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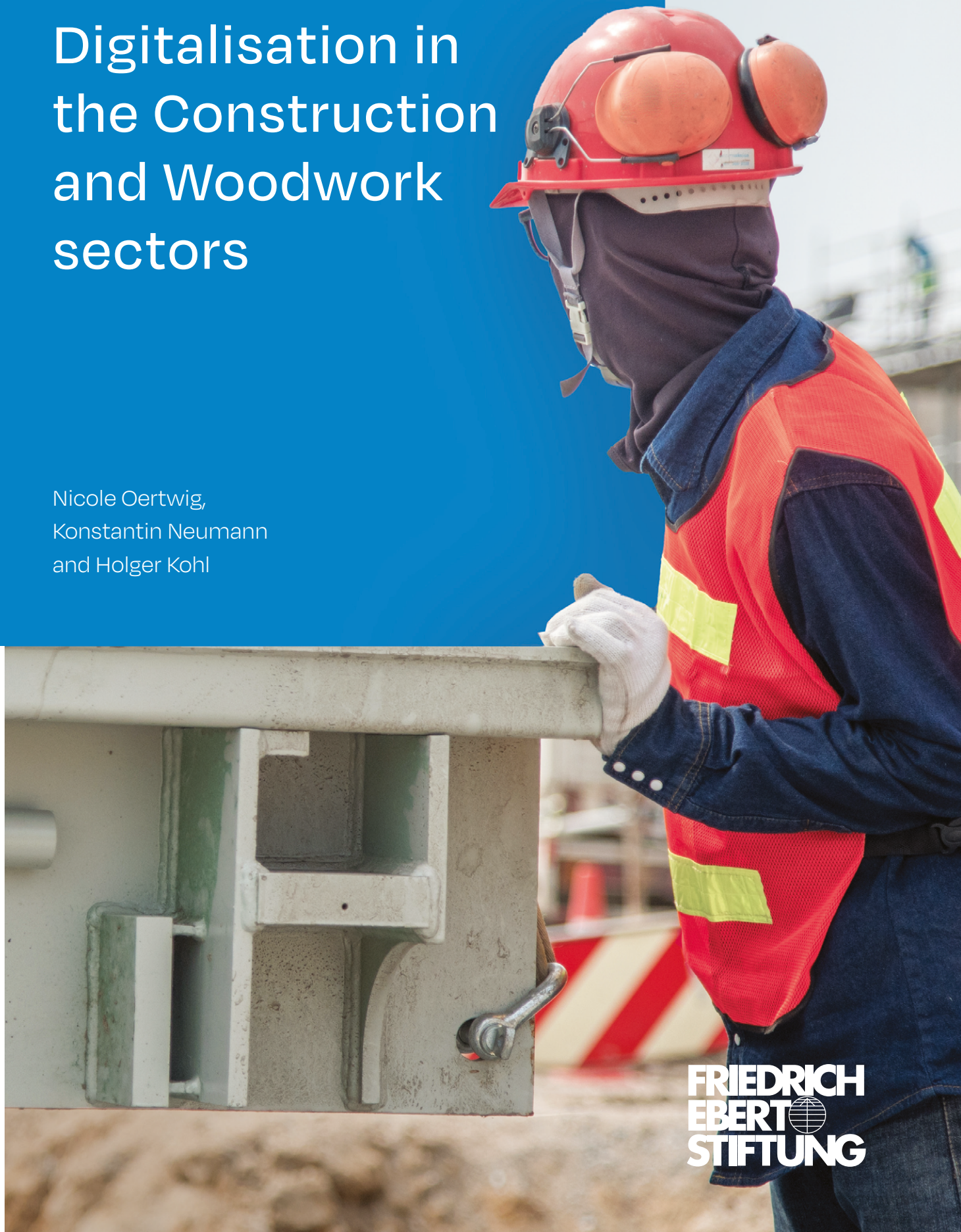

FRIEDRICH EBERT STIFTUNG

New Technologies at the Workplace

NEW TECHNOLOGIES AT THE WORKPLACE

DIGITALISATION IN THE CONSTRUCTION AND WOODWORK SECTORS

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Fraunhofer IPK

European Federation of Building and Woodworkers

EFBWW

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SUMMARY

The study investigates the impact of digital technologies on workers in the construction and woodworking sectors and how trade unions are responding to these changes. To answer these questions, an initial desk research, mainly focussing on impact, was carried out. This was complemented by interviews with trade union representatives in six different countries (Denmark, Italy, Spain, the Netherlands, Sweden, Austria).

In most cases, digital technologies, especially robots/automation and the trend towards prefabrication, were seen as having a positive impact in terms of reducing physical strain and improving occupational safety and health (OSH) and the overall working environment. At the same time, it was pointed out that new psychological strains could arise. Digital technologies are expected to improve the efficiency of processes such as planning and communication throughout the value chain. Increased efficiency and automation may lead to downsizing of the workforce, which could trigger fears of job loss. On the other hand, increased efficiency could put a halt to the offshoring of production in the woodworking sector.

All technologies require trained workers, which can be seen as a positive factor, but qualification requirements may also create pressure. The case studies indicate a shift in tasks is expected, and identify a risk of simpler and smaller tasks, which could undermine functions, reducing the need for training and hence wages. Some technologies open up the possibility of monitoring the workforce, although in the interviews positive experiences appeared to outweigh these fears. Digital technologies can also help to ensure fair pay.

The increased use of digital technologies is expected to make the sector more attractive, which is important when it comes to meeting the demand for skilled workers. This development can also encourage the green transition of the construction sector.

Downsized workforces, changes in the location of work, and employees less closely tied to their companies are changing the way trade unions operate. The blurred boundaries of the sector can make it difficult to apply collective agreements.

In most cases, trade unions see technological development as inevitable, and most representatives welcome the positive changes that digital technologies bring. Negative aspects are viewed to be avoidable if appropriate measures are taken. One recurring attitude is that trade unions should act to influence the social impact of technological developments in order to ensure positive outcomes for workers. At present, technological aspects are not typically included in collective agreements, although they are being discussed in the ongoing social dialogue, and not just during collective bargaining. Accordingly, collective agreements do not cover what is already taking place in the sectors, where technology is being introduced, albeit slowly. There are often no clear guidelines on how to include these aspects in collective agreements, although such topics are included in discussions about vocational training. At the company level, the launch of new technologies is being discussed with works councils or local trade union representatives. However, due to the many small companies in the construction sector, there is often no formal employee representation.

In general, the challenges and approaches identified in the case studies are similar at a higher level and are not related to specific technologies. While generally positive attitudes prevail, there are slight differences to be found, not only in terms of attitude, but also in approaches, e.g. views regarding where technological aspects need to be regulated. These differences should be taken into account, as should different paces in the adoption of technologies, with these differences perhaps even being greater in the Eastern European countries not covered in the survey.

