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Future-oriented occupations in the EU: main features, employment conditions, and job strain

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Table of Contents

1. Introduction

The way we work is changing due to developments associated with the digital and green transition as well as demographic change, as a driver of current and future labour shortages. As these transitions impact job content, tasks and processes, they will change how people work, the skills needed to carry out jobs, employment conditions, and, ultimately, dimensions of their job quality. These transition-related changes in occupations are of high relevance for workers, job applicants, and students training to join these occupations, as well as stakeholders, and policy makers, at the sectoral, national, and European levels. While their impacts are separately treated in this analysis, the green and digital transitions can further exacerbate labour shortages given the skill profiles required by related occupations.

Overall, this paper aims to shed light on job holder profiles, their employment conditions, and some aspects of job quality experienced by workers in occupations of relevance for these transitions. It looks both at job groups relevant for one single transition, which are termed 'occupations of interest', and relevant for two or more of the three transformations, which are defined as 'future-oriented' occupations. Furthermore, as part of the digital transition, we also specifically consider occupations more likely to be exposed to the impacts of AI. Thereby the analysis aims to provide an early indication of the types and characteristics of jobs and subgroups of workers that may be affected by these technological advances. The occupational category related to exposure to AI will be treated separately from the other categories, as it has emerged recently, but can still provide insights into the level of occupational change expected in the near future.

The specific step-by-step objectives of this paper are to:

- Identify 'occupations of interest' relevant to either digitalisation, greening, or labour shortages;
- Construct groups of 'future-oriented occupations' by looking at the intersection between occupations of interest that are relevant for two or more of these transformations;
- Analyse the workforce characteristics of current job holders and their employment conditions;
- Investigate dimensions of job quality in these groups of occupations, as well as the quality of working life for their workers; and
- Summarise findings for 'future-oriented occupations' and lessons learned.

Using the 2021 European Working Conditions Telephone Survey (EWCTS)[1] and 2021 EU Labour Force Survey (EU-LFS) data, this paper analyses the job quality, employment conditions, and demographic characteristics of workers in occupational groups of interest and those identified as 'future-oriented occupations'. 2021 data are used to create a (occupation) group summary that can include jobs within the same occupation that have, for example, different levels of digitalisation. Summary groups allow a clearer understanding of very diverse situations and support an assessment of the main issues at stake.

Demographic change is a driver of labour shortages and, as a result of population ageing, it also increases the need for greater labour market activation and/or potentially attracting workers from abroad. Job quality is a multidimensional concept and there is no agreed upon definition or standardised way of measurement of job quality, with different approaches emphasising different dimensions. Dimensions of job quality in a context of population ageing, digitalisation, and the green transition are becoming more relevant.

This paper will analyse data collected by the EWCTS, which covers six dimensions stemming from Eurofound's job quality index (see Section 5) based on the OECD Job Quality Framework, as well as additional factors considered important for and associated with job quality, such as access to and participation in training. The measurement of job quality considers characteristics of work and employment which have a proven causal relationship, positive or

([1]) Sample sizes across countries ranges from 1,000 to 4,200 interviews which enables high quality European-level estimates.

negative, on health and well-being, as proven by epidemiological studies. Analyses of the European Working Conditions Survey (EWCS) have confirmed the strong association of job quality with health and well-being, work-life balance, financial security, skills match, engagement, and social climate, as well as willingness and ability to work until 60 years of age (Eurofound, 2012; Eurofound, 2017; Eurofound, 2022). Although considered an important element of job quality, this report does not cover wages.

Overall, understanding job quality dimensions, employment conditions, and demographics of workers in future-oriented occupations can yield lessons for boosting employment in jobs likely to be crucial for the medium to long-term transformation of the European Union (EU) economy, as well as fostering more balanced and inclusive labour market participation. By identifying the specific challenges associated with future-oriented occupations, the analysis presented in this paper can support the transformations.

At the policy level, several steps have been taken to tackle labour shortages, improve gender equality, and support the digital and green transitions. This includes the European Commission (2024a) Action Plan to tackle labour and skills shortages adopted on 20 March 2024 in particular focuses on "supporting underrepresented people to enter the labour market", "providing support for skills, training and education", "improving working conditions", as well as "attracting third country nationals from abroad".

This paper is structured as follows:

- In the second section, occupations of interest and future-oriented occupations are identified;
- In the third section, the socio-demographic characteristics of current job holders in these occupations are presented;
- In the fourth section, the employment conditions and, in the fifth section, the various dimensions of job quality for occupations of interest and future-oriented occupations are analysed, together with specific challenges; and
- In the sixth section, the paper closes with conclusions and policy lessons.

2. Defining future-oriented occupations and occupations of interest

In this section, we first construct occupations of interest which are relevant to either the digital or green transition, or experience persistent labour shortages. These occupations are identified on the basis of the International Standard Classification of Occupations (ISCO-08) 4-digit level. Then future-oriented occupations are identified, which are at the intersection of digital jobs, green jobs, and labour shortages.

The International Standard of Classification (ISCO)

The ISCO is a classification scheme of occupations developed by the International Labour Organisation that supports the international comparison of occupations.

A *job* is defined as "a set of tasks and duties performed, or meant to be performed by one person, including for an employer and in self-employment". An *occupation* refers to the kind of work performed in a job and is defined as a "set of jobs whose main tasks and duties are characterized by a high degree of similarity". *Skill* is defined as the "ability to carry out the tasks and duties of a given job". Two dimensions of skills are considered in ISCO: skill level and skill specialisation.

ISCO is organised hierarchically: each of the 10 major groups (denoted by a 1-digit code) is made up of one or more sub major groups (ISCO 2-digit code), which in turn are made of one or more minor groups (ISCO 3-digit). The 130 minor groups are made of one or more unit groups (ISCO 4-digit). Each group in the classification is designated by a title, a code, and is associated with a description that specifies the scope of the group.

Table 1. Overview of groups and skill level of ISCO 08 classifications of occupations

Major groups	Sub major groups	Minor groups	Unit groups	Skill level
1 Manager	4	11	31	3 and 4
2 Professional	6	27	92	4
3 Technicians and Associate professionals	5	20	84	3
4 Clerical Support workers	4	8	29	2
5 Service and Sales Workers	4	13	40	2
6 Skilled Agricultural, forestry and fishery workers	3	9	18	2
7 Craft and related workers	5	14	66	2
8 Plant and Machine operators, and Assemblers	3	14	40	2
9 Elementary Occupations	6	11	33	2
10 Armed forces	**3**	**3**	**3**	**1,2 and 4**
Total number of groups	**43**	**130**	**436**	

2.1 Occupations of interest

The creation of occupational categories of interest is based on prior scoping of how to best classify categories of occupations that are, or will become, relevant for the EU economy and the digital and green transitions. As a result, 4 categories of occupations of interest are considered (Figure 1). As noted, the occupational category of exposure to AI will not be dealt within the digital occupations, as it emerged recently, and it will be presented as a separate category.

Figure 1: The four occupational categories of interest as the starting perspective

2.1.1 Digital occupations: digital skills intensity by occupation

This paper uses the Digital Skills Intensity Index by Barslund (European Commission, 2022) to classify occupations in the EU with different levels of digital skills intensity. This Index measures the average number of digital skills used by a worker, based on their ISCO classification. The Index measures the proportion of digital skills among all skills required for each occupational group at ISCO 3-digit level[2]. For example, if an occupation requires 10 skills and one of those skills is digital, the Index value is 10%.

This approach gives a useful approximation of the proportion of work requiring digital skills and competences, yet it also has some limitations. For instance, it does not indicate the importance of digital skills in carrying out a given occupation, the level of those skills (basic or advanced), nor how often they are used at work.

This paper classifies occupations with an Index value of 10% or greater[3] as having higher digital skills intensity. Other recent definitions identify similar occupations as highly digitally intensive, but with several differences in how occupations compare. Occupations with an Index value of less than 10% but greater than 0% are classified as having intermediate to low digital skills intensity[4].

(2) The ESCO classification system contains descriptions of approximately 3,000 occupations and more than 13,000 different skills and competences in the EU Member States. To create the Digital Skills Intensity Index, EU-LFS data are linked to ESCO through the ISCO occupation code classification system. The ESCO classification system is then harmonised with the DigComp Framework, allowing to identify digital skills among the 13,000 different skills.

(3) Based on Barslund's narrow definition (European Commission, 2022).

(4) This means that occupation with no digital skills are not included in this group.

Exposure to AI: AI Occupational Impact Exposure (AIOE) scores

The digital transition allows for AI to reshape labour markets extensively, such as by changing work content, workflow processes, job tasks, and by automating jobs to varying degrees. The concrete effects of AI on jobs are on-going and have not fully materalised yet. The forecasted impact on labour markets caused by AI and machine learning has been found to vary. Studies investigating effects present different conclusions. Cazzaniga et al. (2024) find that almost 40% of global employment is exposed to AI, and a recent study conducted by the OECD (2023) suggests that 27% of jobs in OECD countries rely on skills that could easily be automated by AI in the future[5]. Felten et al. (2019) found that occupations impacted by AI experience, on average, positive changes in wages, but no significant shift in employment. While job losses are theoretically possible, these are not inevitable. However, overall, jobs will evolve requiring new skillsets, which will affect workers differently and will depend on their demographic characteristics, job sectors/occupations, and skillsets.

Felten et al. (2021) categorise AI applications using the Electronic Frontier Foundation's AI Progress Measurement project and link them to O*NET data. This forms the basis for the AIOE measure, using 10 selected AI applications[6]. These applications represent fundamental and likely scenarios of AI use affecting the workforce. The AIOE studies the characteristics of occupations with varying exposure to AI by linking the selected AI applications to workplace abilities and occupations. According to Felten et al. (2019), occupations most exposed to AI advancements, according to the AIOE, primarily involve white collar roles requiring advanced degrees, such as financial examiners and actuaries. Conversely, when focusing on occupations with an AIOE of lower than 1, some of less exposed jobs involve a substantial degree of manual labour.

This paper analyses the workforce, employment, and job quality characteristics of jobs with a higher exposure to AI. While the occupations analysed may not yet be impacted by the spread of AI, the aim is to gain an understanding of the types of occupations and the demographic of workers potentially impacted by greater exposure to AI. This research focuses on 98 occupations with an AIOE higher than 1. By exclusively concentrating on occupations scoring above 1, the objective is to spotlight those occupations that are currently, or soon will be, most susceptible to the rapid influence of AI.

Most of the "AI-exposed" occupations are found in the occupational groups of professionals (ISCO2), technicians and associate professionals (ISCO3), then managers (ISCO1) and clerical support staff (ISCO4).

2.1.2 Green occupations: new and emerging, enhanced, and increased demand[7]

The impacts of the green transition on the labour market are widely expected to yield more jobs, but also to require substantial shifts in education and training to equip workers with the necessary skillsets. Crucially, not all groups of workers will be affected by these shifts in the same way.

([5]) Jobs at highest risk were defined as those using more than 25 of the 100 skills and abilities that AI experts consider easily automated.

([6]) The 10 selected AI applications are abstract strategy games, real-time video games, image recognition, visual question answering, image generation, reading comprehension, language modelling, translation, speech recognition, and instrumental track recognition.

([7]) To note that the approach presented in this paper should not be taken as the Commission approach to measure green jobs, which is still in an exploration phase.

Recent estimates suggest that policies under the scope of the European Green Deal are expected to have net positive effects on employment[8]. The EU's commitment to reach climate neutrality by 2050 was enshrined in the European Climate Law, adopted in July 2021. The Employment and Social Developments in Europe (ESDE) 2023 report notes that, if supported by the right employment and education policies, by 2030, net-zero policies could create between 884,000 (Asikainen et al., 2021), one million (European Commission, 2020) and 2.5 million (Cedefop, 2021) jobs in some sectors. While net positive employment effects are widely forecast, job losses are expected in certain industries as well, such as those that are carbon-intensive and encompass the automotive sector and the production of steel and iron.

Over the years, various definitions of green jobs have emerged. At present, an agreed definition is missing. Green jobs can thus be defined in relation to a specific sector or their activities across sectors, to green products and services, or to environmentally friendly processes, and should provide 'decent' employment (International Labour Organization (ILO), 2016). While the concept of 'green' is particularly pertinent to jobs in sectors with an environmental purpose, activity-based definitions of green jobs risk focusing on an overly narrow area of the economy. Other approaches thus investigate decarbonisation through the greening of their tasks or through workers, who need green skills to perform these tasks.

This paper follows the so-called 'greening task-based' approach. More specifically, "the greening of occupations refers to the extent to which green economy activities and technologies increase the demand for existing occupations, shape the work and worker requirements needed for occupational performance, or generate unique work and worker requirements" (Dierdorff et al., 2009 and 2013). This approach has been widely used in recent research on green jobs (European Commission, 2019; Maldonado et al., 2024; OECD, 2023a; OECD, 2024). It builds on the O*NET, an online database that provides occupational definitions, supported by the United States (US) Department of Labour. The O*NET database identifies the tasks required in any given occupation and classifies those tasks as green or non-green. Its approach is unique, as green occupations may require a mix of green and non-green tasks, making 'green' a continuum rather than a binary distinction. The O*NET classification counts any occupation that will be affected by greening as a green job and considers three summary categories (Hancké & Bowen, 2019):

- **New and emerging green jobs** are unique jobs (defined by worker requirements) created to meet the new needs of the green economy. This new occupation can be entirely novel or 'born' from an existing occupation (e.g. fuel cell engineers);
- **Green enhanced skills jobs** are existing jobs that require significant changes in tasks, skills, and knowledge as a result of greening (e.g. electric vehicle electricians); and
- **Green increased demand jobs** are existing jobs that are expected to be in high demand due to greening, but which do not require significant changes in tasks, skills, or knowledge. The work context may change, but the tasks themselves do not (e.g. bus drivers).

To analyse these occupational categories of O*NET, SOC 2010 was transposed to the ISCO 2008 classification. In the process, some ISCO occupations were identified as clearly non-green, and these were removed manually. Limitations of the green task-based approach to measuring green jobs include the time lag between evolving green technologies and practices used within occupations and the O*NET database. For example, fast paced advances in solar photovoltaic technology affect how these are produced, installed and maintained. Also, supplementary contextual information can be needed to determine whether a task is related to greening the economy (such as for instance repair tasks) and hence the granularity of a task-based approach leaves room for subjective interpretations regarding classifications.

([8]) The EU's commitment to reach climate neutrality by 2050 entails a shift to cleaner production modes. It was enshrined in the European Climate Law adopted in July 2021. The European Green Deal Industrial Plan and the Net Zero Industrial Act were introduced to accelerate this process.

2.1.3 Critical labour shortages today and tomorrow

Examining the job quality dimensions and employment conditions in occupations facing persistent labour shortages has become a focal point for researchers and policymakers amidst recent historically low unemployment rates and tight labour markets during the COVID-19 recovery in the EU economy. Recent research has increasingly focused on job strain, employment conditions, and demographic dimensions of labour shortages as drivers of tight labour markets.

