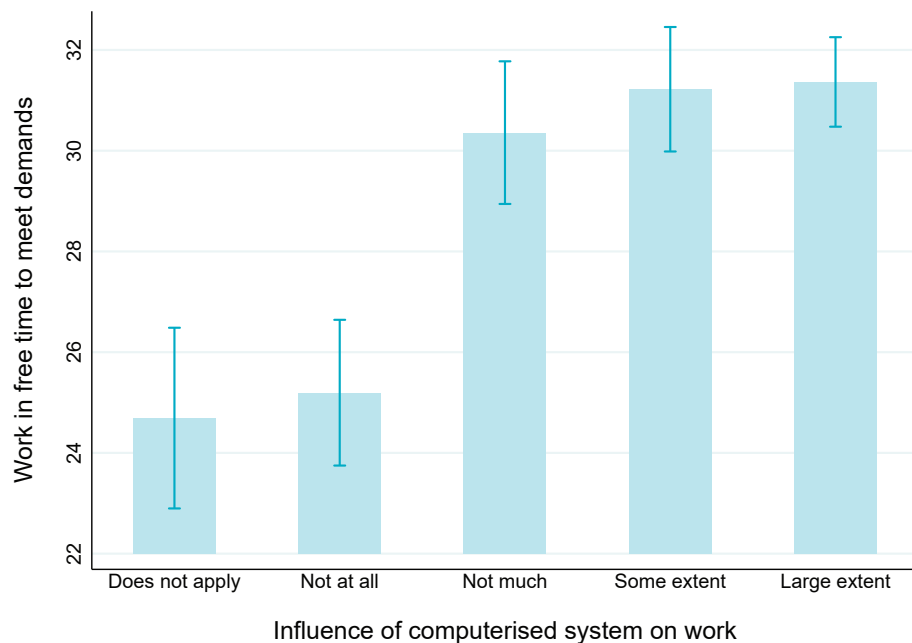
This presumption is tested, first, by analysing a spillover of work beyond paid working hours as an evidence of blurring of work/non-work boundaries. Figure 9 shows that workers who experience some influence of computers on their work are significantly more likely to work in their free time to meet work demands than workers who do not report such an influence. Interestingly, the extent of computer influence does not make a discernible difference in this respect. Whether the influence of computer systems is small or large, the average increase in frequency of work spillover is similar. In the education sector, however, this relationship is stronger and more linear, with spillover increasing, the more influence digital technologies exert on work.

A second analysed measure – extended availability for work – is the number of hours worked per week and, in particular, the incidence of very long hours, over and above the legal limit of 48 hours per week (Figure 10). Overall, workers who are exposed to computer influence report working more hours per week and are more likely to work long hours than those who are not exposed at all. The results are very similar to those shown above for working in free time, the main difference being related to the presence of computer influence as such rather than its extent. Contrary to what might be expected, workers subject to the least computer influence work the longest hours, on average, longer than persons subject to extensive influence, although these differences are not statistically significant.

Extended availability for work could also be captured indirectly through self-reported work–life balance, namely, the extent to which working hours fit in with the respondent's family and social commitments outside work. The results presented in Figure 11 reveal a significantly worse work–life balance among workers whose work is influenced by computer systems. Interestingly, this negative effect of digitalisation on work–life balance is stronger for men than for women.