Based on the findings, the following recommendations are made:

(1) Trade unions should try to take a proactive approach to digitalisation issues before it takes place on a larger scale, especially in the construction sector. This is important because the level of digitalisation in the construction sector is currently low compared to cases in the woodworking sector in this study. If trade unions could get involved at an early stage, they would have more influence.

Trade union initiatives, working in tandem with the employer side, could help build up the necessary knowledge base and cultivate a shared vision within the unions, but also between the so-called social partners (employers on the one side, labour on the other). On the basis of these results, trade

unions can provide training for trade union representatives at all levels. Initially, the focus could be on currently emerging technologies and trends such as automation, 3D printing or prefabrication. However, trade unions should keep an open mind and become more keenly aware of emerging trends. In most cases in this study, trade unions have been slow to react to digitalisation, and a speedier response would be highly important.

Based on the lessons learned from initiatives that interplay between trade unions and employers' organisations, model agreements and guidelines could be developed specifically for the construction and woodworking sectors to help individual trade unions. The »European Social Partners Framework Agreement on Digitalisation« could serve as a guideline. Guidelines like this should still allow some individual freedom. This is particularly important in the context of different trajectories of development, e.g. for larger companies and SMEs, as they have different needs. At the policy level, solutions are needed to ensure that SMEs are not left behind when it comes to digitalisation.

These trade union initiatives could also ascertain best practice in other sectors and possibly even serve as cross-sectoral initiatives on specific technologies. This would allow the construction and woodworking sector to keep pace with technological developments in other sectors and increase the influence of the trade unions.

(2) As technologies are introduced into everyday work, there is a clear need for appropriate training for workers in their initial approach to the job, but also for on-the-job training.

An important aspect of training workers is to generate curiosity and a willingness to become involved in changes among workers, possibly by presenting new technologies in an »experience centre«, e.g. a sort of innovation technology centre, or at digital hubs. Trade unions acting together with employers in relevant national bodies should define content and curricula in relation to technological development so that it is recognised at the national level. Adequate funding must be made available to ensure that these technologies are accessible in schools (educational bodies). Unions and employers should set frameworks for who is to receive training and under what conditions, so that this does not have to be negotiated on an individual basis. Finally, safety mechanisms need to be put in place for those who do not manage to upgrade their skills.

(3) Digitalisation should be included in the ongoing sectoral social dialogue and in collective agreements, as these can be leveraged to shape the social parameters of technological change. The interviews demonstrated that trade unions are aware of technological change and have ideas about how to shape its social impact, so they should now turn this awareness and these ideas into action.

Digitalisation affects tasks, which is why function-building in collective agreements should also reflect this, e.g. by adding new functions relating to digitalisation. Wages should be considered in this context, either because of the direct impact of technology or because of the indirect impact of increased skills. In the process of transformation there is a risk, particularly in smaller companies, that employee participation will be insufficient because there is no works council or similar body. Trade unions could promote the advantages and provide solutions for SMEs to involve their employees in the transformation process, e.g. by offering guidelines or best practice. If small companies adopt such practices, public procurement processes could be modified to incentivise such behaviour. Mandatory risk and hazard analysis could be one way of protecting workers from adverse conditions, e.g. in the form of new kinds of stress.

INTRODUCTION

Construction and woodworking are key industries in the European Union. The construction sector accounts for 5.5% of gross value added in Europe (Eurostat, 2023) and provides employment for more than 12 million people (2021 data) (FIEC, 2023). The woodworking industry is smaller, but still provides jobs for about 2.3 million people (CEI-Bois). The sheer magnitude means that even small improvements will have a big impact (Baldini et al., 2019), and digitalisation promises to deliver some of these improvements. However, while other sectors are already digitalised, European construction firms remain less digitalised than other sectors, even compared to their American counterparts (European Investment Bank, 2020).

This could be due to the specialties of construction projects, where different trades work on-site together to construct a building. Compared to other industries, this results in construction tasks exhibiting a high degree of complexity (Oesterreich & Teuteberg, 2016a) and considerable variations between them (Baldini et al., 2019; Koeleman, Ribeirinho, Rockhill, Sjödin, & Strube, 2019). External effects (e.g. weather) create a high degree of uncertainty (Oesterreich & Teuteberg, 2016a) and harsh conditions in which to operate hardware (Koeleman et al., 2019). There are many stakeholders involved in a project (Koeleman et al., 2019; Oesterreich & Teuteberg, 2016a) and often there is no consistent project team (Koeleman et al., 2019). Furthermore, the different lifecycles of buildings and information and communication technology present another difficulty (Baldini et al., 2019).

Not only projects, but also the construction sector with its high level of fragmentation and conservative culture poses some challenges for increased digitalisation. The sector is characterised by low investment in research and development (European Construction Sector Observatory, 2021; Oesterreich & Teuteberg, 2016a) and a low innovativeness and conservative culture (Oesterreich & Teuteberg, 2016a). Organisations are decentralised (Koeleman et al., 2019) and the sector exhibits a high degree of fragmentation – many companies are SMEs which do not have the financial means to invest in new technologies (Baldini et al., 2019). Moreover there are few IT employees in the Architecture, Engineering and Construction sector, especially in SMEs who still tend to invest – not or little in IT specialists (Baldini et al., 2019). All in all, the lack of awareness and the lack of skilled workers are the biggest barriers to overcome (European Construction Sector Observatory, 2021).

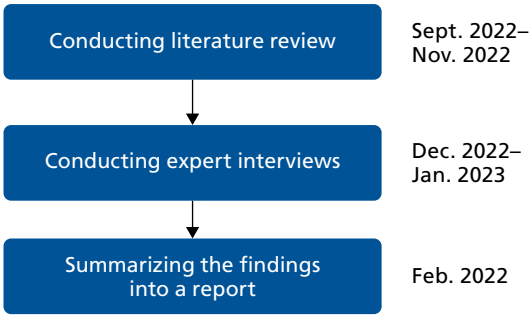
Considering the specific characteristics of the construction sector and also the woodworking sector, the present study seeks to answer the following research questions:

- How do changes in organisational processes due to new technologies impact everyday working conditions, qualification, and experiences of workers?
- What is new in terms of technology and what merely constitutes a higher degree of digitalisation of existing processes/technology?
- How can trade unions construct a collective bargaining agenda based on these findings?
- What is already regulated in collective agreements or other types of agreements?
- Are there any trade union policies on how to deal with these transformation processes?
- Are there any policies/experiences with those processes? If so, are there any types of agreements/procedures at the company level (participation in the implementation process; training; checks; involvement of external expertise, etc.)?