Labour shortages typically arise when the demand for workers qualified in a particular occupation or sector exceeds the supply. There is no universally agreed methodology to measure labour shortages in the EU, leading to different institutional actors and reports adopting various approaches. The European Commission's Business and Consumer Survey (BCS) collects quarterly survey data by asking employers whether labour is a major factor limiting their production. Eurostat's job vacancy statistics also shed light on labour demand in sectors. However, a drawback of using job vacancy statistics is that they reflect demand for labour but do not distinguish between job vacancy rates driven by high turnover or by labour shortages. In addition, data availability is limited. EU-level data is available only since 2012 and data is missing for certain Statistical Classification of Economic Activities (*Nomenclature statistique des activités economique,* NACE) sectors. ISCO 4-digit level breakdowns are also not covered. The European Labour Authority (ELA) identifies labour shortages across occupations by Member States based on occupational classifications. Despite certain limitations, such as differences in geographical scope and reference periods used across years, this methodology provides information about labour shortages at the most disaggregated occupational levels.

This paper uses the list of critical labour shortage occupations at EU level identified for the proposal of an EU Talent Pool (European Commission, 2023a). To identify shortage occupations at EU level that persist over the medium term (2017-2022) at ISCO 4-digit level, this list records occupations indicated at least twice and included at least once since the COVID-19 pandemic, in ELA and European Commission reports. The list likewise identifies widespread labour shortages in the context of the transition to net-zero emissions and digitalisation, based on the sector's direct contribution to the implementation of EU climate and digitalisation targets[9].The EU Talent Pool list of critical labour shortage occupations also includes occupations that were not previously in a state of widespread shortage but with possible shortages in the future due to their active role in the acceleration of greening activities. These include, for example, environmental engineers.[10]

To construct future-oriented occupations, occupations in the finalised list of critical current and future labour shortage occupations (European Commission, 2023a) were compared for overlap with those occupations classified as green, as well as those with high and intermediate to low digital skills intensity. Therefore, the list of (residual) labour shortages features critical occupations at EU level not overlapping with these categories of occupations. These are primarily related to long-term care, hospitality, and construction related to the green transitions (e.g. bricklayers).

2.2 From occupations of interest to future-oriented occupations

In order to next construct future-oriented occupations, each identified occupation was mapped against the groups of occupations of interest. In general, with the exception of jobs exposed to AI, occupations which belonged to more than one group then joined a new future-oriented occupations group. Therefore, if an occupation of interest belonged to two groups, it was added to a new group. For the occupational groups with high digital skills intensity

(9) The EU Commission's Digital Decade policy programme encompasses concrete targets and objectives for 2030, guiding Europe's digital transformation. To deliver the EU Green New Deal, the EU Commission also sets long-term targets for climate neutrality by 2050.

(10) To identify occupations with labour shortages in the sectors relevant for the twin transitions, employment data from EU-LFS 2021 were used to map occupational information (at ISCO-08 3-digit level) by sector (NACE 1-digit). In each sector, occupations were filtered based on their employment rate share, and different thresholds were applied to indicate the prevalence of an occupation (80th, 90th and 95th percentile). The final list includes only occupations whose parent groups (ISCO-08 3-digit level) are either prevalent in at least two sectors of interest, and/or fall in the 95th percentile of occupational employment rate in a sector of interest.

and medium to low digital skills intensity, if an occupation included on the list belonged only to this group, it was at the same time also left in its origin group. Therefore these occupational groups of interest remained unchanged. Critical labour shortage and green occupations joined the occupations of interest list if they overlapped and were removed from their original groups.

In total, six groups of future-oriented occupations are identified, alongside the four net (e.g. residual) occupations of interest, with details reported in Table 2:

- Green in-demand intermediate to low digital occupations (GDDI)
- Green enhanced tasks intermediate to low digital occupations (GEDI)
- Green new intermediate to low digital occupations (GNDI)
- Current labour shortages in digital occupations (LST-D)
- Green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills intensity (LST-LSF-GD)
- Green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills intensity (LST-LSF-GNE)

A description of these groups is available in Table 2.

Table 2. Proportion and description of future-oriented occupations and (residual) occupations of interest, based on the 2021 EWCTS

	Proportion of the workforce (%) EU27, 2021)	Examples of occupations in the group	Description
Future-oriented occupations			
Green occupations with increased demand and intermediate to low digital skills intensity (GDDI)	7% of current jobs	3359 – Regulatory government associate professionals 9333 – Freight handlers 6111 – Field crop and vegetable growers 7421 – Electronics mechanics and servicers 8344 – Lifting truck operators	35 occupations Jobs in this category belong to most occupation groups except for 1, legislators, and 5, service and sale workers. Group 2, professionals, and group 9, labourers, are only represented by one occupation each
Green enhanced occupations with intermediate to low digital skills intensity (GEDI)	6% of current jobs	1120 – Managing directors and chief executives 1221 – Sales and marketing managers 2412 – Financial and investment advisers 8211 – Mechanical machinery assemblers	34 occupations Occupations mostly found in ISCO group 1, legislators 2, professionals and 3, technicians and associate professionals, and to a lesser extent group 7, craft and related workers, and 8, plant and machine operators, and assemblers
Green new and emerging occupations with intermediate to low digital skills intensity (GNDI)	5% of current jobs	3322 – Commercial sales representatives 2421 – Management and organization analyst 2149 – Engineering professionals 3339 – Business services agents 2422 – Policy administration professionals	20 occupations Occupations mostly belong to groups 2, professionals and 3 technicians and associate professionals

		1219 – Business services and administration managers	
Labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D)	3% of current jobs	5321 – Health care assistants 2411 - Accountants 2514 – Applications programmers 7511 – Butchers, fishmongers and related food preparers 2511 – System analysts	8 occupations Mostly belong to group 2, professionals, but also include occupations where delivery, and documentation needs have been impacted by digitalisation
Green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD)	4% of current jobs	8331 – Bus and tram drivers 7115 – Carpenter 7212 – Welders 7412 – Electrical mechanic	12 occupations Mostly belong to the occupational group 7, craft and related workers
Green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE)	6% of current jobs	8332 – Heavy truck and lorry drivers 7231 – Motor vehicle mechanics and repairers 7411 – Building and related electricians 7126 – Plumbers and pipe fitters 2142 – Civil engineers	13 occupations Mostly belong to groups 7, craft and related workers, 2, professionals, and 3, technicians and associate professionals
Occupations of interest (residual groups)			
Occupations with higher digital skills intensity (DH)	2% of current jobs	3512 – Information and communications technology user support technicians 3513 – Computer network and systems technicians 1330 – Information and communications technology service managers 2522 – Systems administrators	15 occupations Mostly belong to groups 2, professionals, 3 technicians and associate professionals
Occupations with intermediate to lower digital skills intensity only (DI)	32% of current jobs	2330 – Secondary education teachers 5223 – Shop sales assistants 8322 – Car, taxi and van drivers	169 occupations Cover most occupational groups, most belong to groups 3, 7, and 2
Green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED)	7% of current jobs	5221 – Shop keepers 1420 – Retail and wholesale trade managers 1213 – Policy and planning managers	36 occupations Mostly in group 1 legislators, 6 skilled agricultural workers and 9 elementary workers

Critical labour shortage occupations, current and future, excluding occupations relevant to green and digital transitions (LST)	6 % of current jobs	7112 – Bricklayers and related workers 2211 – Generalist medical practitioners 9112 – Cleaners 5131 – Waiters 5120 – Cooks 5321 – Personal care workers in health services 2212 – Specialist medical practitioners	7 occupations

Overall, it is found that the digital transition, green transition, and labour shortages are affecting the work performed by about 8 out of 10 of total workers. A total of 32% of workers in 2021 are found to be working in future-oriented occupations, meaning that they are of relevance to two or more of either current or future labour shortages, the ongoing digital transition and/or the green transition, while 47% of workers were in residual occupations of interest (Table 2). All together future-oriented occupations and (residual) occupations of interest are found to account for 79% of total employment, indicating the high relevance and impact of the transitions on the labour market. This probably constitutes a lower estimation, as the dual transitions continue to take their course and several positions in labour shortage occupations are likely to remain open. Furthermore, within this, 28% of jobs are found to be in AI-exposed occupations.

Future-oriented occupations cover 60% or more of workers in the occupational groups of craft and related workers, plant and machine operators, and a third or more of workers in managers, professionals, technicians and skilled agricultural workers. The highest proportion of future-oriented occupations are found in construction and transportation and storage (both 59%), industry (51%), and agriculture (37%). 50% or more of workers in the occupational groups of technicians, managers, and skilled agricultural workers belong to (residual) occupations of interest. The highest proportion of (residual) occupations of interest can be found in health and commerce (both 60%), financial services (58%) and agriculture (56%). The impact of AI-exposed occupations is identified to be highest for professional managers, technicians, and clerical workers. These figures highlight the transformative impact of the transitions on jobs.

Out of the future-oriented groups that are found to account for nearly one third of jobs, all except for digital occupations experiencing labour shortages (LST-D) are made of occupations of relevance for the green transition. About 40% of the future-oriented occupations include occupations experiencing shortages, suggesting that labour shortages could remain a policy concern in the years to come, in the context of the implementation of the dual transition and demographic ageing.

Occupations exposed to AI

Felten et al. (2021) developed the AI Occupational Exposure (AIOE), which studies the characteristics of occupations with varying exposure to AI by linking specific applications of AI to workplace abilities and occupations. This paper focuses on occupations with a higher-than-average AIOE (1 or more). Occupations with an AIOE over 1, based on EWCTS, account for 27% of current employment in the European Union.

Within this selected cohort, certain occupations emerge with notably lower exposure to AI. Legal secretaries (ISCO code 334) and receptionists (ISCO code 422) are all professions where the influence of AI is comparatively subdued. Recognising the spectrum of AI exposure helps understand the varied landscapes of job vulnerability and adaptation in an evolving technological era.

In the evolving labour market, certain occupations can be significantly impacted by the growing use of AI in the workplace. Finance and health professionals are among those likely to face heightened exposure to AI. Occupations with the highest AIOE includes health service managers (1342), medical secretaries (3342), financial managers (1211), and budget analysts (2411). Within this context, the health sector stands out as one of the 35 widespread shortage occupations. Similarly, mathematicians both have higher exposure to AI (AIOE of 1.516) and are also part of occupations characterised by higher digital skills intensity. As workers navigate the intricacies of AI integration into various fields, understanding these dynamics becomes crucial for informed decision-making and proactive adaptation within these professions.

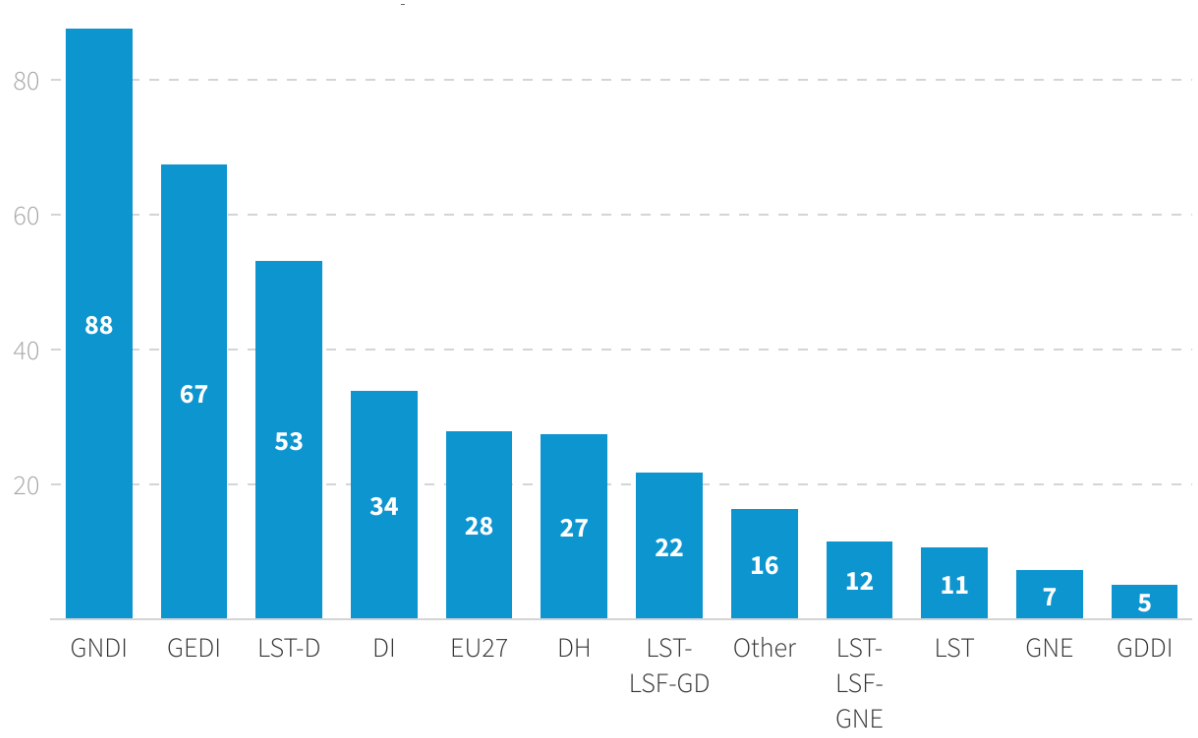
Table 3. Proportion and description of AI-exposed occupations, based on the 2021 EWCTS

	Proportion	Examples of occupations	Description
Occupations exposed to AI	28% of current jobs	4110: general office clerks 3322: commercial sales representatives 2330: secondary education teachers 4120: secretaries – general 2411: accountants 2310 university and education teachers	Occupations with a AIOE Index of 1 or above. 98 occupations About 60% belong to group 1, managers, and group 2, professionals. Above 50 % are found in group 3, clerical support workers, and above a third in group 4, technicians and associate professionals

Overall, about a fifth of occupations are found to be exposed to changes due to AI. According to EWCTS 2021 data, most AI-exposed jobs are currently in financial services (70%), education (41%), other services and public administration (both 39%) and 22% of jobs in health and construction are also likely to be impacted by the increased use of AI. Similarly, Felten et al. (2021), when ranking occupations by their reliance on abilities that are likely to be affected by advances in AI technology, find that financial services, accounting, insurance, and legal services are most exposed. On the other hand, they identify industries involving more manual labour as less exposed.

A simulation of the impact of AI on future-oriented occupations and (residual) occupations of interest (see Figure 2) suggests that AI will strongly impact the following future-oriented occupations: less digitally intensive new (88%), and enhanced (67%) green jobs, digital occupations experiencing labour shortages (53%) and job with intermediate/lower digital skills intensity (34%). This reinforces the need to monitor developments in these three futures-oriented groups of occupations. On the other hand, AI is least anticipated to impact less digitally intensive green jobs with increased demand, which encompasses manual labour-intensive green jobs. An example of a job in the category could be electricians needed for solar panel installations.

Figure 2. Likely impact of AI on future-oriented occupations and (residual) occupations of interest



Source: EWCTS 2021.

After having constructed our groups of occupations of interest based on the intersection between the digital, green, and labour shortages, we examined the workforce characteristics of current job holders.

3. Workforce characteristics across identified occupations

In this section, the gender and age of current job holders in future-oriented occupations and occupations of interest are considered drawing on EWCTS and LFS data.

Overall, gender segregation in the identified occupations is considered high, confirming the need to continue policy actions that support gender equality at work. Age participation across occupations of interest is more balanced across age groups, except in the group of occupations experiencing labour shortages. The age distribution of workers impacted by the dual transition confirms the relevance of work organisation practices that support learning. This reinforces the need to ensure that lifelong learning is available and can be organised in such a way that it accommodates workers in busy stages of their life course, where they might combine paid work with younger and older relatives' care.