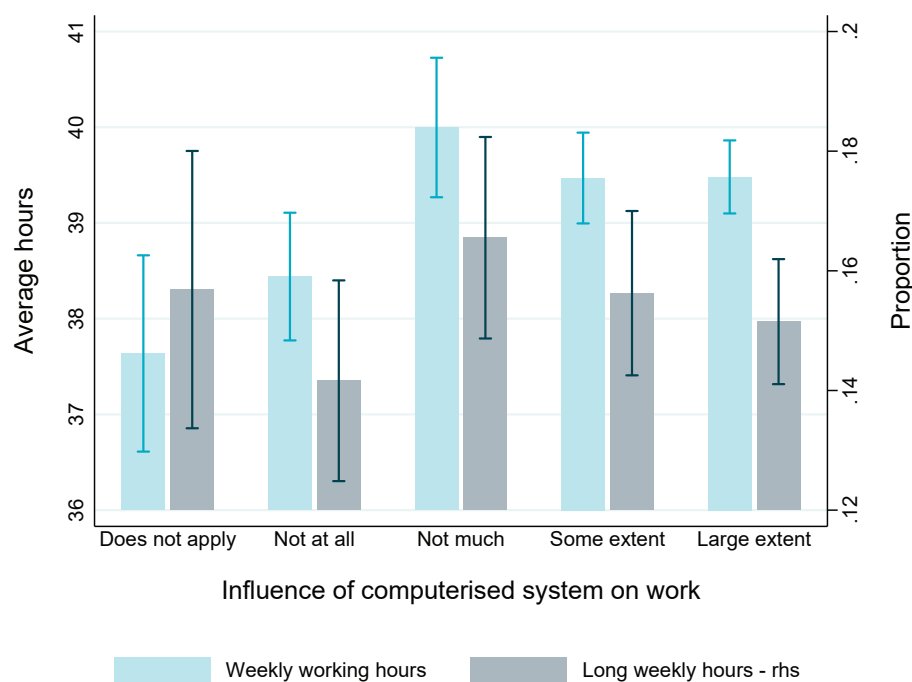
Overall, then, work with digital technologies that influence work organisation is associated with a greater spillover of work into workers' private time, including a higher incidence of work in free time and generally longer working weeks and days, with negative consequences in terms of work–life balance. This extended availability for work does not seem to be affected by the extent of computer influence, however, and does not increase with an increasing impact of digital technologies. This is puzzling, and although care has been taken to control for a variety of confounding influences, such as individual differences between workers and differences related to job type and employment status, there may still be some factors that were not included because of data limitations and that merit further investigation.

Figure 9 Influence of computers and spillover of work, EU27



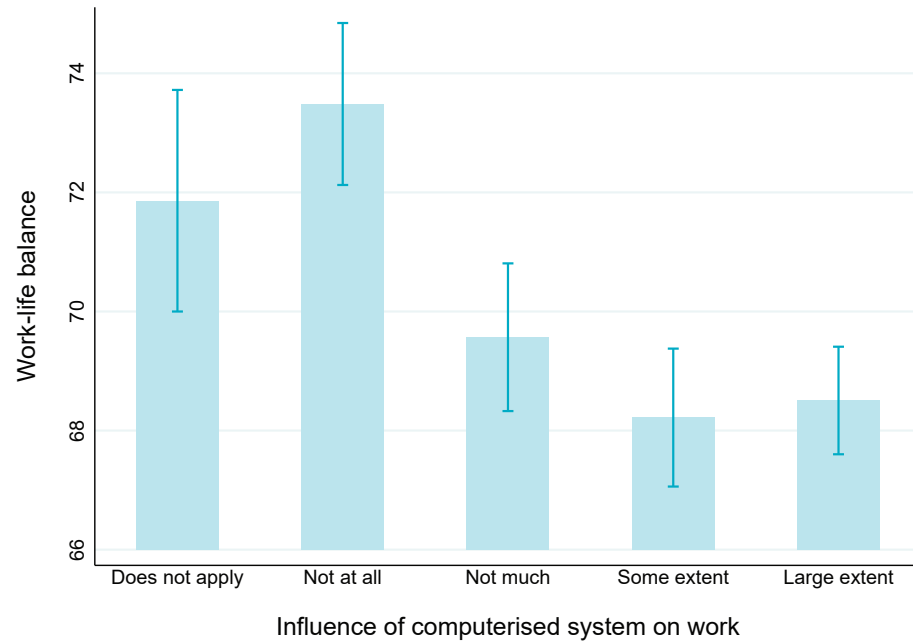
Note: predicted scores from regression analysis, with 95% confidence intervals, controlling for gender, age, employment status, detailed occupational group (2-digit ISCO) and country.