Fraunhofer Institute for Production Systems and Design Technology IPK was commissioned by the Competence Centre on the Future of Work (Friedrich-Ebert-Stiftung) to perform this study. The European Federation of Building and Woodworkers (EFBWW) was involved in its capacity as an associated partner.

The Competence Centre on the Future of Work was founded in 2021 by the Friedrich-Ebert-Foundation. It aims to promote the debate on the future of work by focusing on such

Figure 1:
Course of the study



areas as responsible digitalisation, new forms of work and new technologies at the workplace.

The European Federation of Building and Woodworkers is the European Trade Union Federation, grouping 76 national free trade unions from 34 countries, with members in the building, building materials, woodworking, forestry and allied industries and trades.

As part of the Fraunhofer-Gesellschaft, Fraunhofer IPK is a research and development institution working in the field of production technology in Berlin, Germany.

The scope of the research was defined with the client and its partner, the EFBWW. As reflected in the research questions, the main objective is to analyse changes in construction and woodworking from the workers' perspective and how the trade unions are responding to these changes. The research in the construction sector focuses on building construction, in particular shell construction, roofing and finishing, while the part on the woodworking sector is centred on the prefabrication of wooden products for construction purposes as well as large-scale, automated furniture production.

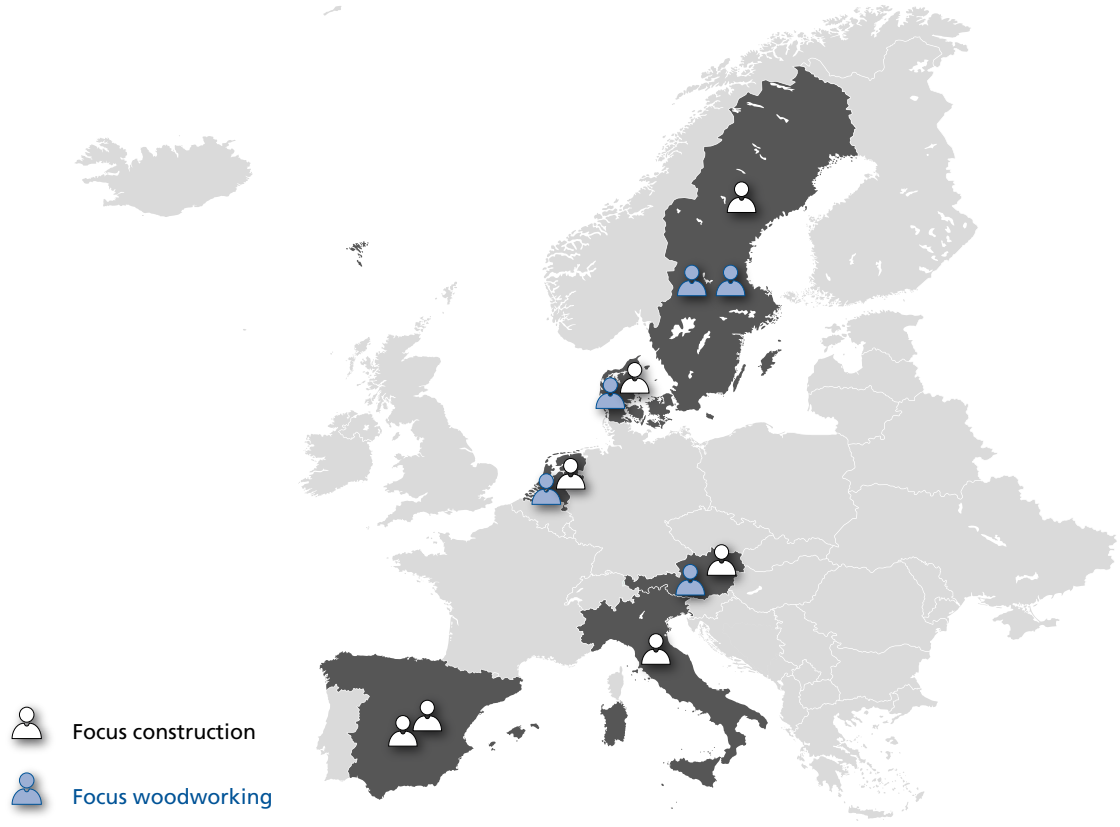
During the different stages of the study, which are highlighted in Figure 1, several progress meetings were held with the client. The first step was a desk-based literature review using scientific (SCOPUS, Google Scholar) and non-scientific (Google) search engines. The technologies selected for the first round of research are based on an initial screening. After review by the project team and coordination with the client, the set of technologies was specified. Then key words were defined for the database searches based on the scope, the technologies identified and synonyms for them. As the intention was to perform a qualitative rather than a quantitative analysis, the addition of new sources was aborted when this was not contributing any significantly new aspects. This approach was used to research applications, impacts on workers and policies. The interview guideline was derived from the results of the desk research and the research questions formulated.

The interviews were conducted as semi-structured interviews. The interview guideline is presented in annex A. It was supplemented by a short survey form that was sent to the participants before the actual interview (together with an overview of the questions and a consent form for use of data).

The countries to be included were discussed on the basis of the expected level of digitalisation and the availability of interview partners, with the EFBWW providing these contacts. In total, 9 interviews were conducted with 12 trade union representatives from 6 countries, as shown in Figure 2.

Findings from the literature review and interviews were then summarised in this report.