3.1 Gender segregation concerns most future-oriented occupations and (residual) occupations of interest

The European Union supports higher gender equality. Indeed, Article 8 of the Treaty states that "in all its activities, the Union shall aim to eliminate inequalities, and to promote equality between men and women". The current Gender Equality Strategy (2020-2025) indicates in its first paragraph that "in business, politics and society as a whole, we can only reach our full potential if we use all of our talent and diversity. Gender equality brings more

jobs and higher productivity – a potential which needs to be realised as we embrace the green and digital transitions and face up to our demographic challenges". This implies, inter alia, achieving more balanced participation across different sectors of the economy.

Previous research on labour shortages (European Commission, 2023b; Eurofound, 2023a), green jobs (Eurofound, 2022; OECD, 2024) and digital jobs (EIGE, 2018) have identified strong gender segregation in occupations of relevance to digitalisation, decarbonisation, and labour shortages.

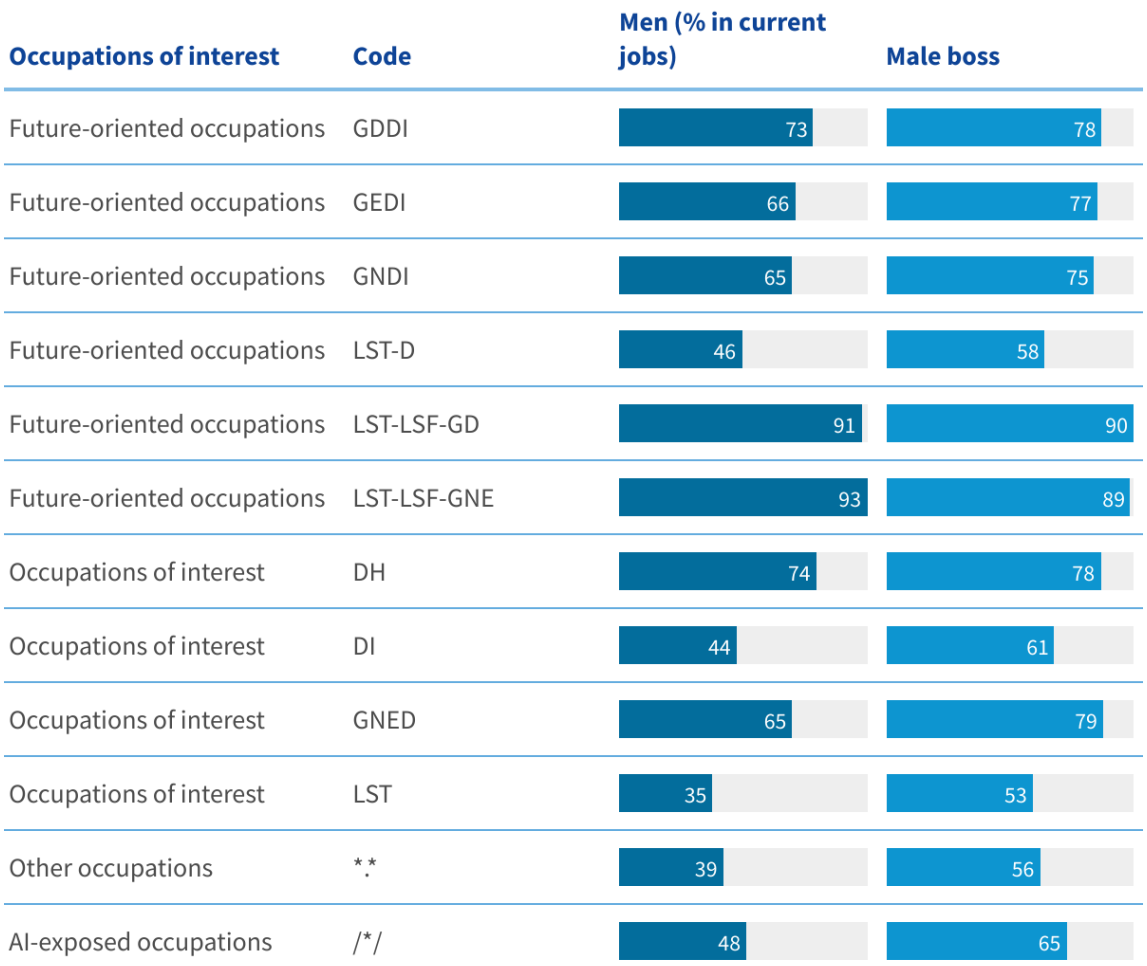
In terms of the demographic characteristics of workers in persistent labour shortage occupations, the ESDE (2023) report found that only 14% of occupations facing shortages are gender-balanced, with men accounting for most workers in certain labour shortage occupations, such as in the field of science, technology, engineering, and mathematics (STEM), and women making up the most workers in shortage occupations in healthcare. Recent research also highlights that the scarcity of healthcare and ICT professionals was exacerbated by the COVID-19 pandemic (Eurofound, 2023a). Within the ICT sector, shortages stemmed primarily from a lack of foresight in hiring practices and ineffective alignment between skills availability and demand, with the underrepresentation of women worsening the issue.

As highlighted by ESDE 2023, ICT occupations are by far the most digitally intensive forms of work in the EU, with one-third of ICT professionals' skills being digital. However, they have an underrepresentation of women and older workers, who tend to work in occupations with lower digital intensity (European Commission, 2023). Brussevich et al. (2018) found that, on average, women perform more tasks that are prone to automation by digital technologies, placing a larger portion of the female workforce at a higher risk of automation impacts. Similarly, Cazzaniga et al. (2024) note that women could disproportionately be affected due to their overrepresentation in sectors more exposed to AI. A report by the Organisation for Economic Co-operation and Development (OECD) also highlights that the green transition could risk being gender imbalanced (OECD, 2024). Using green-task jobs at the level of occupations, based on the greenness of their task content (Vona et al., 2019) and O*NET classifications for over 900 occupations providing a taxonomy of their 'greenness' (Dierdorff et al., 2009), it explored the socioeconomic characteristics of task-based green jobs. The report states that the green transition is likely to include pronounced gender segregation within occupations, with women underrepresented in green-task jobs, and making up just 28% of those jobs.

LFS 2021 data confirms that amongst (residual) groups of interest, occupations with higher digital skills intensity are more male-dominated, while, in contrast, a slightly higher share of women are employed in occupations with intermediate to low digital skills intensity. On average, green occupations of interest are also more male-dominated, in particular green occupations with increased demand. Similar to recent findings on the gender dimension of the green transition (OECD, 2023), the (residual) categories of green occupations employ a higher share of men. On the other hand, critical labour shortage occupations have a higher share of women on average (nearly two in three workers), with women particularly being overrepresented in jobs relevant to care work and men overrepresented in construction-related occupations. Future-oriented green new, enhanced, and in-demand occupations experiencing labour shortages with intermediate to low digital skills intensity are almost exclusively taken up by men. This raises the issue of women's labour market participation in these jobs, both to increase the labour market participation generally, and to ensure an inclusive digital and green transition.

As indicated by Figure 3, most future-oriented occupations are male-dominated, with a proportion of men in employment being above 60%. In this group only labour shortage occupations with higher to lower digital skills intensity (including occupations such as programmers and accountants) are more gender-mixed. Residual digitally intensive and green jobs are male-dominated, while residual labour shortage occupations (encompassing jobs such as cleaners, nurses, and care workers) are female-dominated. In all future-oriented occupations with the exceptions of digital occupations experiencing labour shortages (LST-D), the proportion of male managers is also higher than the average at EU level (66%).

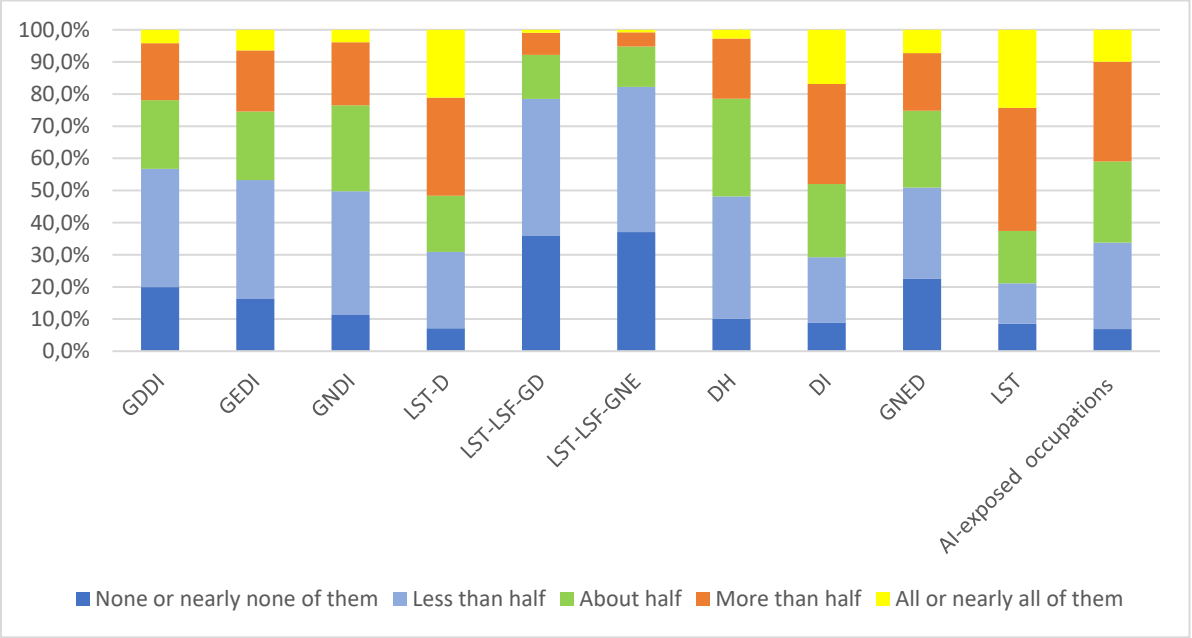
Figure 3. Gender segregation in future-oriented occupations and (residual) occupations of interest, by gender, EU27



Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations.

A further dimension of gender segregation at work is assessed by the proportion of men and women in a specific (e.g. that of the respondent) workplace (see Figure 4). This can be illustrated by the example of hairdressers, which on average are gender-mixed, whereas most male hairdressers work in barber shop and female hairdresser in salons. A similar picture of gender segregated workplaces emerges for around 80% of workers in future-oriented green occupations experiencing labour shortages with intermediate to low digital skills intensity. These are largely made up of different types of jobs related to mechanics, transport, agriculture, and construction. They report that in their workplaces less than half of their colleagues are women. About 36% of them (LST-LSF-GD and LST-LSF-GNE) report that they have “no or nearly no women colleague”. At the other end of the spectrum, 24% of workers in the occupational group of labour shortages report that all or nearly all of their colleagues are women.

Figure 4. Proportion of workers reporting that in their workplaces less than half of their colleagues are women, EU27



Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations.

Occupations exposed to AI

EU-LFS 2021 data suggest that occupations with higher exposure to AI are broadly gender-balanced, with a slightly higher proportion of current job holders being held by women (52%). Analysis of EWCTS data reveals similar findings. However, women still remain underrepresented in occupations with the highest exposure to AI. This pattern may also make women overall more vulnerable to the ongoing digital transition and less prepared to take advantage of the benefits of AI. This is also underlined by recent findings that the 'AI workforce', defined as those with the skills to develop and maintain AI systems, is both small and male-dominated (Green & Lamby, 2023).

As mentioned, health professionals, finance professionals, mathematicians, actuaries, and statisticians are among those likely to face heightened exposure to AI. Some of these occupations are identified as gender segregated. The health sector stands out as one of the 35 widespread shortage occupations, with health care professionals having among the highest AI exposure (AIOE of 1.528 & 1.26) and women constituting the majority of workers in healthcare-related shortage occupations, albeit also including occupations with a lower AIOE, such as nurses. Mathematicians have a high AIOE score of 1.516 and are predominantly male, as well as being characterised by a higher digital skills intensity.

3.2 Core age groups workers (25-55) are more involved in future-oriented occupations

In our analysis we find that 75% or more of workers aged between 25 and 55 years old ("core age workers") are working in future-oriented occupations, as well as occupations with a higher level of digital skills (Figure 5.) Furthermore 76% of core age workers are working in occupations with a higher level of AI-exposure.

Figure 5. Core age workers (25-55 years old) in future-oriented occupations and occupations of interest

Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations.

When the age profile in the analysed occupations is considered (Figure 6.), the following considerations emerge:

- In less digitally intensive new, emerging and enhanced green jobs and labour shortage occupations the proportion of workers aged 56 and up is found to be higher.
- In less digitally intensive enhanced green jobs, workers aged between 45 and 55 years old are more present.
- Younger workers are less involved in future-oriented occupations and (residual) occupations of interest. The exception is the group of occupations experiencing labour shortages, where young workers hold 10% of the current jobs. Less digitally intensive new, emerging and enhanced green jobs have a lower share of workers aged 15-29, especially as compared to occupations with higher digital skills intensity.

- Jobs with greater digital skills intensity have a comparatively higher share of young people than other occupational categories, with approximately one in four workers between 15-29 years of age, and a lower share of older workers, aged 55-64. Workers aged between 25 and 34 years old hold an above average proportion of jobs (when compared to their average in the working population) in occupations with a higher level of digital skills.
- For occupations with intermediate to low digital skills intensity, the share of younger and older workers is roughly equal. In contrast, (residual) green occupations of interest have a lower share of workers aged 15-29, indicating scope to make these jobs more attractive to a younger workforce.
- The share of workers aged between 35 and 44 years old is higher in all occupations of interest, except for those with intermediate to low digital skills and occupations experiencing labour shortages.

Figure 6. Future-oriented occupations and occupations of interest by age groups, EU27

	16-24 years old	25-34 years old	35-44 years old	45-54 years old	56 years old and over
	16-24	25-34	35-44	45-55	56+
Future- oriented occupations - GDDI	8	20	27	28	17
Future- oriented occupations - GEDI	4	20	25	32	19
Future- oriented occupations - GNDI	4	21	26	30	20
Future- oriented occupations - LST-D	7	21	28	30	15
Future- oriented occupations - LST-LSF-GD	8	22	25	30	15
Future- oriented occupations - LST-LSF-GNE	8	19	26	29	18
(residual) occupations of interest					
(Residual) occupations of interest - DH	7	23	27	28	15
(Residual) occupations of interest - DI	9	21	23	29	18
(Residual) occupations of interest - GNE	8	17	27	29	18
(Residual) occupations of interest - LS	10	20	21	27	22
Other	9	20	25	28	18
AI exposed	4	20	26	30	20

Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations.

This analysis confirms the relevance of policies supporting gender equality at work and addressing gender segregation. Apart from workers in (residual) labour shortage occupations, most workers in future-oriented occupations and occupations of interest are of core age. This also reinforces the need to continue policies

supporting lifelong learning and ensuring that it is accessible to workers throughout different stages of their life course, including when they are likely to be full-time employed and/or have caring responsibilities.

4. Employment and working conditions in future-oriented occupations

In this chapter, the employment conditions, encompassing contract type, employment status, financial security, and the possibility to telework in occupations of interest and future-oriented occupations are examined.