Figure 10 Influence of computers and weekly working hours, EU27



Note: predicted scores from regression analysis, with 95% confidence intervals, controlling for gender, age, employment status, detailed occupational group (2-digit ISCO) and country.

Figure 11 Influence of computers and work–life balance, EU27



Note: predicted scores from regression analysis, with 95% confidence intervals, controlling for gender, age, employment status, detailed occupational group (2-digit ISCO) and country.

5.4 Empowering workers and resources at work

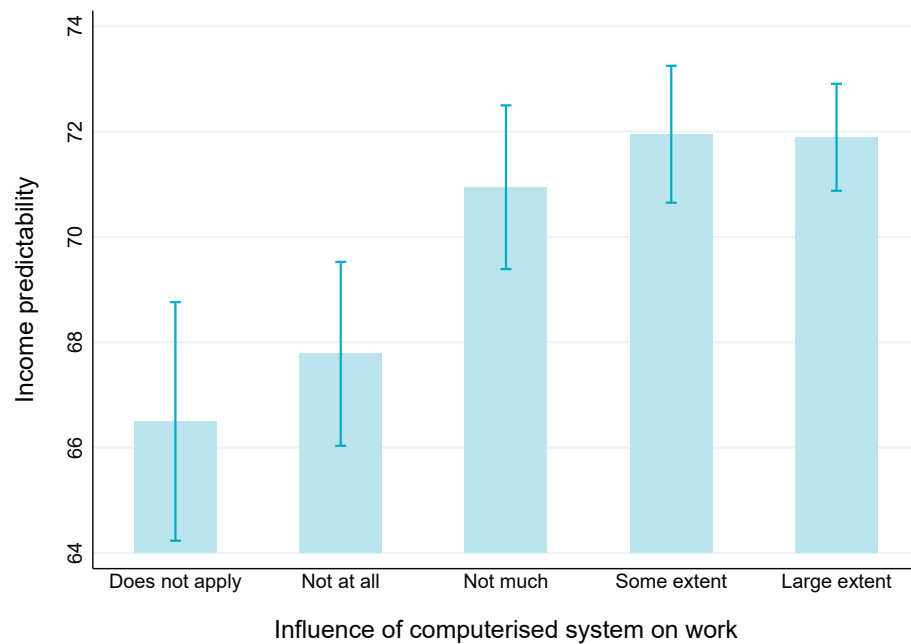
Given the transformative impact of digital technologies on the temporal structure and demands of work, as outlined above, it is important to consider whether the digitalisation of work provides workers with additional resources. This may point to avenues for positive (from the workers' perspective) change. The digital revolution has been linked to various positive processes, such as upskilling or releasing workers from having to perform mundane, dangerous or unpleasant tasks. Jobs penetrated by ICT to a larger extent should on this basis turn out to be of better quality, at least on some dimensions.

Leaving aside an apparently positive relationship between computer use and earnings, which partly results from the fact that higher-skilled professionals are more likely to work with computers than lower-skilled and lower-paid workers in elementary occupations, Figure 12 illustrates the relationship between income quality and digitalisation net of such compositional effects. Income quality is measured by the extent to which earnings are predictable, and the results indicate a significant and positive relationship. Income security is thus higher among workers who experience the impact of digital technologies on their work, even when comparing very similar types of jobs.

While incomes may be more predictable, jobs influenced by digital technologies are actually less secure. Figure 13 shows a decline in job security as the influence of computer systems at work increases. Workers exposed to computer influence