Figure 2:
Case studies conducted



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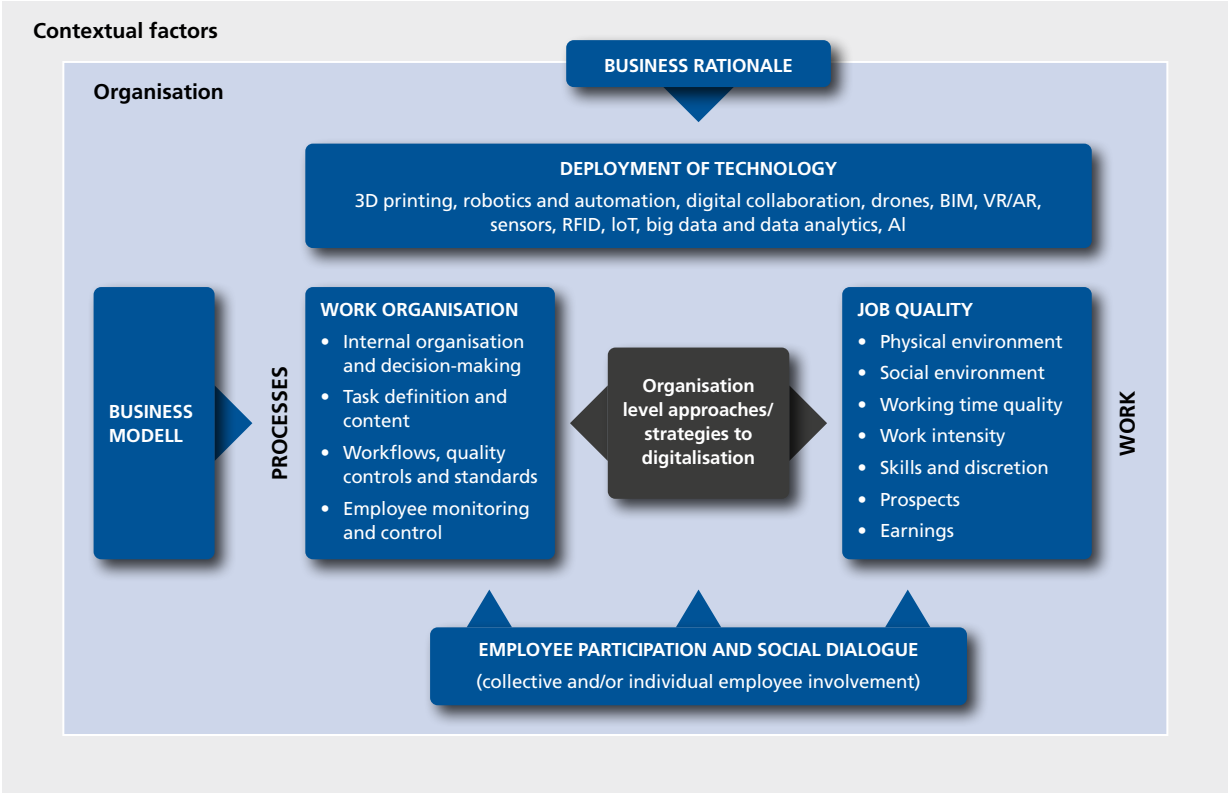
TECHNOLOGICAL DEVELOPMENTS AND THEIR IMPACT ON WORKERS

This chapter first presents the framework which is used to assess the impact of digitalisation on workers, then presents applications of technologies based on the literature. Finally, their impact is described using the framework, based on literature and interviews. In this process, the following research questions are answered:

- How do changes in organisational processes due to new technologies impact everyday working conditions, qualification, and experiences of workers?
- What is new in terms of technology and what is just a higher degree of digitalisation of existing processes/ technology?

The framework developed by Eurofound (2021), shown in Figure 3, was used for the analysis. The focus is on the aspects of work organisation and job quality and, in later stages of the research, on employee participation and social dialogue as a moderating function. Work organisation describes »how work is planned, organised and managed within companies« (Eurofound, 2022a), whereas job quality includes all »characteristics of work and employment that have been proven to have a causal relationship with health and well-being. Positive and negative features of the jobs are included.« (Eurofound, 2022b). These factors are embedded in the organisation, which has a business rationale and a business model. The organisation itself is influenced by contextual factors.

Figure 3:
Model (adapted from Eurofound, 2021)



1.1 TECHNOLOGIES AND THEIR APPLICATIONS

An extensive list of technologies was compiled during the first phase of the literature review. These technologies and their impact were summarised in the course of the project. During the interviews, it became clear that not all of these technologies currently play a role in trade union work. Figure 4 shows the topics that the representatives identified as currently relevant to their daily work, although other technologies were also mentioned during the interviews. All of these are to be discussed in this chapter, although only the technologies identified as most relevant are listed in Figure 4.

3D PRINTING

3D printing, or additive manufacturing, refers to the creation of objects from digital 3D models through the successive addition of materials (Guamán-Rivera et al., 2022) and was mentioned in several interviews (Denmark, Italy, Netherlands, Austria).

In construction, many materials can be used for 3D printing, such as concrete, plastic, metal and, in a broader sense, bricks (Goger, Reismann, & Breitwieser, 2019). Where once formwork and cast-in-place were necessary (Eurofound, 2021), it is now possible to print concrete structures such as straight and curved walls, columns, and, less frequently, beams and ceilings (Guamán-Rivera et al., 2022). Components can be prefabricated, and optimised parts such as structural supports or insulation can be printed (Guamán-Rivera et al., 2022).

In woodworking, where conventional subtractive technologies such as cutting and milling followed by an assembly step were previously used, it is now also possible to print wood-filled filaments or wood-like products which can be used to create ornaments on furniture and other products with complex shapes (Wimmer, Steyrer, Woess, Koddenberg, & Mundigler, 2018). Recently, it has also become possible to print mycelium-based furniture (Bitting et al., 2022). Furthermore, it could be feasible to integrate 3D printed metal parts into traditional construction or woodworking processes.

Figure 4:
Current involvement with technologies in the case studies

AUSTRIA		• BIM • Data protection aspects of all technologies • 3D printing
DENMARK		• Mobile communication devices • Robotics and automation incl. collaborative robots (cobots) • BIM
ITALY		• Digital data exchange and VR on union level • BIM from worker level
NETHERLANDS		• BIM • Automation • Prefabrication
SPAIN		• BIM • Drones • Digitalized applications for processes • Prefabrication
SWEDEN		• Further development of ID cards • Automation

ROBOTICS AND AUTOMATION

The automation of processes and tasks was mentioned in all the interviews. These technologies include the automation of existing equipment as well as teleoperated (human planning and manipulation), programmed and cognitive robots (Bock, 2004). Forms can range from a simple robotic arm to humanoid robots (Goger et al., 2019). It is also possible to equip humans with an exoskeleton to enhance their muscular strength and endurance (Goger et al., 2019).

Solutions such as driverless vehicles are another option for automation, which can be used especially in controlled environments with a high number of repetitions, as is the case in prefabrication and woodworking. The application in these scenarios can be compared to those in manufacturing processes in other sectors.

On the construction site, single-task robots are used for tasks such as concrete finishing, fire protection spraying, quality control (Bock, 2004), welding, lifting (Aghimien, Aigbavboa, Oke, & Thwala, 2020), and so on. Whereas in the past these tasks were carried out by humans using machines and equipment, today a human can control the automated machines or work alongside them.

As automation is easier and therefore cheaper to achieve in controlled environments with high repetition rates, the ever-stronger trend toward prefabrication is adding to this pool of technological solutions.

DIGITAL COLLABORATION, COMMUNICATION AND MOBILITY

In contrast to the aforementioned technologies, which directly change the way the construction or production is carried out, increased digital collaboration, communication and mobility, changes the surrounding factors in which these processes are carried out. These technologies are enabled by high-speed broadband connectivity and intuitive design and user interfaces using handheld devices (Agarwal, Chandrasekaran, & Sridhar, 2016). This all makes information accessible and allows the exchange of information back and forth in a virtual workspace – anywhere, anytime (Goger et al., 2019). It also facilitates collaboration and data-sharing with a single model as a single source of truth, where all stakeholders have the appropriate rights to view and modify data according to their role (Goger et al., 2019).