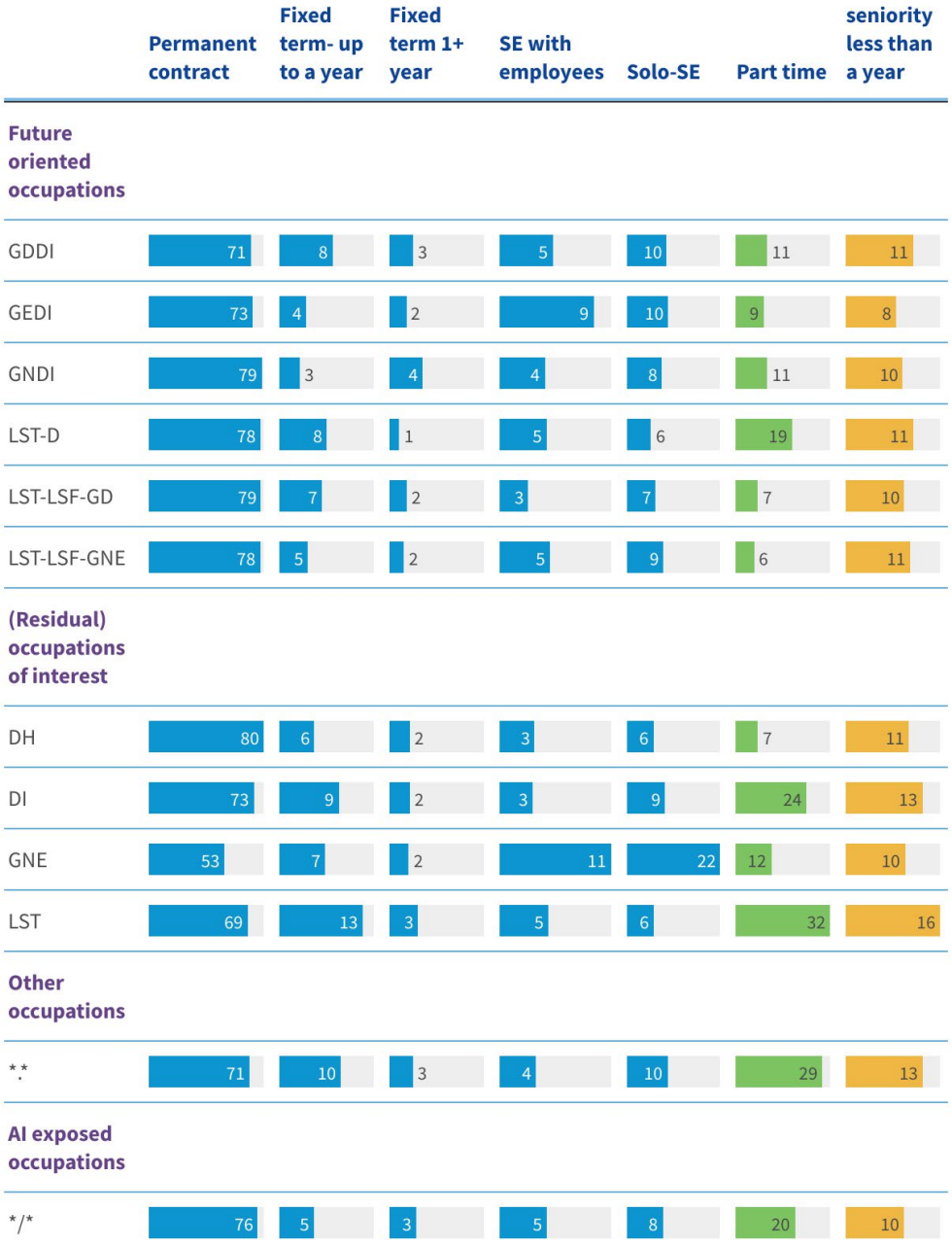
In summary, most workers in future-oriented occupations have stable employment conditions. A high proportion of workers are employed on permanent contracts and the proportion of new entrants in the job (operationalised as the proportion of workers with less than a year seniority) stands at about 10% (see Figure 7). Job stability can be positively associated with labour supply and therefore boosting employment in these jobs, especially in the context of tight labour markets. Only 50% of workers in (residual) occupations experiencing labour shortages and in green in-demand jobs, however, are in a position to accurately predict their earnings in the next three months (see Figure 8). Teleworkability is found to be heterogeneous across occupational groups, with the majority having lower than average teleworkability. This is particularly the case for occupations experiencing labour shortages.

4.1 Employment conditions in future-oriented occupations

This section examines employment conditions in future-oriented occupations and (residual) occupations of interest (Table 2).

As shown by Figure 7, self-employment is not very common in future-oriented occupations and (residual) occupations of interest with the exceptions of less digitally intensive enhanced green jobs (where 9 % of employment is made of self-employed workers with employees and 10% of solo self-employed workers) and residual green jobs (made up of 11% of self-employed workers with employees and 22% of solo self-employed workers). While this is likely related to the high proportion of these green occupations in agriculture, where self-employment is commonplace, it nevertheless implies more restricted access to social protection and is associated with higher exposure to the risks of sickness and unemployment, as well as more restricted access to training opportunities (Spasova et al., 2017; Spasova et al., 2020).

Figure 7. Employment conditions in future-oriented occupations and occupations of relevance, EU27, 2021 EWCTS



Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations. Other occupations are defined as occupations that are operationalised in the paper as neither future-oriented occupations nor (residual) occupations of interest.

Dependant employment, specifically on indefinite contracts, is higher than average in most future-oriented occupations. It is highest in occupations with a higher level of digital skills. It is lowest in the GNE (53%) and labour shortage (69%), two (residual) occupations of interest groups. Fixed term contracts of less than a year are more

frequent in residual labour shortage occupations (13%), encompassing diverse occupations such as medics, truck drivers, nurses and waiters, and jobs with intermediate to lower digital skills intensity (9%).

In most occupational groups (both future and residual), the incidence of part-time work is lower than average. It is lowest in the two future-oriented groups of new, emerging and enhanced green jobs with labour shortages (6%) and green in-demand jobs with labour shortages (7.5%) and within occupations with higher digital skills intensity (7%). It is highest in occupations belonging to the labour shortage occupational group of interest (32%), which is female-dominated, as well as occupations with medium to low digital skills intensity (DI) (24%) and digital occupations experiencing labour shortages (19%), which both are more gender-balanced occupational groups.

Also based on LFS 2021 data, we, in particular, found that within (residual) occupations of interest employment in digitally intensive jobs are more secure than the EU average. A majority of workers in jobs with higher digital skills intensity are employees, working on permanent contracts, with only a minority employed on less secure fixed-term contracts. Over 90% of workers are employed full-time, with part-time work being far less common than for other occupational categories or compared to the EU average (17.7% in 2021).

The overall proportion of new entrants (operationalised here as the proportion of workers with less than a year seniority) in future-oriented and (residual) groups of interest, except in residual labour shortage occupations (16%), is similar to or lower, as compared to workers in occupations which are neither future-oriented nor (residual) occupations of interest (13%).

Employment conditions in AI-exposed occupations

Workers in AI-exposed occupations have an above average level of job security. They have a higher-than-average incidence of permanent employment (4 percentage points higher than the average of 69.7%). Fewer workers than average hold a temporary contract of less than a year (3 percentage points lower than average of 8.3%).

They are also in stable employment. Around 10% have a seniority of less than a year (compared with 13% for the rest of workers), and 28% of less than 5 years (3 percentage points less than workers in non-AI-exposed occupations) and 44% have a seniority above 10 years (5 percentage points more than workers who are not in AI-exposed occupations). In addition, workers in AI-exposed occupations report a higher incidence of full-time employment (3 percentage points more than workers who are not in AI-exposed occupations). As noted earlier, the full extent of AI's impacts on the labour market has not yet materialised yet and these results are based on 2021. However, they can be taken as a baseline against which to assess future developments.

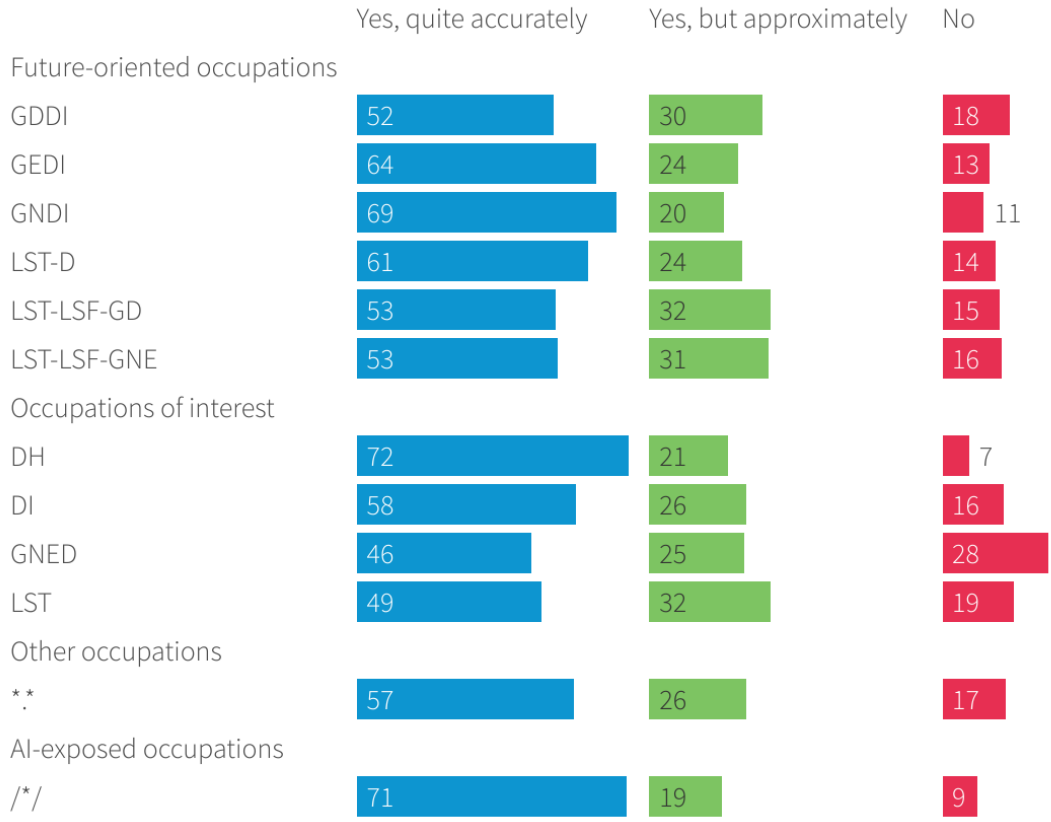
4.2 Predictability of earnings in the next 3 months in future-oriented occupations

To assess the financial security of workers, earnings predictability is also measured. This 2021 EWCTS question asks survey respondents if they can tell in advance how much they are going to earn in the next 3 months. On average, 57% of respondents answered that they know this quite accurately, 27% answered that they can predict earnings approximately and 17% responded that they could not predict their earnings.

The ability to predict earnings is found to be heterogeneous across the occupational groups analysed. Overall, between 49% and 72% in our occupations of interest groups answered that they can accurately predict their earnings in the next 3 months (Figure 8). Between 19% and 32% answered that they can predict their earnings in the next 3 months, while the rest (up to 28%) report that they cannot do this. Earnings in the next 3 months were predictable for about 50% of workers in occupations with labour shortages and in-demand green jobs. Predictability of earnings is highest in occupations with higher digital skills intensity and AI-exposed occupations and lowest in green jobs and (residual) occupations experiencing labour shortages. It is low in future-oriented

occupations experiencing labour shortages, as well as the group of green in-demand occupations with low to intermediate digital skills.

Figure 8: Earnings predictability in the next three months, by occupation of interest, 2021 EWCTS



Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations. Other occupations are defined as occupations that are operationalised in the paper as neither future-oriented occupations nor (residual) occupations of interest.

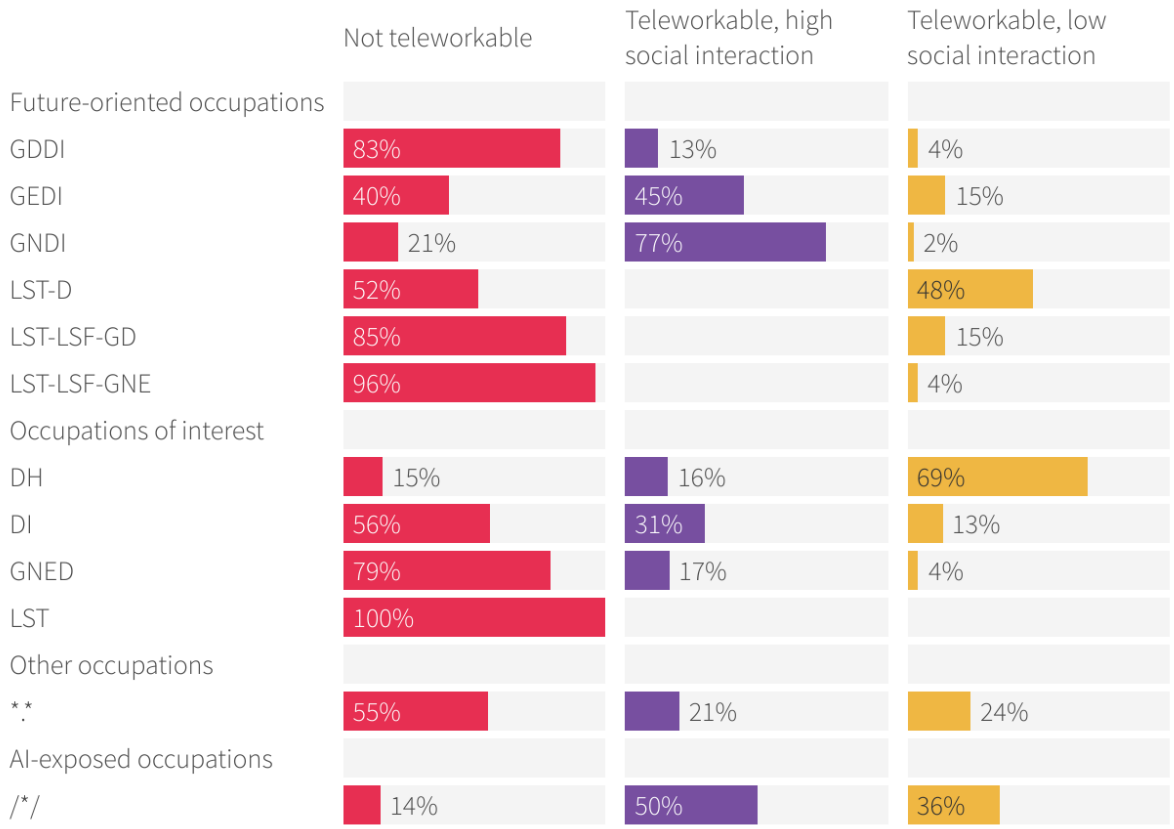
4.3 Teleworkability of future-oriented occupations and occupations of interest

This section examines the teleworkability of future-oriented occupations and occupations of relevance. Overall, occupations with a high level of digital skills and AI-exposed occupations report the highest level of teleworkability (Figure 9). Green occupations report some teleworkability and occupations experiencing labour shortages report the lowest.

Teleworkability is defined in a task perspective, as "the material possibility of providing labour input remotely into a given economic process" (JRC, 2020). It depends on technical feasibility, based on tasks (information-processing, social interaction, and physical tasks) that can be remotely undertaken with the technology available and the degree of required social interaction in the job (Eurofound, 2022b). Based on this taxonomy, occupations can be characterised into 3 categories:

- Teleworkable with low level of social interaction;
- Teleworkable but with difficulty due to social task content; or
- Not teleworkable.

Figure 9. Teleworkability of future-oriented occupations and occupations of interest, EU27



Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations. Other occupations are defined as occupations that are operationalised in the paper as neither future-oriented occupations nor (residual) occupations of interest.