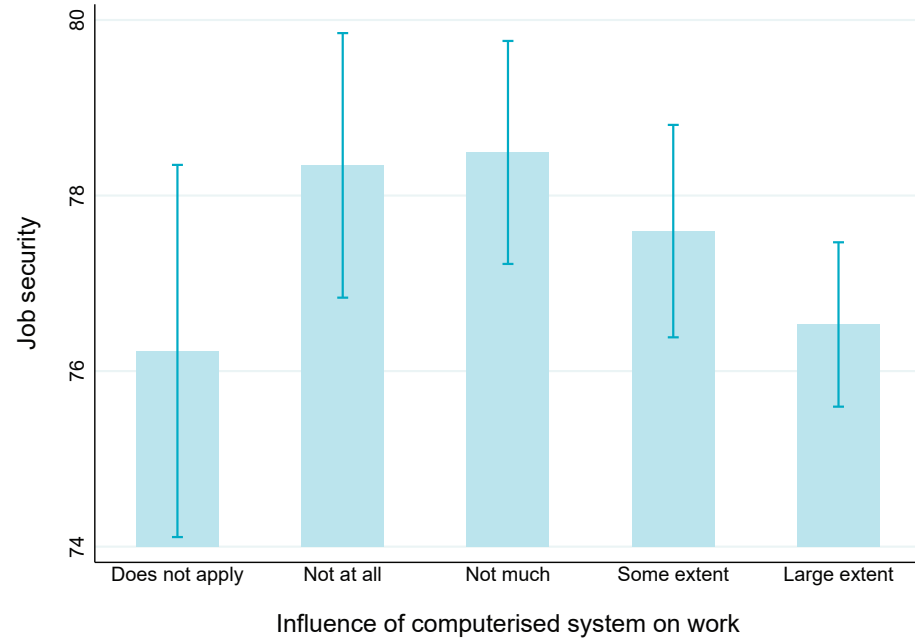
at work are then more likely than others to think that they could lose their job in the next six months. However, they are also more optimistic about their career prospects, particularly those exposed to computer influence to some degree (Figure 14). Nonetheless, it is not possible to tell from the available data whether this greater optimism about prospects and career development is related to a greater perceived employability – that is, greater likelihood of finding a new job, perhaps thanks to digital skills already developed in the current job – or to a view that digitalised jobs in general are likely to grow in the future.

Figure 12 Influence of computers and income predictability, EU27



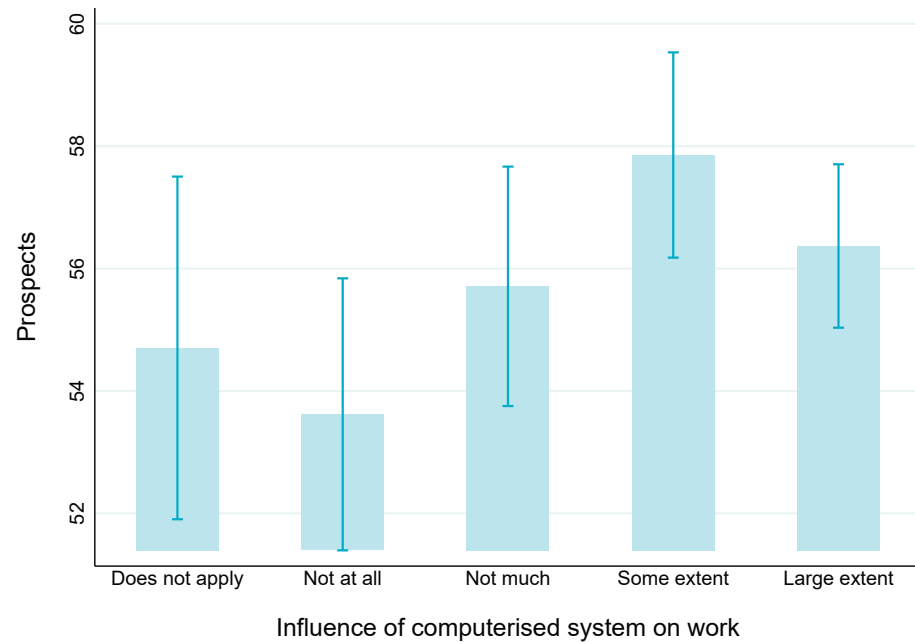
Note: predicted scores from regression analysis, with 95% confidence intervals, controlling for gender, age, employment status, detailed occupational group (2-digit ISCO) and country.

Figure 13 Influence of computers and job security, EU27



Note: predicted scores from regression analysis, with 95% confidence intervals, controlling for gender, age, employment status, detailed occupational group (2-digit ISCO) and country.