In the construction industry, mobile communication enables central-planning teams and on-site construction teams to connect and to share real-time information (Agarwal et al., 2016). By digitising the entire process and allowing mobile access, various aspects such as access to 3D drawings, progress and crew-tracking, quality control and many other aspects can be improved (Agarwal et al., 2016). Previously, most tasks were performed on paper or in software solutions for individual tasks (Agarwal et al., 2016), resulting in long communication processes involving management and the need to physically look things up (Goger et al., 2019).

Although the potential for digital communication and mobility also exists in woodworking, it is assumed that the impact is lower, as there is a centralised location where production takes place. End-to-end digital processes will also ensure more efficient execution in woodworking.

DRONES

Drones, or unmanned aerial vehicles (UAV), come in different varieties, such as fixed-wing, helicopter or multi-copter, which are controlled by a pilot on the ground and use a variety of sensors (Rachmawati & Kim, 2022). They can also be combined with 3D scanning to produce a 3D dataset, e.g. by optical sensing (Fobiri, Musonda, & Muleya, 2022).

In a construction context, drones can be used in the preparatory phases of earthworks surveying, where aerial monitoring provides the data to create 3D objects and maps of the building site (Heinrich, 2021; Rachmawati & Kim, 2022), e.g. to support preparation for prefabrication. During construction, they can be used for on-site management, such as progress monitoring, tracking material movements or virtual site visits, e.g. for safety inspections (Heinrich, 2021; Rachmawati & Kim, 2022). Thus they enable immediate measurement of the construction performance through images/videos and direct decision-making (Yang, Park, Vela, & Golparvar-Fard, 2015). Drones can also be used to inspect hard-to-reach structures like bridges (Goger et al., 2019; Rachmawati & Kim, 2022), as well as for the preservation of historic buildings and transportation, although the payload is limited (Rachmawati & Kim, 2022). As they can be used to track movement of people and machines, they can also potentially be used for video security surveillance of buildings (IG BAU, 2019).

BUILDING INFORMATION MODEL (BIM)

BIM can be seen as the central driver of digitalisation in the construction sector (Karmakar & Delhi, 2021). There are different forms of BIM, which in its simplest form is a 3D digital model of a construction project that contains detailed information such as specifications, materials, etc. (Goger et al., 2019). BIM can be used for accessibility planning or coordination of simultaneous processes (Goger et al., 2019). The integration of time and schedules creates a 4D BIM, which becomes a 5D BIM when costs are added (Goger et al., 2019; Karmakar & Delhi, 2021) and a 6D BIM when facility management information is included (Goger et al., 2019). Therefore, BIM acts as a digital twin, which is the central information medium of the as-is state (Goger et al., 2019).

Prior to the introduction of BIM software, tools for individual phases or tasks and different platforms that are not synchronised had to be used (Agarwal et al., 2016). The extension of conventional 3D visualisation now opens up the possibility of several applications:

- Use for improved collaborative building design and thus improved information flow during the construction process (Forcael, Ferrari, Opazo-Vega, & Pulido-Arcas, 2020; Karmakar & Delhi, 2021)
- Simulation of energy consumption (Forcael et al., 2020)

- Enabling collision resolution and detection (Karmakar & Delhi, 2021)
- Supporting design by applying a generative design principle (Karmakar & Delhi, 2021)
- Rule-based compliance checking for approvals (Karmakar & Delhi, 2021)
- Identification of potential worker safety hazards (Karmakar & Delhi, 2021)
- Project management and control (Karmakar & Delhi, 2021)
- Recording the as-is state as a digital twin (Karmakar & Delhi, 2021)
- Repair existing buildings based on 3D scan (Karmakar & Delhi, 2021)
- Simulation and planning of the demolition sequence (Karmakar & Delhi, 2021)
- Documenting everything related to a building in one place, simplifying reports (Heinrich, 2021)
- Allowing faster communication and analysis of data (Heinrich, 2021)
- Visualising projects so that changes can be made early on, enabling easier control of versions (Heinrich, 2021)
- Documentation of changes during the lifecycle to increase transparency (Heinrich, 2021)

While BIM is heavily focused on construction, a similar approach is used with computer-aided systems (CAx) in woodworking. The applications here are similar to those in the manufacturing sector, where they are already widely used.

VIRTUAL REALITY (VR)/ AUGMENTED REALITY (AR)

VR describes the simulation of real or imagined environments that can be visually experienced in three dimensions, e.g. with VR glasses, by creating right and left-eye images of a specific 3D object or scene (Okechukwu & Udoka, 2011). Meanwhile, AR enriches information from the real world by overlaying data from virtual reality (Goger et al., 2019).

There are many applications of VR and AR in construction, most of which could be transferred to woodworking, because they are application-independent visualisation tools. Most of the VR applications revolve around visualising and testing a design, identifying problems in the early stage of a project, solving complex problems through visualisation or checking progress (Heinrich, 2021). It can also be used to train various aspects such as occupational safety (Safikhani, Keller, Schweiger, & Pirker, 2022).

AR can be used in various construction tasks to display instructions and additional information (Goger et al., 2019), e.g. crane operators can be provided with a high-level overview to avoid crane collisions or loss of balance (Hajirasouli, Banihashemi, Drogemuller, Fazeli, & Mohandes, 2022). It can be used for feature recognition, where software scans the real world and compares it to a 3D model. Thus, no further identification element is needed to identify parts (Goger et al., 2019). For maintenance tasks, it is possible to provide additional information, thereby reducing time and errors (Hajirasouli et al., 2022). In problem-solving, remote experts can be involved in the process (Goger et al., 2019). Many of these applications use conventional 3D models for the same task without using AR or VR.

SENSORS, RADIO FREQUENCY IDENTIFICATION (RFID) AND INTERNET OF THINGS (IoT)

There are a wide variety of sensors and interfaces that are often combined to collect data, either embedded or via an interface (Calvetti, Mêda, Chichorro Gonçalves, & Sousa, 2020). They can be used to measure environmental conditions, generated forces, information about the condition of a building component or the status of machinery (Goger et al., 2019).

A specific form of a sensor is radio frequency identification (RFID), which describes a technology in which electromagnetic fields automatically identify and track tags attached to objects (Controltek, 2014). The tag transmits digital data, usually an identifying inventory number, back to the reader (Controltek, 2014). It can be used either as a passive tag, where the reader emits high-frequency radio waves that detect the transponder (an antenna), or as an active transponder to increase range (Goger et al., 2019). Often, these sensors are integrated into a network, creating the Internet of Things, which describes the use of sensors or actuators on inputs, outputs, components or other physical objects (Eurofound, 2018b; Ghosh, Edwards, & Hosseini, 2021). These so-called cyber-physical systems feed data via the Internet to computers which can analyse the data and manipulate the system (Eurofound, 2018b). This is therefore closely related to 5G technology, which provides fast mobile Internet.