5. Job quality dimensions of future-oriented occupations

The concept of job quality is multidimensional. As noted earlier, there is no agreed upon definition or approach to the measurement of job quality. In this paper, we examine job quality along the six dimensions of Eurofound's job quality index (Table 4) and other dimensions of job quality, such as health and safety at work and access to training, and those associated with it, such as forms of work organisation. The Eurofound's job quality index considers characteristics of work and employment that have been proven to have a positive or negative relationship with health and well-being. Specifically, this section, firstly, uses a job quality index considered in terms of so-called 'job strain', and then, secondly, focuses on some sub-dimensions of this index where differences between future-oriented occupations and occupations of interest emerge.

According to the EWCS series (Eurofound, 2012; Eurofound, 2017; Eurofound, 2021), job quality is associated with the quality of the working environment that is health and wellbeing, engagement, trust and cooperation in the workplace, making ends meet and work-life balance. In the recent context of tight labour markets, it has been

found that certain occupations experiencing persistent labour shortages have higher job strain (ESDE, 2023). Job quality supports an inclusive labour market and the work engagement of various groups of workers. It also supports the development of sustainable work over the life course for individuals at work, as well as higher engagement from workers, lower absenteeism and thus contributes to the performance of companies (Eurofound 2012, 2017, and 2021).

To summarise, the following findings emerge from our analysis of 'job strain' and the various sub-dimensions of job quality explored within the EWCTS, which are presented in-depth in the following sub-sections.

Our analysis finds that, both in terms of the overall measured levels of job strain and the identified specific sub-dimensions of job quality, future-oriented occupations have different profiles. Occupations with a higher level of digital skills intensity and AI-exposed jobs on average experience the lowest job strain, while occupations experiencing labour shortages and green in-demand jobs report high job strain. The highest incidence of job strain is identified among workers in (residual) occupations with labour shortages. A similar pattern emerges when workers assess whether their health and safety is at risk because of work. Overall, the following trends are identified:

- **Job strain:** Amongst future-oriented occupations, job strain is found to be highest in less digitally intensive green jobs with increased demand (34%), which encompass manual labour-intensive jobs such as train drivers, freight handlers and crop growers. It is also above the EU average in future-oriented occupations with some form of labour shortage. Concerning occupations of interest, those experiencing labour shortages report the highest proportion of job strain (48%), while occupations with higher digital skills intensity have the lowest (16%).
- **Exposure to physical demands and physical risks:** This exposure is higher, while access to job resources, such as autonomy and opportunities for organisation participation, is lower for workers in occupations experiencing some form of labour shortages and green in-demand occupations. The opposite pattern can be observed for workers in occupations with a high level of digital skills and AI-exposed occupations.
- **Social demands:** While workers in occupations with labour shortages report the highest level of social demands (that is discrimination and violence and harassment), differences between workers in all groups of occupations considered are quite small.
- **Work intensity:** Workers in future-oriented occupations report in most cases above average work intensity. The access to the corresponding job resource autonomy is high and can help compensate for these levels of work intensity for less digitally intensive new, emerging and enhance green jobs. However, this is not the case for the other groups of occupations. A similar pattern is experienced in relation to opportunities for organisational participation.
- **Long working hours**: Long hours are found in all future-oriented occupations, in particular those supporting the green transitions. This is also the case for AI-exposed occupations. Workers in future-oriented occupations, however, report higher access to working time flexibility.
- **Fearing undesirable change:** About 20% of workers report that they fear undesirable change in their work in the future. This proportion rises to about one in four for workers in occupations in green in-demand (both GDDI and LST-LSF-GD), and new, emerging and enhanced green occupations (GEDI, GNED), as well as occupations experiencing labour shortages (LST).
- **Job insecurity**: This is lower in all future-oriented occupations. with the exception of green in-demand jobs experiencing labour shortages. It is higher in most occupations of interest with the exception of those with higher digital skills intensity. About 60% of workers report career prospects, above the European average. Lower career prospects are reported by workers in occupations experiencing labour shortages. AI-exposed occupations, on the other hand, report better job prospects. Workers in AI-exposed occupations often hold higher-skilled, white-collar jobs.
- **Intrinsic motivation:** The motivation of all workers is identified as high. Around 90% of workers report doing useful work and 83% of workers in occupations with a high level of digital skills intensity say that

this is the case within their jobs. Workers in less digitally intensive green jobs with increased demand report slightly a below average incidence of useful work. Most workers in future-oriented occupations report being fairly paid in relation to their efforts, with important differences existing between the various groups of occupations considered. Workers in less digitally intensive green jobs with increased demand and digital occupations experiencing labour shortages report less frequently being recognised for their work.

- **Access to learning at the workplace:** Whether through training provided by the employer or on-the-job, access to learning is more common in future-oriented occupations. It is around average in residual green jobs and jobs with intermediate to lower digital skills intensity but lowest for workers in labour shortage jobs and higher for workers in higher digital skills intensity occupations. Workers in AI-exposed occupations also report a work environment that supports learning.
- **Recent participation in training**: Overall, this section also finds that the opportunities and the uptake of training for workers in future-oriented occupations and (residual) occupations of interest could be increased.

5.1 Job strain in future-oriented occupations and occupations of interest

The EWCTS 2021 data provides a picture of how the different aspects of work that contribute to job quality are distributed across the working population. This framework of analysis (OECD, 2017) distinguishes six job quality dimensions including job demands, which affect workers negatively, and job resources, which affect workers positively (Bakker Demerouti, 2007).

The EWCTS uses the concept of 'job strain' to identify and assess lower levels of job quality, by measuring how job demands weigh up against resources. Specifically, when job demands exceed job resources, a job is considered 'strained'. 'Job strain' can increase the risks for health and well-being and lowers sustainability of work, putting at risk the capacity of current job holders to continue in their jobs. The demands and resources associated with each job quality dimension, as measured by the EWCTS 2021 data, are detailed below and summarised in Table 4.

- **Physical and social environment:** refers to the features of the physical space in which work is undertaken and the relationships among workers in the workplace.
- **Job tasks**: refers to the conditions under which workers carry out their tasks, including work intensity, and task discretion and autonomy.
- **Organisational characteristics**: refers to the possibility of workers to be part of the decision-making processes at work, including practices that give employees opportunities to be involved in decision-making concerning their work. This dimension also includes one demand relevant only to self-employed workers, namely dependence, as measured by a lack of freedom to make important decisions on how to run the business and recruit staff.
- **Working time arrangements**: refers to how working time is organised, including unsocial work schedules and working time flexibility.
- **Job prospects**: refers to the opportunities to advance in one's career, and opportunities to develop skills through training.
- **Intrinsic job features**: refers to the opportunity for contributing to a goal in line with personal values.

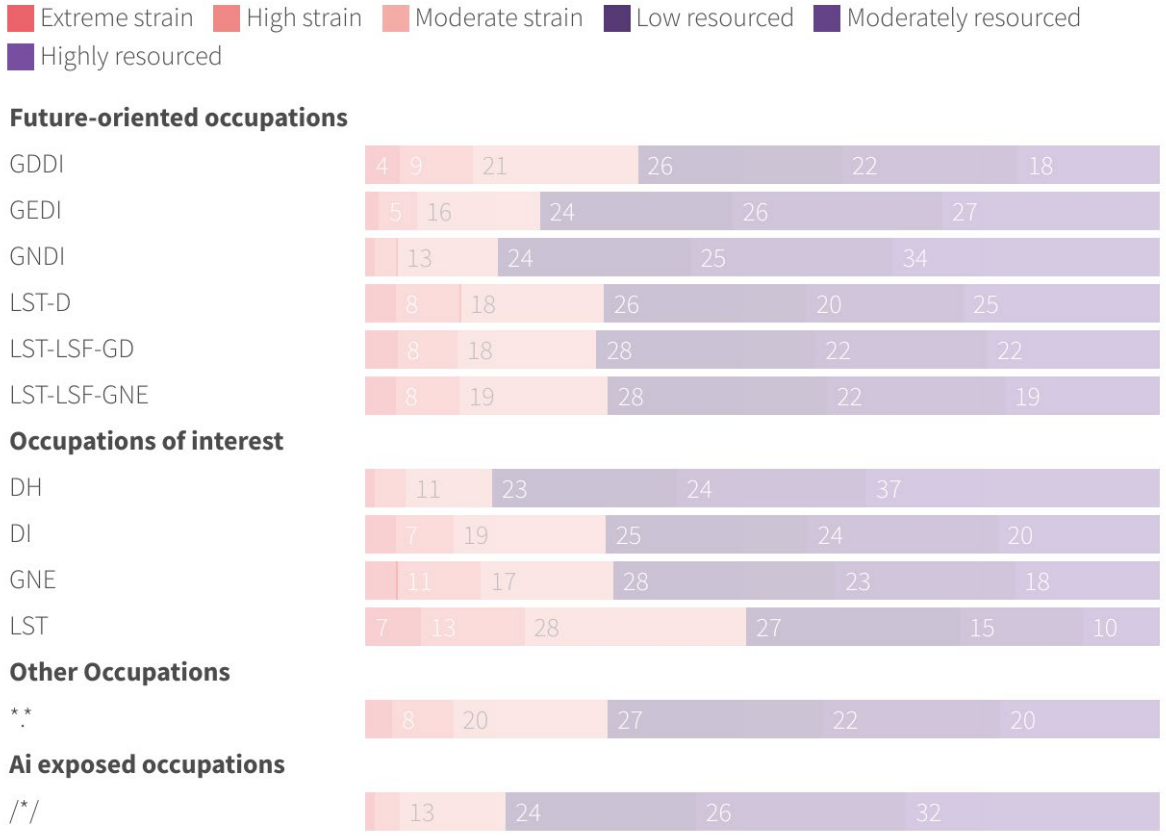
Table 4: Dimensions of job quality and corresponding job demands and job resources

Dimensions	Job demands	Job resources
Physical and social environment	Physical risks (e.g. exposure to chemicals, noise)	Social support
	Physical demands (e.g. lifting and carrying heavy loads)	
	Intimidation and discrimination	
Job tasks	Work intensity (high speed and tight deadlines)	Task discretion and autonomy
Organisational characteristics	Dependence (self-employed only)	Organisational participation and workplace voice
Working time arrangements	Unsocial work schedules	Flexibility of working hours
Job prospects	Perceptions of job insecurity	Training and learning opportunities
		Career advancement
Intrinsic job features		Intrinsic rewards
		Opportunities for self-realisation

Source: Eurofound 2022.

Figure 11. shows a very mixed picture of job quality in future-oriented occupations and occupations of interest. When considering job strain, job quality in future-oriented occupations is on par with the EU average, and better in less digitally intensive new, emerging and enhanced green jobs (with a lower proportion of job strain, respectively 17% and 22%). The proportion of job strain is highest in less digitally intensive green jobs with increased demand (34%), which encompasses some traditional white-collar jobs but also manual labour-intensive jobs such as freight handlers, crop growers, and truck operators. It is also above average in green new, emerging and enhanced jobs experiencing labour shortages (for example car mechanics requiring skills in electric vehicle repair), green jobs with increased demand experiencing labour shortages, and digital jobs experiencing labour shortages. For certain future-oriented occupations, such as field crops and vegetable growers, poorer working conditions could be additionally compounded by an increased exposure to climate change risks (Eurofound, 2024)

Figure 11. Job strain in future-oriented occupations and occupations of interest, EU27, EWCTS 2021



Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations. Other occupations are defined as occupations that are operationalised in the paper as neither future-oriented occupations nor (residual) occupations of interest.

Starker differences between occupational groups can be observed when only occupations of interest are considered. Occupations experiencing labour shortages report the highest proportion of job strain (48%), while occupations with higher digital skills intensity report the lowest (16%) and DI and GNE are on par with the EU average.

5.2 A detailed analysis of job quality dimensions

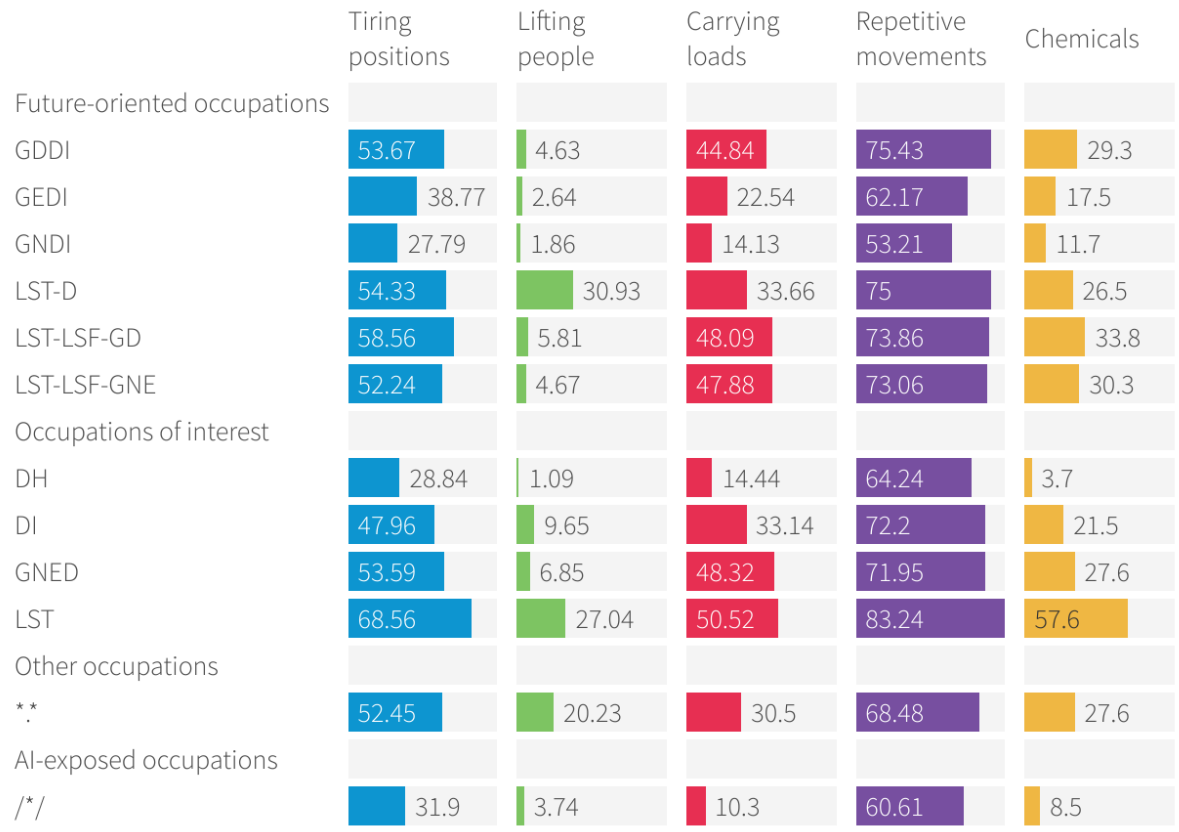
In the following sub-sections, aspects of the six dimensions of Eurofound's job quality index are examined in relation to future-oriented occupations and (residual) occupations of interest. Next, other dimensions relevant to job quality and practices that support job quality and learning are also examined.

5.2.1 Physical and social environment

Physical demands can put strain on workers, with repetitive movements increasing the risks of musculo-skeletal disorders (MSDs). Chemicals are an important part of certain workplaces, with knowledge gaps remaining on the risks incurred by certain chemicals in the workplace.