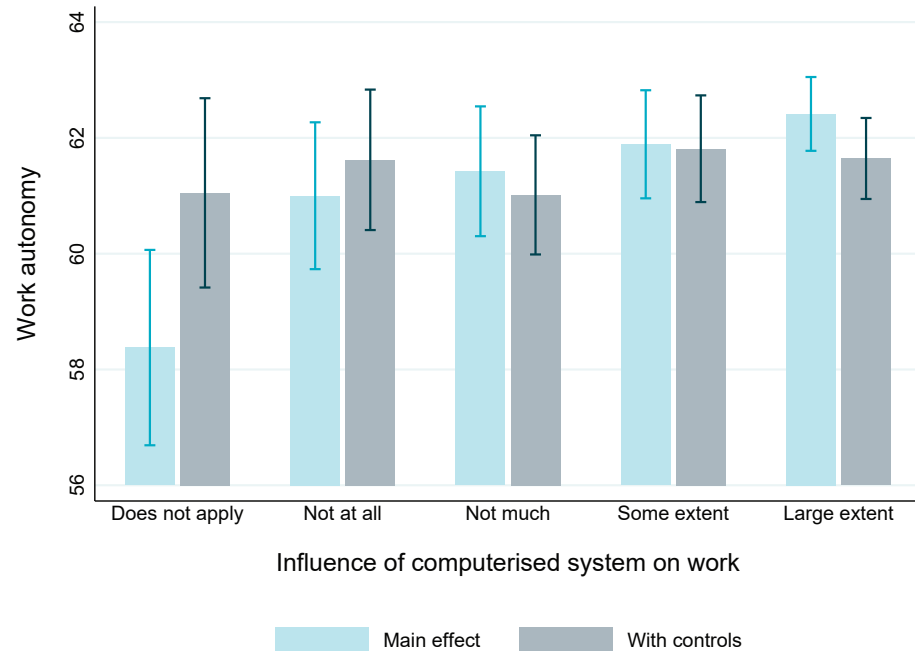
Figure 14 Influence of computers and job prospects, EU27



Note: predicted scores from regression analysis, with 95% confidence intervals, controlling for gender, age, employment status, detailed occupational group (2-digit ISCO) and country.

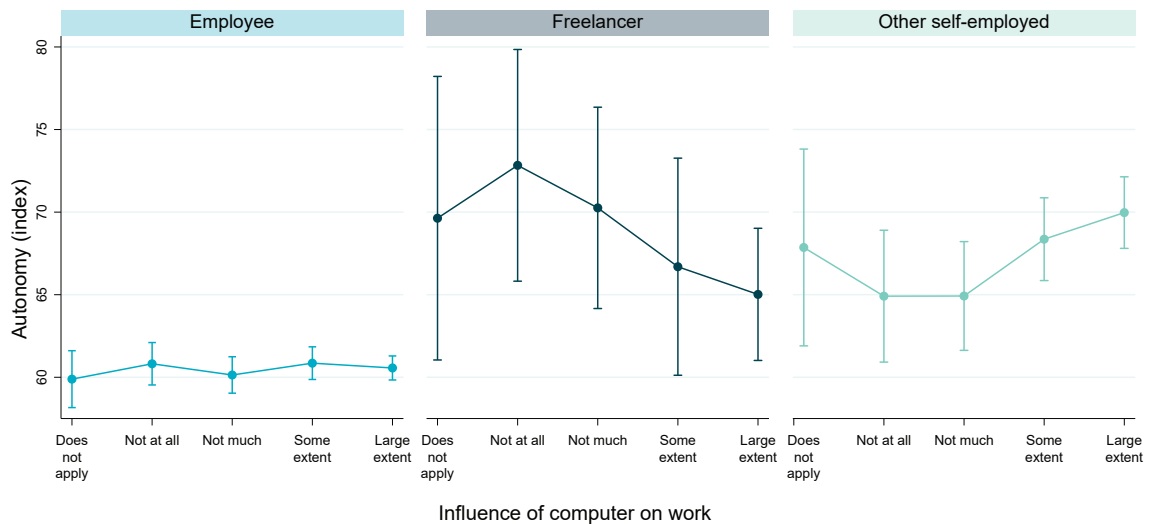
Another important area of influence of digital technologies is worker autonomy. As with earnings, we might expect compositional effects to play a role here, with computer use being generally more common among more autonomous professionals. This is indeed the case, as shown in Figure 15. Although the differences in the degree of autonomy at work are not large, workers strongly affected by computers at work have somewhat greater scope for autonomy. Interestingly, these differences disappear when compositional effects are taken into account. Therefore, while the development of new skills associated with digitalisation and perhaps more self-governing work models should in theory lead to more autonomous work, the influence of digital technologies also appears to be associated with increased scope for control, monitoring and managerial direction of work, all of which limit workers' autonomy. The results suggest that this is not the case for all workers, however, and in fact there is a significant interaction between employment status and the autonomy outcomes of digitalisation. This is shown in Figure 16. After controlling for compositional effects, employees do not show significant differences in their autonomy in relation to digitalisation. Among freelancers, however, there is a net negative impact of digitalisation on autonomy. This means that for this more vulnerable group of workers, which almost certainly includes bogus self-employed as well as platform workers, digitalisation of the work process leads to more control and subordination rather than to entrepreneurial liberation. Bearing in mind that freelancers are also more exposed to digital technologies at work (see Figure 2), this is a cause for concern. The opposite is true for other self-employed persons, a group including directors or managing partners who are self-employed. This generally less precarious group seems to be the only one to benefit from digitalisation in terms of increased autonomy.