Due to the large number of possible sensors, application scenarios are seemingly endless, depending on which devices are used. Also, the boundaries between sensors, RFID, IoT and 5G are not always clear-cut. Some examples are described below.

A combination of several sensors can be used to assess the strain experienced by workers (Calvetti et al., 2020). Personal protective equipment can be equipped with sensors to support the execution of activities (Soares Júnior et al., 2021). Furthermore, RFID tags and readers can provide workers with additional information like weights, handling instructions and assembly methods (Lu, Huang, & Li, 2011).

Wearables could be used to improve construction safety (Ghosh et al., 2021), e.g. by alerting workers to increase their awareness of unhealthy movements, or by using a real-time digital twin of the construction site to alert them in case of an emergency or threat (Agarwal et al., 2016; Heinrich, 2021; Mendoza et al., 2021). Moreover, RFID tags could be embedded into safety equipment and automatic access control would prohibit entry without the equipment (Lu et al., 2011). Similarly, RFID could be used for access control and automated time sheets (Agarwal et al., 2016; Lu et al., 2011).

Sensors attached to machines can monitor the status and the data generated can be used for preventive maintenance, thereby reducing unplanned downtime (Agarwal et al.,

2016; Heinrich, 2021; Lu et al., 2011). RFID can be used in both construction and woodworking to track objects such as machines, materials or workers (Agarwal et al., 2016; Lu et al., 2011). When sensors are applied to material, the data can be used for inventory management, order scheduling or material localisation (Agarwal et al., 2016; Lu et al., 2011). Sensors for external conditions and fuel consumption can improve the energy efficiency of machines (Agarwal et al., 2016).

Another use case involves autonomous machines and remote-controlled machines that use sensors to gather information from their environment in real-time (Mendoza et al., 2021).

All the information gathered by sensors can be transmitted in real time, allowing remote monitoring of progress and better-informed decision-making, reducing time and costs, increasing productivity and the quality of the end result, and avoiding short- and long-term problems (Goger et al., 2019; Mendoza et al., 2021).

The use of sensors even extends to the use of the building, where data can be used by occupants or facility managers. (Goger et al., 2019) Vibration sensors can be used to test strength and reliability (Agarwal et al., 2016), so they can be used to monitor structural health, e.g. through real-time monitoring (Ghosh et al., 2021).

Similar use-cases are possible for the woodworking sector, although the focus is likely to be on machinery rather than environmental variables, as the processes take place in controlled environments. These can also be compared with applications in the manufacturing sector.

Most of these applications would not have been possible without this technology, or would have required uneconomical amounts of manual data collection. This, combined with the huge number of possible applications, highlights the high disruptiveness of the technology (Eurofound, 2021).

BIG DATA AND DATA ANALYTICS

Big data describes the fast analysis of large amounts of data to generate insights, support decision-making and automate processes (Ismail, Bandi, & Maaz, 2018). The technology is closely associated with sensors and RFID, as well as IoT. For example, data from IoT devices like sensors can be analysed and used in IoT applications (Ismail et al., 2018). Big Data can also be used for resource and waste optimisation, for generative design approaches, collision detection, performance prediction or facility management (Bilal et al., 2016). Further applications are possible, mainly depending on the availability and quality of relevant data. Applications in woodworking are similar to those in construction. In the past, such data analysis was only possible to a limited extent.

ARTIFICIAL INTELLIGENCE (AI)

AI is software that can solve complex tasks by interpreting data collected from the environment and drawing conclusions based on this data (Eurofound, 2022d). It can also adapt its behaviour based on the results of previous actions (Eurofound, 2022d). Machine learning and deep learning are two approaches within artificial intelligence that use different learning approaches (Akinosho et al., 2020). The technology is often used in combination with other technologies.

Applications in woodworking are similar to those in manufacturing, and there are several possible applications in the construction industry, most of which have not been possible to this extent before:

- Use for advanced analytics (Agarwal et al., 2016)
- Controlling robots to enable non-routine tasks (Goger et al., 2019)
- Analysing data and identifying problems based on patterns (Heinrich, 2021)
- Structural health monitoring and prediction (Akinosho et al., 2020)
- Construction site safety (Akinosho et al., 2020)
- Workforce assessment and activity recognition (Akinosho et al., 2020)
- Building occupancy modelling and performance simulation (Akinosho et al., 2020)
- Building energy demand prediction (Akinosho et al., 2020)
- Construction cost prediction (Akinosho et al., 2020)
- BIM model classification (Akinosho et al., 2020)
- Software quality assurance (Heinrich, 2021)

1.2 IMPACT OF THE TECHNOLOGIES

A review by Eurofound (2021) carried out analysis of the impact across sectors, not just limited to construction and woodworking. While some technologies (like BIM) and their applications are unique to construction and woodworking, and implementation may present some difficulties due to the specificities discussed in chapter 2, it is expected that the impact on workers will be comparable to other sectors. Therefore, this review and other sources from the literature, regardless of sector, are used. These will be enriched with insights from the interviews. Based on this, the aspects of contextual factors, business model, work organisation and job quality are discussed in the following, while the aspect of employee participation and social dialogue is discussed in chapter 4.

CONTEXTUAL FACTORS

Implementing digital technologies along the supply chain can improve performance and margins. This in turn can reduce the price and enable investment in R&D by achieving higher margins. This opens up the possibility of investing in new technologies (Baldini et al., 2019).

Increased digitalisation can also improve the image of the sector and thus increase its attractiveness for (young) professionals of all genders genders (Baldini et al., 2019; CECE, 2019; García de Soto, Agustí-Juan, Joss, & Hunhevicz, 2022; Oesterreich & Teuteberg, 2016b). This view was affirmed in several interviews (Netherlands, Spain, Sweden).

BUSINESS MODEL

Platform business models and other business models based on digital technologies could disrupt the construction sector and lead to changes in management (Baldini et al., 2019; Eurofound, 2018a). This, in turn, would have an impact on the planning and contracting, but potentially also on the execution phase of construction, and thus on workers.

Externally, more IT-oriented companies might see a business opportunity in the less digitalised construction sector (Baldini et al., 2019). At the same time, there could be an increased number of digital start-ups, but currently most of them are related to environmental engineering and services (Baldini et al., 2019). Both factors would influence the general ecosystem in which workers operate.

WORK ORGANISATION

INTERNAL ORGANISATION AND DECISION-MAKING

3D printing is expected to have little impact on internal organisation or decision-making (Eurofound, 2021).