Future-oriented occupations involving green in-demand occupations and occupations experiencing labour shortages report the highest exposure to physical risks and demands (see Figure 12). A similar pattern emerges also for exposure to chemicals. Repetitive movements are very frequent in many occupations. They are comparatively less frequent, however, in green new, emerging and enhanced occupations with intermediate/lower digital skills intensity and jobs with higher digital skills intensity. AI-exposed occupations also report low exposure to physical demands and physical risks.

Figure 12. Exposure to physical demands and physical risks, by type of future-oriented occupations

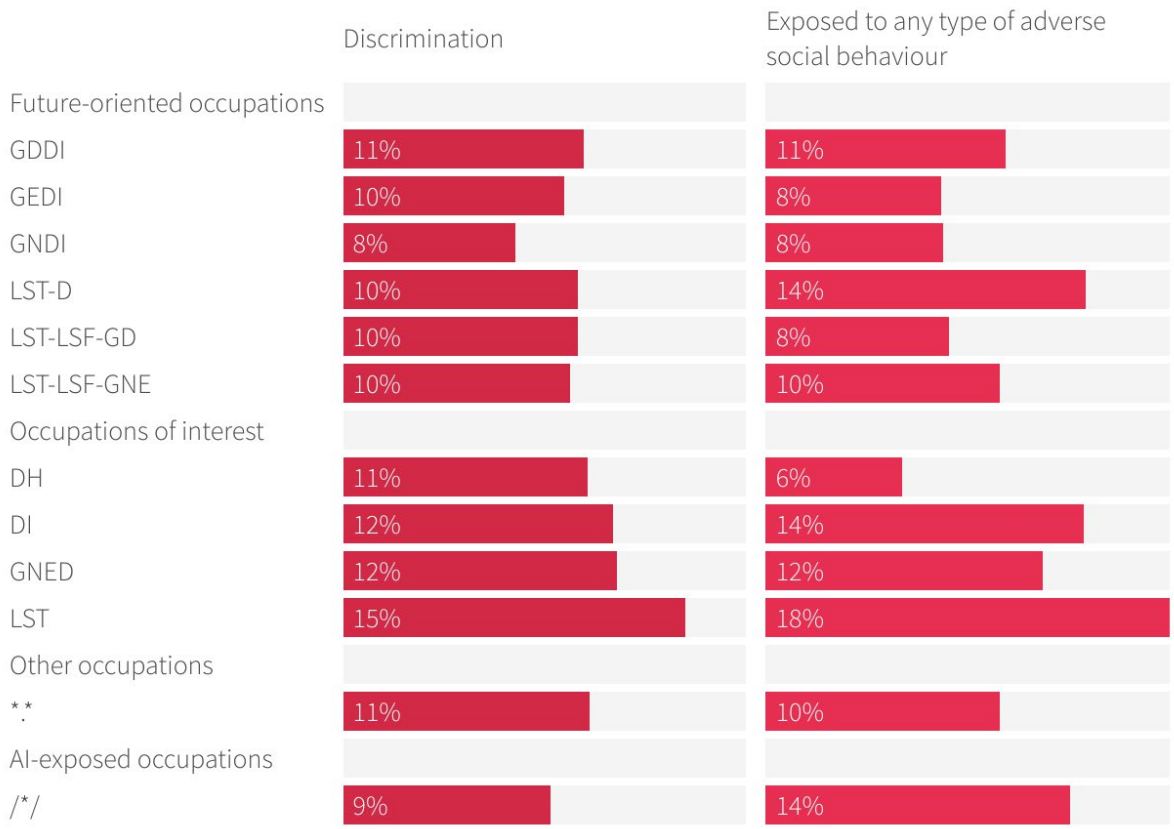


Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations. Other occupations are defined as occupations that are operationalised in the paper as neither future-oriented occupations nor (residual) occupations of interest.

The proportion of workers reporting being discriminated at work is lower than average in future-oriented occupations but higher in occupations of interest (with the exception of workers in occupations with higher digital skills intensity). Workers in AI-exposed jobs report the lowest level of discrimination (9%), while workers in

occupations experiencing labour shortages, which encompass occupations with high levels of social contact such as doctors, nurses and waiters, report the highest level of discrimination (15 %). Adverse social behaviour emerges as a significant concern for workers in residual labour shortage occupations (18%), workers in digital occupations experiencing labour shortages and in occupations with lower to intermediate digital skill intensity more generally (both 14%).

Figure 13. Social demands at work, by type of occupations



Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations. Other occupations are defined as occupations that are operationalised in the paper as neither future-oriented occupations nor (residual) occupations of interest.

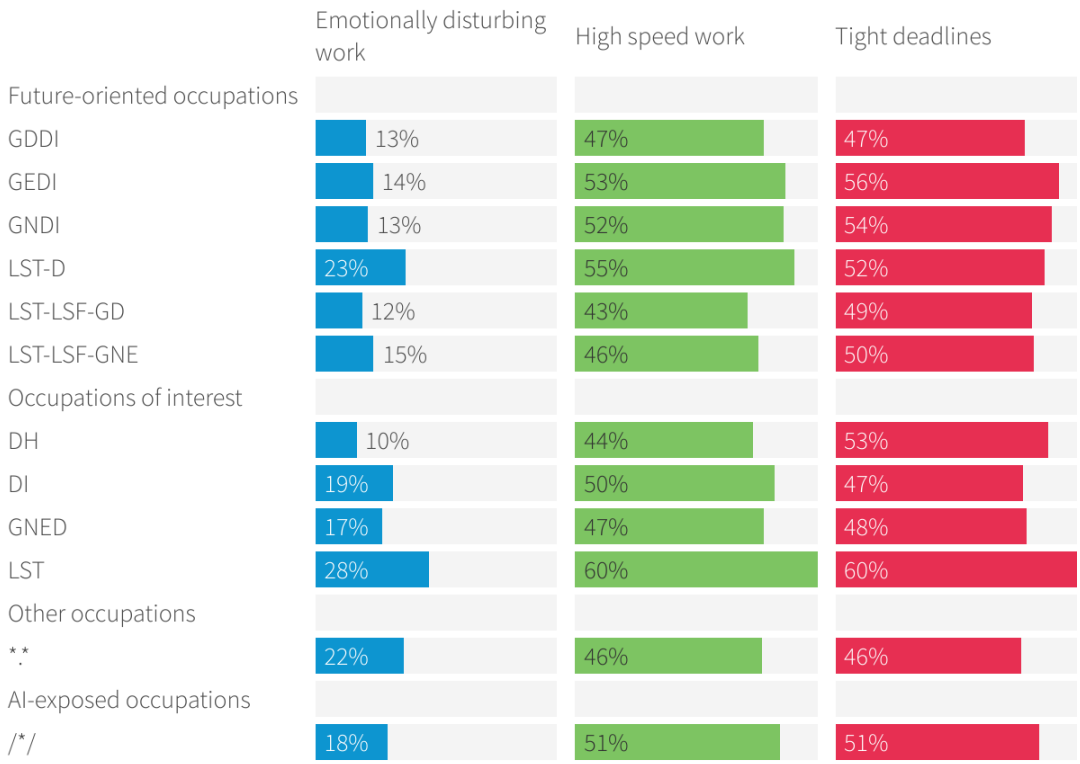
5.2.2 Job Tasks

The conditions under which jobs are performed vary considerably, including in terms of their intensity of work and the degree of discretion and autonomy workers have in performing tasks. Work intensity is a job demand necessitating a sustained effort on the part of the worker. Task discretion and autonomy concern the scope workers have to decide the way in which they carry out their activities, their working methods, and their pace of work. In the EWCTS, these are seen as resources that allow workers to deal with the demands of their jobs.

In terms of work intensity, the level of emotionally disturbing work is found to be highest in occupations experiencing critical labour shortages, reflecting also occupations in care and health with a high level of client interaction and teamwork. Current job holders in two groups of future-oriented occupations (LST-LSF-GD and LST-

LSF-GNE) experience less work intensity. Workers in less digitally intensive green new, emerging and enhanced occupations, encompassing for example managers, analysts, and policy professionals, report a high level of high-speed work and dense work (work to tight deadlines).

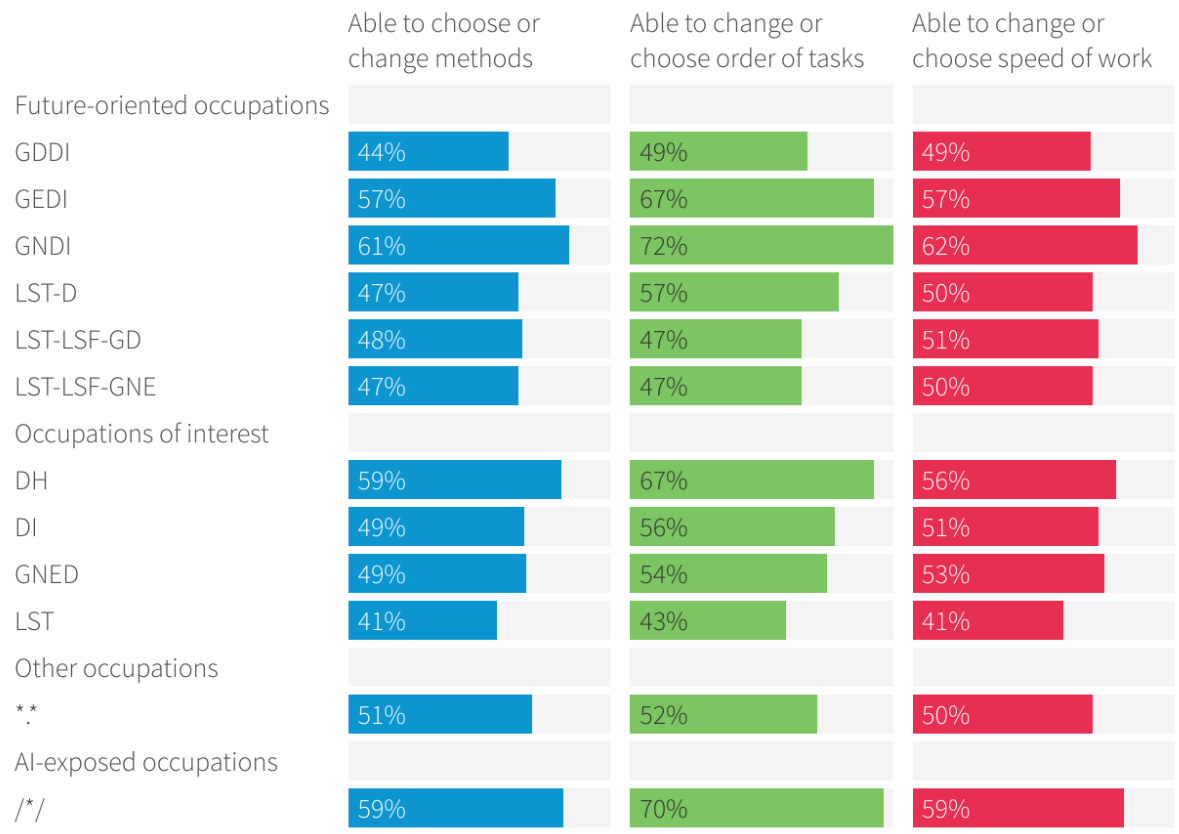
Figure 14. Work intensity, by type of occupations



Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations. Other occupations are defined as occupations that are operationalised in the paper as neither future-oriented occupations nor (residual) occupations of interest.

Task discretion refers to the ability of workers to influence the way in which they carry out their immediate activities. Epidemiological studies have shown that it is positively associated with health and wellbeing and supports learning and skills acquisition. Only workers in less digital skills intensive green new, emerging and enhanced jobs (which include professionals, managers, and analysts), as well as those in AI-exposed jobs and occupations with a high level of digital skills intensity, report a high level of task discretion. The lowest levels are reported by workers in residual labour shortage occupations, which encompasses diverse occupations such as medics, truck drivers, nurses, cleaners, cooks, and waiters.

Figure 14. Autonomy, by type of occupations



Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations. Other occupations are defined as occupations that are operationalised in the paper as neither future-oriented occupations nor (residual) occupations of interest.

5.2.3 Organisational characteristics

The policies and practices that companies set to organise and manage work play a key role in shaping the conditions under which jobs are performed and, ultimately, job quality.

Organisational participation and workplace voice refer to the extent to which employees are able to influence decisions in the workplace through direct consultation, rather than through their representatives. Organisational participation and employee voice are job resources. The involvement of workers in their company's decision-making processes has been found to have positive effects on performance, learning and skills development, and creativity (Eurofound & Cedefop, 2020). More engaged workers can also have a better understanding of the consequences of management decisions for how work is performed, are less likely to oppose these changes, and may better anticipate risks (OECD, 2017).

Workers in less digitally intensive green new, enhanced, and emerging jobs report higher opportunities for organisational participation. Workers in labour shortage occupations, and, to a lesser extent in jobs with intermediate/lower digital skills intensity, less digitally intensive green jobs with increased demand (which includes

professionals, service and sale workers, as well as labourers) and the remaining groups of occupations experiencing some forms of labour shortages, report having limited opportunities. AI-exposed occupations report above average opportunities for participation.

Figure 15. Organisational participation, by type of occupations

Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations. Other occupations are defined as occupations that are operationalised in the paper as neither future-oriented occupations nor (residual) occupations of interest.

5.2.4 Working time arrangements

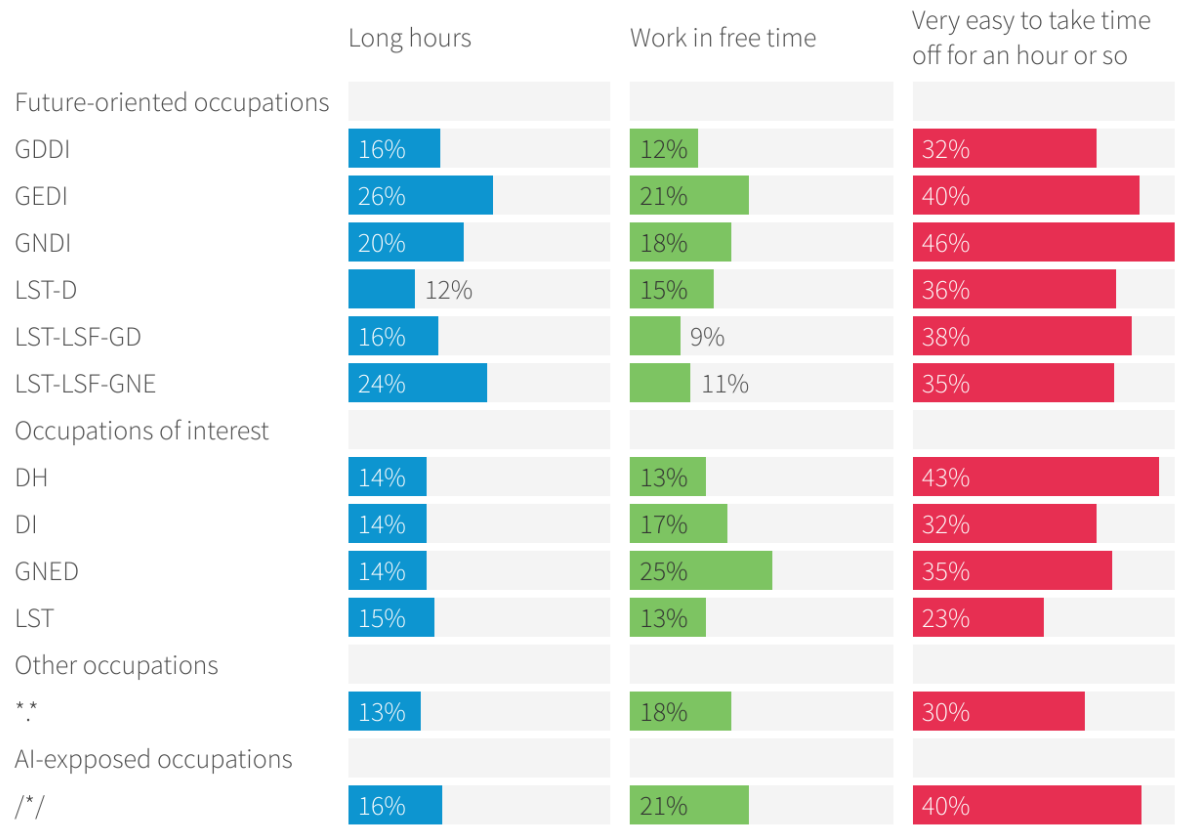
Overall, working time flexibility (employer-and employee-led) has been increasing in the last decades. Working time – in terms of its duration and organisation – contributes to job quality.