Figure 15 Influence of computers and work autonomy, EU27



Note: predicted scores from regression analysis, with 95% confidence intervals, controlling for gender, age, employment status, detailed occupational group (2-digit ISCO) and country. 'Main effect' shows the average scores in the sample, while 'with controls' shows the average scores after accounting for the compositional differences.

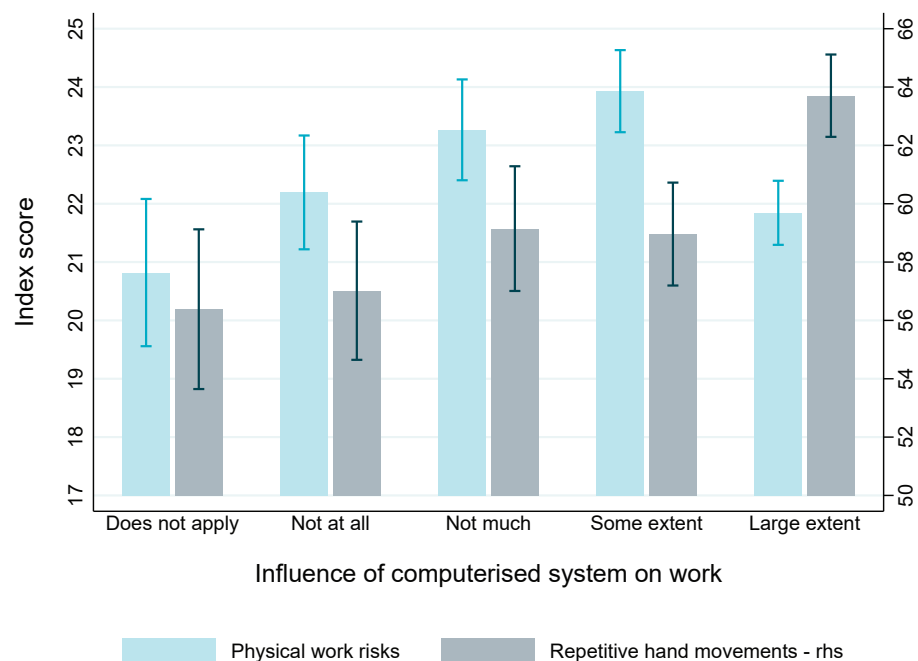
Figure 16 Influence of computers and work autonomy, by employment status, EU27



Note: predicted scores from regression analysis, with 95% confidence intervals. Controls: gender, age, employment status, detailed occupational group (2-digit ISCO) and country fixed effects.