IoT can increase the amount of information available and thus influence management techniques (Grande, Vallejo-Peña, & Urzí Brancati, 2021). For example, it can support individual decision-making by providing role-specific data and also support communication between departments (Eurofound, 2021).

With the use of **AI,** there is a potential loss of autonomy over decisions (Eurofound, 2022c). It is important for AI to be designed to enhance workers' decision-making and to support learning rather than replace human decision-making (Nurski & Hoffman, 2022).

More details in the design of construction processes through the use of **BIM** could lead to better integration of departments (Syben, 2018). BIM can support faster communication on-site, off-site and along the supply chain, thereby influencing decision-making (Heinrich, 2021).

AR and **VR** can support greater individual decision-making (Eurofound, 2021).

By collecting data or making information more accessible, **drones**, **RFID** and other **sensors**, especially when combined with **Big Data,** can support data-based decision-making. This can be further enhanced by digital collaboration tools that allow workers to access information (Kölzer, 2021), make decisions potentially without the management, and speed up communication.

As roles change, so does the organisational structure, moving from fragmentation of planning and execution to a platform-based integration. At the same time, the building owner becomes more involved in all processes. (García de Soto et al., 2022)

On the other hand, one trade union in the case studies expects only little in the way of changes in organisation, as people will continue to work in teams and according to lean processes in the future (Denmark).

TASK DEFINITION AND CONTENT

The digitalisation of processes may lead to changes in tasks and therefore in job profiles and job locations (Di Nunzio & Rugiero, 2021; Eurofound, 2018a; Goger et al., 2019). For example, **sensors** (Goger et al., 2019) or **drones** could change the location from on-site to a more remote-based approach.

Tasks are expected to become more complex and workers will be required to actively retrieve information from systems (Goger et al., 2019). There will also be an increased need to manage, monitor and control automated processes and plan processes, as machines will carry out more tasks (García de Soto et al., 2022; Goger et al., 2019). At the same time, it is expected that there will be an increase in corrective actions when planned routines fail and that more collaboration will be required between the parties involved (Goger et al., 2019).

Activities will be planned in more detail in advance, so practical knowledge which can be provided by supervisors and forepersons will be needed at earlier stages. Especially supervisors will be involved in planning steps to minimise potential practical risks. At the same time, supervisors and forepersons will be required to do increased scheduling tasks. Forepersons and labourers need to control the execution of work with support of new technologies, while supervisors will monitor processes from a control room and provide support in case of problems. (Goger et al., 2019)

Another view of how roles change with the use of **robots** in a construction project is presented by García de Soto et al. (2022). In their case study, the authors suggest new roles surrounding digital fabrication (dfab). They propose the roles of dfab technicians for the actual **robot** system, dfab programmers for the control and dfab managers/coordinators for the supervision of the project. In the planning phase, the task of the dfab manager is to provide advice on automation options. Later, this role shifts to that of a strategic advisor. The dfab coordinator works mainly with the **BIM** throughout the whole project until the model is handed over to the owner. The dfab programmer on the designer's side coordinates the software and organises data storage. The dfab programmer on the contractor's side has to derive the programmes for the machines to be used from the BIM model. The dfab coordinator supports the entire process by checking the planning and by coordinating between different contractors. During the execution of the project, the role of a conventional construction worker would shift to that of a dfab technican, who would set up and operate machinery. All in all, there are some changes in existing roles, although they are generally still needed. (García de Soto et al., 2022)

New roles (e.g. BIM manager and BIM coordinator) could weaken the professional authority of existing roles, but at

the same time existing personnel could fill these new roles (Sherratt, Dowsett, & Sherratt, 2020; Syben, 2018). The view that current team leaders could fill the role of highly specialised and trained individuals is shared by Goger et al. (2019). A risk of undermining existing functions was seen in one case (Netherlands).

BIM enables individual task planning, and regular changes depending on construction status and administrative tasks could be digitally supported, potentially even automated (Goger et al., 2019). There may be less control over tasks, as these are defined by BIM-enabled architects (Schober, Hoff, Lecat, Thieulloy, & Siepen, 2017).

The introduction of **3D printing** will automate the creation of the building itself, thus shifting workers' tasks more to pre- and post-processing steps, while reducing physical material handling (Eurofound, 2021). For manual workers, there will be a shift to more cognitive tasks (Eurofound, 2021).

IoT will lead to a shift from manual and routine tasks to managerial and analytical tasks (Eurofound, 2021). Similarly, **Big Data** is expected to reduce manual analytical tasks. No major changes are expected from the introduction of **RFID**.

Depending on the implementation of **AI**, it could remove, complement and support human tasks or create new tasks (Selenko, Bankins, Shoss, Warburton, & Restubog, 2022). A similar mixed result was found for **AR** and **VR**, which could enrich or simplify tasks (Eurofound, 2021).

For routine processes, **robots** can achieve greater efficiency due to faster movements and higher precision, allowing workers to use their time to focus on processes where automation is not possible (Heinrich, 2021). The use of robots therefore reallocates or re-bundles tasks, which can lead to more repetition and a smaller scope, which in turn leads to fragmentation (Nurski & Hoffman, 2022).

This risk was also seen in the case studies, as **automation** could increase taylorisation through small repetitive tasks. There are measures to mitigate this which could even be implemented individually for each worker, such as job rotation. Parallel to this, a lot of very simple manual tasks are reduced. (Austria)

A risk of taylorisation, which should be avoided and, instead, competencies expanded to enrich tasks, is also seen in Sweden (Sweden).

WORKFLOWS, QUALITY CONTROL AND STANDARDS

Many technologies make more information possible, which makes everything clearer and easier to understand, thus enabling better processes (Italy). For example, **BIM** has the advantage of fewer change requests, reduced time for information requests, improved transparency (Schober et al., 2017) and optimised workflows for data acquisition (Syben, 2018). This could increase quality and reduce information costs.

Other digital technologies are also expected to improve processes. **3D printing** creates more efficient and stable workflows (Eurofound, 2021). The same can be said for **IoT**, which improves quality control and optimises workflows, which can subsequently lead to better planning (Eurofound, 2021). **AR** and **VR** can visualise projects early on, allowing for early changes, which in turn improves processes (Eurofound, 2021).

Many technologies, such as **RFID**, **sensors**, **drones** or **Big Data** improve quality control and optimise workflows and processes through the availability and analysis of data, which in turn leads to better planning and reduces the time needed. Implementing standards in digital tools and applications ensures compliance.

Robots and **automation** can create collaborative workflows, greater precision and improved quality control, and also shorten process chains by integrating tasks.

The use of **digital communication tools** and a generally higher level of digitalisation can lead to better planning and improved processes (in terms of efficiency). These create a better overview, improve communication and collaboration, ensure better flow and continuity, reduce errors and create a common language across the value chain. (Denmark)

This view is shared in the case of Italy, where technologies are seen as a way to provide more information, making everything clearer and easier to understand, thus facilitating better processes (Italy).