Our analysis finds that workers in future-oriented occupations tend to report a higher incidence of long working weeks. This is mostly the case for green occupations (GEDI, GNDI, and GNED, as well as LST-LSF-GNE). The incidence of night work is highest (above 25%) in all groups of occupations experiencing labour shortages.

Work in free time, which illustrates blurring frontiers between work and non-work life and is facilitated by the diffusion of digital technologies, is found to be most frequently experienced in green occupations (GEDI, GNDI, GNED) encompassing occupations with diverse skill sets, such as life science professionals, construction workers, and economists, and occupations with intermediate to lower digital skills intensity (DI). For example, 25% of workers in residual green occupations report working in their free time, either daily or several times a week. This is

coherent with the high proportion of long hours reported by workers in these occupations. Work at short notice is also highest in occupations experiencing critical labour shortages (LST) and residual green occupations (GNED).

Figure 16. Working time, by type of occupations



Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations. Other occupations are defined as occupations that are operationalised in the paper as neither future-oriented occupations nor (residual) occupations of interest.

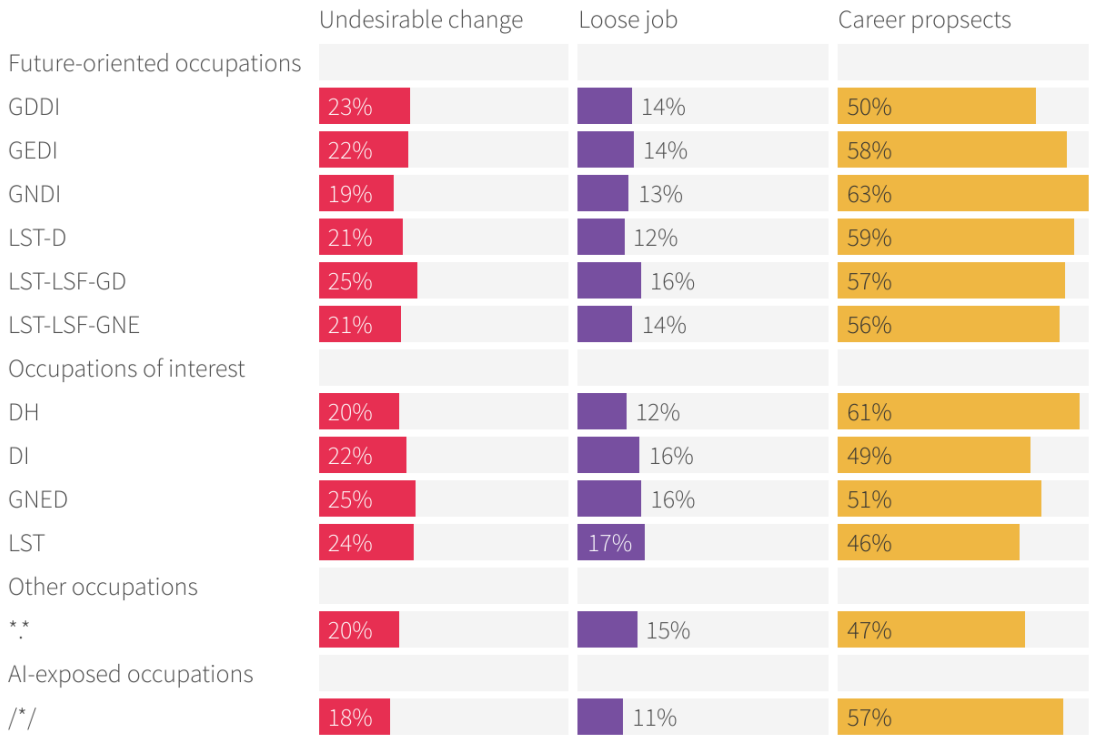
5.2.5 Job prospects

Job prospects influence job quality in different ways. Positively, when jobs provide opportunities for training, learning, and career advancement, and negatively, when insecurity is a feature of the job. Research has found that the negative effects of job insecurity on well-being are similar to that of unemployment, as well as associated with several medical conditions (De Witte, 1999; Burchell, 2011; Sultan-Taïeb et al., 202; Niedhammer, 2022). The EWCTS measures different forms of job insecurity, encompassing fear of losing one's job but also fear that their job will change in an undesirable way. Fewer workers in future-oriented occupations than average fear losing their jobs in the next six months. However, some 25% of workers in green in-demand jobs experiencing labour shortages and residual green jobs expect undesirable changes in their work. Interestingly, this is not the case, however, for occupations experiencing current and future labour shortages and in green in-demand occupations, where 16% of workers report that they are likely to lose their job. All occupational groups of interest report above average fear of

losing their jobs. Here again, occupations with higher digital skills intensity are an exception. Workers in AI-exposed occupations report the lowest level of job insecurity and an above average level of career prospects.

Career opportunities are assessed as higher in future-oriented occupations, except in occupations belonging to in-demand green jobs with intermediate to low digital skills intensity. 56% or more of workers in future-oriented occupations report having career prospects. A different picture emerges in occupations of interest, with the exception of occupations with higher digital skills. In these occupations less or about 50% of current job holders report having career prospects.

Figure 17. Job prospects, by type of occupations



Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations. Other occupations are defined as occupations that are operationalised in the paper as neither future-oriented occupations nor (residual) occupations of interest.

5.2.6 Intrinsic job features

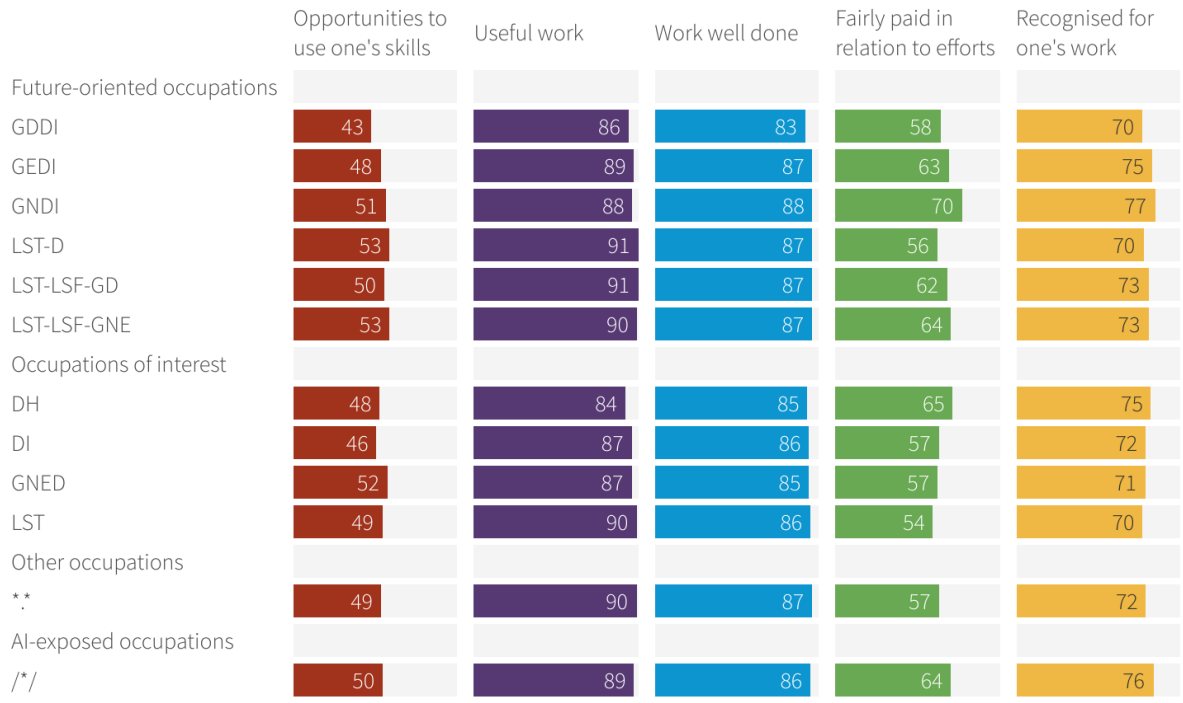
People engaging in work may have expectations not only around income and job security but also intrinsic rewards, including opportunities for personal development, fulfilment, and self-expression at work.

On average, 72% of workers agree that they receive the recognition that they deserve for their work. The highest agreement (75% and more) on the recognition for one's performance is expressed by workers in green new, enhanced and emerging occupations with intermediate/lower digital skills intensity and higher digital skills intensity, which encompasses jobs at the forefront of the green and digital transitions, such as ICT technicians, agricultural technicians and chemical engineers. With the exception of less digital skills intensive green jobs with increased demand and digital occupations experiencing labour shortages, workers in future-oriented occupations

also report above average agreement with the statement that that their pay is fair in relation to the efforts that they put into their work. A high 76% of workers in AI-exposed occupations also agree that they receive the recognition that they deserve. On the other hand, about 20% of workers in occupations in critical labour shortages (LST), digital occupations experiencing labour shortages (LST-D) and less digitally intensive green jobs with increased demand (GDDI), report the highest levels of disagreement that they have received the recognition they deserve at work (3 percentage points above the average). Workers in GDDI report a slightly lower incidence of useful work and work well done, as well as opportunities to use their skills in their work and being recognised for their work. Workers in occupations with higher digital skills intensity also report a lower incidence of perceived usefulness of their work.

Workers in all future-oriented occupations also report a high level of usefulness of their work. The highest proportion is reported by workers in groups of occupations experiencing some labour shortages. About 60% of workers in future-oriented occupations and occupations of interest report being fairly paid in relation to their efforts. Lower proportions are reported by workers in occupations reporting strict labour shortages and workers in occupations with intermediate to low digital skills (both DI and GDDI).

Figure 19. Intrinsic rewards and opportunities for self-realisation, by type of occupations



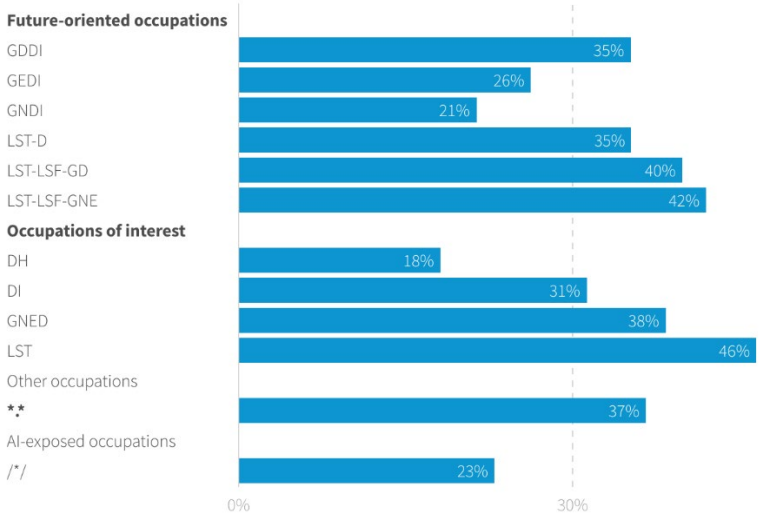
Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations. Other occupations are defined as occupations that are operationalised in the paper as neither future-oriented occupations nor (residual) occupations of interest.

5.3 Health and safety risks at work

Work has a specific impact on health and health is a precondition for sustainable work. Health and safety at work is a long-standing policy area in Europe. In the context of the on-going green transition, health and safety has also been noted as a concern for certain green jobs, in particular those involving extensive manual labour and exposure to chemicals and carcinogens, including asbestos. As indicated in Figure 20, health and safety risks at work are a

significant concern in four groups of occupations. These encompass occupations which experience labour shortages, namely LST-LSF-GD (40 %, 6 pp above the EU average), LST-LSF-GNE (42%, 8 pp above the EU average) and LSF (46%, 12 pp above the average), as well as GNE (38%) and GDDI (35%), which encompasses more manual labour-intensive green jobs. On the other hand, occupations with a higher digital skills intensity (18%), as well as new green occupations with intermediate to low digital skills (21%) and AI-exposed occupations (23%) report below average exposure to health and safety risks at work (34%).

Figure 20. Health and safety at risk, by type of occupations



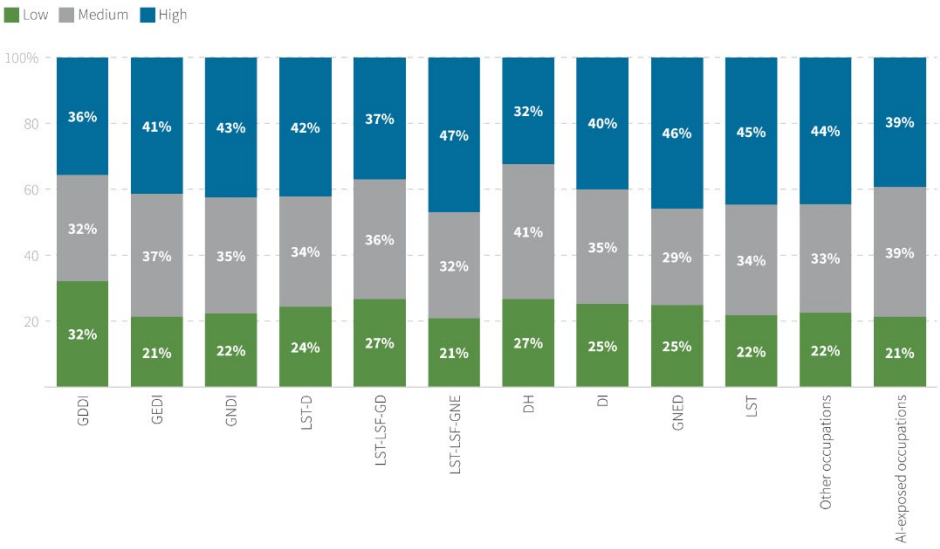
Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations. Other occupations are defined as occupations that are operationalised in the paper as neither future-oriented occupations nor (residual) occupations of interest.

5.4 Engagement in future-oriented occupations

Engagement is associated with performance and innovation at the workplace. Engagement at work is an indicator of workplace well-being. It is captured by asking workers, in the context of the EWCTS, if they felt full of energy at work, if they were enthusiastic about their job, and if they felt that time flies when they are working.