Digital technologies have the potential to free workers, at least in part, from the drudgery of physically demanding or dangerous tasks. However, they also bring with them specific new risks, such as posture related or psychosocial risks. To analyse this impact, we first consider the relationship between digital technologies and more traditional physical work risks. The latter are calculated on an index of exposure to six factors, including noise, chemical substances, infectious materials, tiring or painful postures, lifting and moving people, as well as carrying or moving heavy loads. Higher scores on this index indicate higher exposure. A seventh risk factor, repetitive hand or arm movements, is considered separately as specific to computer use at work, and is measured in the same way, with higher values indicating higher exposure. Figure 17 shows that, contrary to expectations, low and moderate exposure to digitalisation is associated with more physical risk factors than no exposure. Only workers who are heavily influenced by computer systems report relatively good quality outcomes. However, they are most exposed to health risks associated with repetitive hand or arm movements, while workers in non-digitalised environments are least exposed to this particular risk factor. The use of technology to replace the most risky human activities therefore appears to be limited, on aggregate, with important trade-offs between traditional health risks and new risks specific to computer use.

Figure 17 Influence of computers and physical work risks, EU27

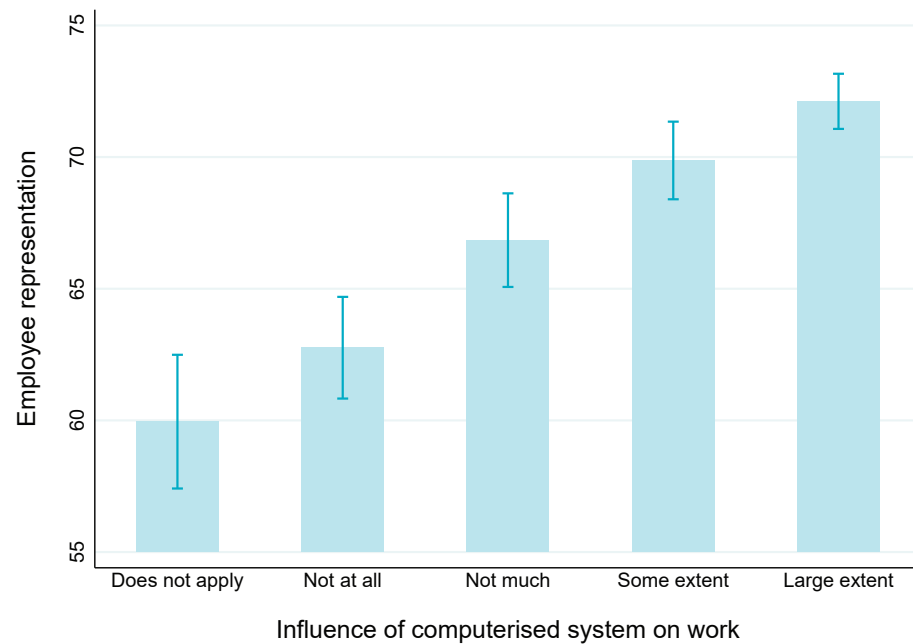


Note: predicted scores from regression analysis, with 95% confidence intervals, controlling for gender, age, employment status, detailed occupational group (2-digit ISCO) and country.

Finally, we examine whether workers in digitalised work environments differ in terms of access to support mechanisms provided by collective representation. This part of the analysis is necessarily limited to employees, thus excluding freelancers and other self-employed, as the latter are not expected to be included in employee

representation mechanisms and were not asked relevant questions in the EWCTS. Overall, access to representation and voice mechanisms has been associated with better job quality outcomes (for example, Piasna 2023b), which could potentially offer workers facing new challenges and risks related to digitalisation the opportunity to negotiate a more worker-centred path to digitalisation. The analysis shows that workers in jobs with greater exposure to computer systems have more access to different worker representation mechanisms (Figure 18). Holding compositional differences constant, increasing exposure to digitalisation goes hand in hand with increasing access to employee representation. While this is a positive finding in itself, we do not find any substantial differences with regard to how access to employee representation affects the various aspects of job quality analysed here in relation to the degree of computer exposure (results not shown).