To summarise, except for new, enhanced, and emerging green jobs with intermediate/lower digital skills intensity (47%), residual green jobs (46%), and labour shortage occupations (45%), high levels of engagement are average or below average in future-oriented occupations and (residual) occupations of interest.

Figure 21: Engagement at risk, by type of occupations



Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations. Other occupations are defined as occupations that are operationalised in the paper as neither future-oriented occupations nor (residual) occupations of interest.

5.5 Work organisation practices that support job quality and learning

Previous research (Eurofound, 2020; Eurofound, 2022) has concluded that so-called 'high-involvement' forms of work organisation offer a better work environment with less physical risk, lower work intensity, and greater job security. High involvement forms of work involve high task discretion and high organisational participation. This type of organisation is more likely to encompass a type of employee representation, such as through a trade union or works council. 'High-involvement' organisation also provides more opportunity for both formal and informal skill development, but it is particularly strongly associated with informal skills development.

Based on employee responses to questions in the EWCTS about their level of task discretion and organisational participation, four types of work organisation could be distinguished. On average in the EU, 33% of employees are in so-called 'high involvement' forms of work organisation, characterised by a high level of discretion and organisational participation, and 30% of workers are in 'low involvement' forms of work organisation. The remainder of workers are shared between 'consultative' forms of work organisation (low task discretion and high organisational participation), where 22% are employed, and 'discretionary' organisations (high task discretion and low organisational participation), a rather less frequent form of work organisation, encompassing 16% of employees. Overall, except for workers in less digitally intensive new, emerging (48%) and enhanced (43%) green jobs, the proportion of workers in the other groups of future-oriented occupations working under 'high involvement' conditions is below the EU average.

Figure 22. High involvement forms of work organisation, by type of occupations

Source: EWCTS 2021. Note: The occupational groupings analysed are the following: Green occupations with increased demand and intermediate to low digital skills intensity (GDDI), green enhanced occupations with intermediate to low digital skills intensity (GEDI), green new and emerging occupations with intermediate to low digital skills intensity (GNDI), labour shortage occupations with higher digital skills intensity and intermediate to low digital skills intensity (LST-D), green occupations with increased demand experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GD), green occupations new and emerging and enhanced task experiencing persistent and future labour shortages with intermediate to low digital skills (LST-LSF-GNE) occupations with higher digital skills intensity (DH), occupations with intermediate to low digital skills intensity only (DI), green occupations – residual strictly new and emerging or strictly enhanced or strictly increased demand (GNED), critical labour shortage occupations, current and future (LST) and AI-exposed occupations. Other occupations are defined as occupations that are operationalised in the paper as neither future-oriented occupations nor (residual) occupations of interest.

5.6 Access to and participation in training within future-oriented occupations and occupations of interest

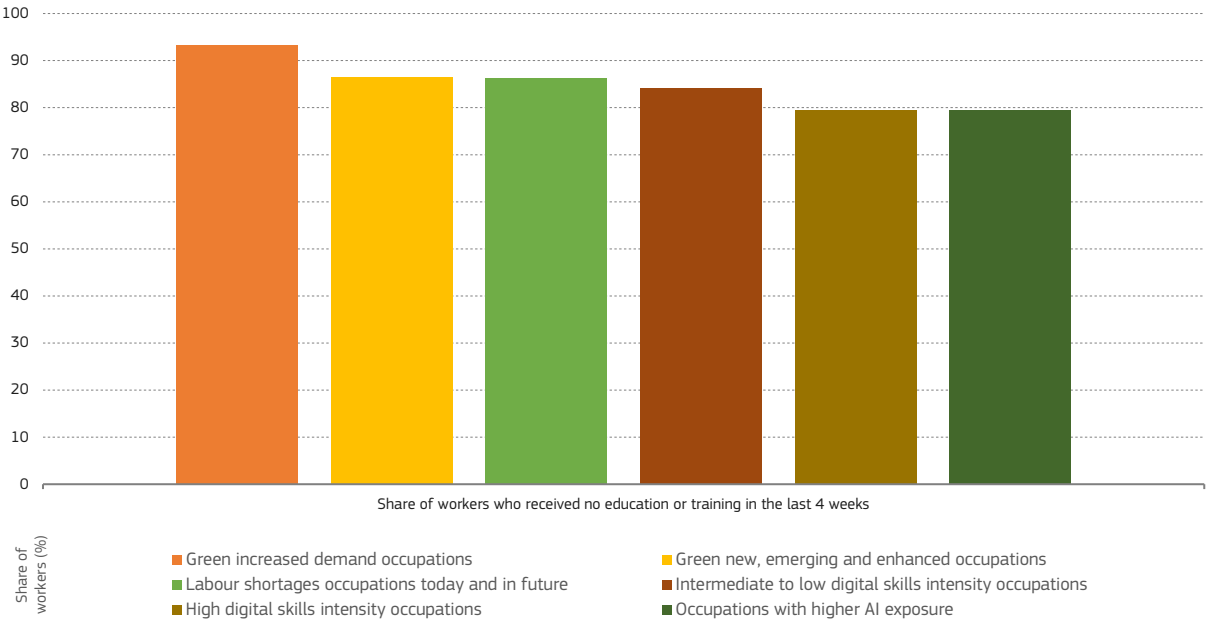
Trainings support the adaptation of new technologies, work processes, and mastery in task performance. Overall, 34% of workers in the EU received training paid for by their employers and 41% received on-the-job training. Close to half of workers in future-oriented occupations and workers in digitally more intensive jobs received training provided by their employers and more than 50% received on-the-job training. Based on EWCTS data, the highest level of training both provided both by employers and on-the-job was made available to workers in less digitally intensive green new and emerging (56% of workers) and enhanced (53%) occupations, including jobs such as life science professionals, physicists, astronomers and financial analysts. Workers in the remaining groups of occupations of interest received far less training. The lowest level of training was provided to workers in the residual group of critical labour shortages occupations.

In addition, between 58% and 70% of workers in future-oriented occupations report learning new things in their job. This is less than workers in occupations with a high level of digital skills intensity (80%). Workers in the residual occupational group experiencing labour shortages report the lowest level of learning in their job (54%).

Across future-oriented occupations, between 10-16% of workers also report receiving training in the preceding four weeks. Based on LFS 2021 data, we find that workers in (residual) occupations of interest relevant to the digital

transition report receiving training more recently (Figure 10). This highlights that more can be done to improve uptake and opportunities for workers in key occupations for the twin transitions and the evolving EU economy. Occupations with higher exposure to AI have the lowest share of workers who have not received training in the preceding four weeks, followed by jobs with higher digital skills intensity. A relatively large share (one in five) report receiving some education or training in the preceding four weeks. Workers employed in jobs requiring a high level of digital skills intensity usually already have the skill set needed to participate in the digital transition, while rapid advances in technology may bring with them the need to update skills regularly.

Figure 10. Share of workers who reported not recently having received education or training, EU27



Source: Authors' elaboration, based on EU-LFS 2021 and outlined occupational category classifications. aNote: Due to smaller sample sizes, green new and emerging and green enhanced occupations are grouped together.

6. Summary of the findings

6.1 Strengths and limits of the work

This paper provides an overview of the workforce, employment and job strain of occupations that are, now and in the future, relevant for and impacted by transformations related to the green and digital transition and demographic change. It aims to contribute to discussions on how and for which subgroups of the workforce policies can help ensure good job quality, widespread and inclusive labour market participation, and a match between workers' skills and upcoming occupational changes. These transformations are ongoing and are also likely to be shaped by EU-level and national regulation, geopolitical events, and workforce attitudes (e.g. the adoption of AI in the healthcare sector could be more limited due to preferences for in-person carers). These findings can therefore only provide an indication of trends and areas needing to be closely monitored.

The list of occupations of interest and future-oriented occupations provides an analytical basis for monitoring labour market and workforce dimensions of these dynamic and interactive transformations. While the list will need to be updated, it offers a starting point for mapping the occupational characteristics of the digital and green transitions building on existing methodologies, as well as their interaction with current and future labour shortages. When new definitions and methodologies are available, similar analysis could be conducted. Future research should include

more advanced statistical analysis, combined with case studies, as well as possibly include a longitudinal component. This would allow capturing the impact of work changes on individuals job quality and well-being.

Overall, this paper provides an initial understanding and mapping of an under-researched area, namely the employment conditions and certain aspects of job quality of future-oriented occupations. Its added value is its occupational focus which combines together different classifications of occupations often considered in isolation. In order to explore these variables, this report builds on two comparative datasets that include all EU-27 Member States, the Labour Force Survey and the European Working Conditions survey. Survey data was collected at various stages throughout 2021, thereby during the final stages of the COVID-19 pandemic. Hence, the working life experiences of workers may have been impacted by this.

Future-oriented occupations are of heterogeneous nature and the report focuses on how occupations are impacted in their tasks by the decarbonisation and digitalisation transformations in a context of demographic change. The transitions, however, impact job quality through other mechanisms, such as the introduction of new production processes or business models in companies and organisations. Likewise, prior work and employment trajectories will impact workers' ability and willingness to engage in work. These additional trajectories are not captured in this research.

In addition, when grouping occupations the crosswalk between the American O'NET and ISCO called for making some research decisions on for example, the threshold for the degree of greening of tasks. This can lead to some minor differences between the various operationalisations performed by research teams. There are also some inherent limits in the transferability of O'NET, an American database of occupations, into a European context.

6.2 Conclusions

Based on the data analysis, the following findings emerge:

Workforce characteristics

- **A considerable number of occupations are changing due the digital, green, and demographic transitions.** More than 90% of the workforce employed as managers, technicians and associate professionals, skilled agricultural workers, craft and trade workers, plant and machine operators are being impacted by all three transitions, while the impact for remaining occupational groups is at least 60%. This calls for support of effective lifelong learning and ensuring access for all groups of workers, encompassing different levels of initial training and personal circumstances.

- **Gender segregation is identified in most future-oriented occupations and (residual) occupations of interest.** In particular, most future-oriented occupational groups and residual occupations with higher digital skills intensity and certain green jobs are largely male-dominated. On the other hand, occupations of interest relevant for critical labour shortage occupations, as well as to a lesser extent jobs with medium to low digital skills intensity, have a higher proportion of women. Progress towards greater gender parity in many of the identified occupations, can boost labour market participation in jobs relevant to the digital and green transitions, while at the same time contributing to more balanced and inclusive labour markets.

- **Both female and male workers experience approximately the same level of higher occupational exposure to AI.** Certain sectors, such as health, finance, and statistics, are likely to see significant AI impacts. At a more granular level, however, gender segregation can be found in certain jobs with higher AI exposure.

- **The majority of workers in future-oriented occupations are in the core age groups:** Overall, 75% or more of workers aged between 25 and 55 years old ("core age workers") are working in future-oriented occupations, as well as occupations with a higher level of digital skills. However, the proportion of workers aged 56 and up is higher in two future-oriented groups of occupations (less digitally intensive green new, emerging and enhanced jobs), as well as in the residual labour shortage occupations. This could raise some concern over

demographic renewal in these groups of occupations, particularly since occupations with labour shortages are already experiencing recruitment tensions.

Employment conditions

- **Future-oriented occupations generally are found to have stable employment conditions.** A high proportion of workers in future-oriented occupations are employed on permanent contracts. On the other hand, only 50% of workers in (residual) occupations experiencing labour shortages and in green in-demand jobs, reported being in a position to predict accurately their earnings in the next three months.

Job quality measured as 'job strain'

- **Job strain in future-oriented occupations is found to be heterogenous.** Whereas job strain is below average in less digital skills intensive new, emerging and enhanced green occupations, it is above average in green and digital occupations experiencing labour shortages and less digital skills intensitve green in-demand jobs. This suggests some room for improving dimensions of job quality, as captured by the EWCTS, in future-oriented occupations, particularly to support the green transition. Improvements can be made over many dimensions, such as the physical environment, social relationships, skills, discretion, workload, work pace, quality of earnings and working time, in addition to improving job and employment security.

- **Occupations with higher digital skills intensity also have much lower job strain, including as compared to the EU average.** Predictability of earnings is also highest in occupations with higher digital skills intensity and AI-exposed occupations. Given that these occupations are currently (and likely in future) in high demand, increased access and availability of relevant education and training would equip more workers with the skills to participate effectively in the digital transition, fill related shortages in the EU economy, and potentially enable workers to move into these higher quality jobs.

- **Job strain is above the EU average for critical labour shortage occupations.** Improving job quality for residual labour shortage occupations, including those relevant for care work, could increase their labour supply, including by encouraging workers to be employed full-time rather than part-time. The comparatively high share of older workers in residual critical shortage occupations also underlines the need to activate workers effectively in these occupations, as they can be expected to retire within the next two decades.

- **Occupations with higher AI exposure have below-average levels of job strain.** Given the exponential pace at which digitalisation is taking place, uncertainty remains high on the type and level of impact that AI will have on the number of jobs, the extent of task restructuring within jobs, and the quality of jobs. This highlights the importance of monitoring the labour market effects of AI use.

- **Continued efforts to support and improve data collection and measurement of the various dimensions of job quality are key.** To support improvements in measuring various dimensions of job quality for a large variety of heterogenous occupations relevant to the twin transitions and demographic change, there is a continued need for high quality data on different aspects of job quality. This could be based on a dual and complementary approach that involves building data based on detailed surveys on working conditions, such as the EWCS, and general population surveys, where validated shorter sets of questions related to job quality dimensions are asked to workers. Having such data allows policymakers and researchers to identify areas of concerns, at risk work situations, as well as map progress over time. In turn, by improving the measurement of various aspects of job quality, we can also gain a better understanding of how to conceptualise and measure job quality within modern labour markets

Specific sub-dimensions and aspects of work

- **Changes in work could create vulnerability for workers and companies.** About 20% of workers report that they fear undesirable change in their work in the future. This proportion rises to about one in four for workers in green in-demand (both GDDI and LST-LSF-GD), and enhanced green occupations (GEDI, GNED), as well as occupations experiencing labour shortages. Policies that support change processes in companies and organisations and mitigate the negative impact of changes on people's working lives will play a key role. Such practices include the development of workers involvement practices and ultimately the development of learning forms of work organisation. As they are tailored to the individual circumstances of the companies and organisations and build on the involvement of the current workforce, they support the motivation of staff and their discretionary effort which can be factors of success for companies and organisations. In 2021, around 45% of employees in two of the future-oriented occupations worked under high involvement work practices.

- **Workers report strong intrinsic motivation to conduct their work.** Around 90% of workers report doing useful work, with only 1.7% stating that they never do useful work. Around 87% of workers report being in a capacity to perform quality work. However, this motivation doesn't translate into high levels of engagement in all future-oriented occupations and occupations of interest.

- **Health and safety remain a significant concern particularly in the three groups of occupations that experience labour shortages.** Efforts should continue to ensure that work is safe and healthy. As future-oriented occupations have different risk exposure profiles, actions that address some risks will end up targeting different groups of workers.

- **For all occupations of interest and future-oriented occupations, the majority of workers have not recently participated in training.** Occupations at higher risk of exposure to AI and with higher digital skills intensity report the highest share of trainings received, while only a minority of workers in residuals occupations relevant to critical labour shortages report receiving training in the preceding four weeks. Given that workers aged 25 to 55 make up the majority of future-oriented occupations, this further underlines the need to support lifelong learning that it is accessible to workers various stages of their life course. Also, women are found to be at higher risk of being left behind in the digital transition and are thus in greater need of education and training on digital skills. Accordingly, it is particularly important to equip women with the skills needed to benefit from the spread of AI technologies in the workplace**.**

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