Figure 18 **Influence of computers and employee representation at the workplace, EU27**



Note: predicted scores from regression analysis, with 95% confidence intervals, controlling for gender, age, employment status, detailed occupational group (2-digit ISCO) and country.

6. Summary and conclusions

The increasing use of digital technologies in European workplaces is undeniable, but its precise impact on the world of work remains to be determined. There is a growing consensus about digitalisation's transformative effects on the structure of employment. Research points to changes in the task content of jobs and the automation of some forms of human labour, accompanied by the emergence of entirely new occupations and job segments (Frey and Osborne 2013). But beyond the structural changes, what has been the impact on job quality and workers' experiences at work? What are the differences in job quality between digitalised and non-digitalised work settings in otherwise similar types of jobs? This working paper aims to address such questions by providing empirical evidence to test some of the presumed effects of technology that have been put forward in the literature.

The impact of digitalisation has been conceptualised on the basis of two theoretical approaches. One focuses on the impact of computerised systems and algorithmic management on working time, task allocation and work intensity; the other looks at digitalisation at work in terms of shifts in job demands and resources for workers. The impact on job quality was measured based on the multidimensional European Job Quality Index. The analysis covered the 27 EU Member States and was based on data from the 2021 EWCTS.

The results provide empirical underpinning to the claims about digitalisation's disruptive impact on existing time regimes at work. In particular, the analysis revealed that the effects of computerised systems on work include more unpredictable, hectic and intense work rhythms, as well as encroachment of paid work beyond its boundaries, longer working hours and a poorer work–life balance. All these effects were found for similar workers in similar jobs, one of the main differences being the extent of technology use and its influence in the work context. This is thus in line with the thesis that with digitalisation working time becomes more 'atomised' and 'punctuated', making it possible for employers to reduce paid work to a minimum and tightly link workloads to staffing levels. Workers fall in line and ensure reliability of labour supply by extending their availability, as postulated in Piasna (2023a).

Moreover, the analysis revealed a complex relationship between the penetration of computerised systems in the workplace and workers' resources and bargaining power. For example, once compositional and individual differences between workers are taken into account, digitalisation is associated with greater income security (measured as predictability of earnings) and better career prospects, but at the same time with less job security. This is consistent with the dissolution

of certain business models based on stable employment in favour of greater fragmentation, labour market mobility and precariousness (Rubery et al. 2016; Sundararajan 2016). However, the analysis presented in this paper shows that not only are these outcomes related to a structural transformation of labour markets, but that the technology-related difference is also observed for workers in otherwise very similar jobs. What is more, the results challenge the view that digitalisation generally leads to greater worker autonomy and show that any increase in worker discretion is the result of compositional factors rather than the direct impact of technology on their work. It is worrying that freelancers, considered to be a relatively vulnerable group, particularly exposed to working with new technologies, actually suffer autonomy losses as a consequence of digitalisation, as predicted by the platform-economy literature (De Stefano 2018; Piasna and Drahokoupil 2021).

Finally, the analysis sheds new light on the relationship between digitalisation and exposure to physical risk factors, as well as access to collective representation. While some traditional physical risks and demands are less common among workers who use computers at work, new risks specifically related to automation and prolonged use of personal computers are emerging in their place, raising the need for further scrutiny of these trends and appropriate regulatory responses. In contrast, a more optimistic picture emerges in terms of access to worker voice and representation, which increases as the intensity of computer influence on work increases. The direction of these relationships could not be determined using the available data, however. It remains to be seen, in other words, whether workplaces with more robust employee representation mechanisms are more likely to adopt new technologies, or whether access to new channels of communication in digitalised environments can foster a sense of shared identity and common interests among workers – as postulated by Vandaele and Piasna (2023) – and thus increase engagement and participation in formal channels of representation. Irrespective of the particular mechanisms in play, however, this shows that workers facing new challenges and risks associated with digitalisation may also have an opportunity to negotiate a more worker-centred path to digitalisation.

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