EMPLOYEE MONITORING AND CONTROL

Most technologies enable collection and subsequently analysis of data. In all cases where personal data is collected, there may be privacy concerns for workers. This data could potentially be generated indirectly by **robots** and **automated machinery**, by **BIM** models that track construction status and task completion, or by **drones** that could also be used to monitor site status. In addition, the data in digital collaboration tools could potentially be used to track workers and **AI** could be used to analyse worker performance (Nurski & Hoffman, 2022). This is less of a concern in the case of **3D printing** (Eurofound, 2021).

For **AR** and **VR,** privacy concerns arise when these are combined with other potentially more invasive technologies, such as IoT (Eurofound, 2021). In particular, **IoT** can open up the possibility to closely monitor employees, which means that employee data could potentially even be used for other purposes (Eurofound, 2021). Sensors play a special role in the context of IoT. Some sensors, such as wearables, allow for assessment of productivity (Calvetti et al., 2020), thus opening the scope for close monitoring of employees. Other **sensors** and **RFID** could also broaden the scope for employee monitoring when their data is collected through these technologies. This risk was seen in one case (Spain) and is particular important to consider when **Big Data** is used to analyse the data. However, one case study observed that the data was not used to monitor and control workers and that

the full potential of the information collected was not being exploited (Grande et al., 2021).

The risk of increased monitoring was seen in nearly all cases. However, this was put into perspective in the same sentence. In Denmark the risk was offset by positive experience with the ID card, which could be used for monitoring as well, and collaboration between the social partners regarding these issues. In Sweden and Italy, it was argued that companies are often very small and it was therefore already possible to monitor employees in the past, so it involves rather a shift from physical to virtual monitoring. Additionally, in Sweden it is argued that a strong union mitigates the effects, while in Austria company agreements were mentioned as a way to mitigate negative effects.

The increased availability of data might also create some opportunities. In Italy, for instance, the acquired data was seen as making it possible to facilitate administrative processes. In Sweden, increased monitoring is seen as a chance to prevent exploitation of workers, e.g. by better control of working time, while possible negative effects can be mitigated through appropriate measures.

JOB QUALITY

PHYSICAL ENVIRONMENT

Digitalisation presents opportunities for occupational safety and health (OSH). It is expected that safety can be improved and therefore the number of fatal accidents can be reduced by new technologies and changed processes (Baldini et al., 2019; Di Nunzio & Rugiero, 2021; Oesterreich & Teuteberg, 2016b).

As for the positive effects of increased digitalisation on OSH, reducing physical strain due to less repetitive work, less heavy lifting, less uncomfortable working positions and an increased distance to dangerous and hazardous environments were among the most frequently mentioned positive, and impacts expected expected (Denmark, Netherlands, Sweden, Austria, Italy and Spain). Indirectly, the trend toward prefabrication will also improve the working environment (Austria and Netherlands). Better ergonomics will in turn improve health at older ages (Austria).

Looking at the specific impact of some technologies, **3D printing** will reduce material handling and therefore can reduce physical strain (Eurofound, 2021). New materials for 3D printing could pose a physical risk, but this could be mitigated by health and safety measures (Eurofound, 2021). **IoT** reduces the physical risk, but potentially increases the exposure to ergonomic risk (Eurofound, 2021). Similarly, more **digital tools** could shift tasks to more remote work and sedentary work, which could create new risks (Nurski & Hoffman, 2022).

The use of **robots** can reduce the risk of injury due to high loads or repetitive tasks, while risk to workers due to dangerous environments can be reduced (García de Soto et al., 2022; Heinrich, 2021). At the same time, more sedentary work could impose new risks (Nurski & Hoffman, 2022). The same goes for collaboration between humans and robots, which might create new risks and has also shown mixed effects on stress (Nurski & Hoffman, 2022). Other studies found no effect on the physical environment (Antón, Fernández-Macías, & Winter-Ebmer, 2021).

AR and **VR** could have a positive impact on the physical environment, although there is a risk if worn for a long period (Eurofound, 2021), and reduced situational awareness when using AR and VR can pose new threats (Kölzer, 2021).

AI in combination with **sensors** like **RFID** could potentially help to avoid dangerous situations (Goger et al., 2019; Nurski & Hoffman, 2022). **BIM** can be used for safety rule checking and design validation as well as for safety training (Matthei, 2021) and therefore also improve OSH. **Big data** is not expected to have an effect on the physical environment. **Drones** could reduce exposure to hazardous environments and thus improve construction safety e.g. by asbestos screening (Spain, Sweden).

SOCIAL ENVIRONMENT

Digitalisation can also have an impact on the social environment in which workers operate. **3D printing** has led to an increase in social interaction between departments and roles, while for **IoT** and **AR/VR** the degree of social interaction depends on the particular application and method of implementation (Eurofound, 2021). Also with regard to the use of **robots,** there are different conclusions regarding the effect on the social environment, depending on implementation (Nurski & Hoffman, 2022).

AI could result in a reduced social identity as well as self-worth of workers if humans are displaced or their decision-making is not required anymore (Eurofound, 2018b). When used to instruct workers, it reduces contacts and communication (Nurski & Hoffman, 2022).

BIM results in more interaction and less centralisation (Huang, Wu, Chen, Lu, & Xiang, 2022). **Drones** could reduce social interaction, as they open up the potential to shift work from on-site to remote work, e.g. with surveying. Similarly, digital tools could change the communication channel from in-person to a virtual communication. **Sensors** and **RFID** as well as **Big Data** are not expected to change the social environment.

WORKING TIME QUALITY

3D printing, **AR/VR** and **IoT** are not expected to change working time arrangements, but help use time more efficiently (Eurofound, 2021). The same assumption could be made for the use of **BIM**, **drones**, **sensors** and **Big Data**. Even when **IoT** is used, 24/7 production shifts continue to apply (Eurofound, 2021).

While remote operation of automated equipment is possible, supervision in person or on-call availability is still necessary and might erode predictable schedules (Eurofound, 2018b).

As high equipment utilisation rates are favoured, they might even increase 24/7 work (Goger et al., 2019).

AI could have negative effects when it is used for scheduling work (Nurski & Hoffman, 2022).

Digital communication could become more widespread and blur the lines between work and leisure, although this is probably less of a concern for construction and production workers than for office workers.

WORK INTENSITY

There is the risk of increased psychological stress (Oesterreich & Teuteberg, 2016a). For example, as workers take on more responsibility, e.g. in the form of problem-solving for automated processes (Goger et al., 2019). This was seen in one case study as well, where it was noted that everything is getting faster, e.g. in the case of troubleshooting, which requires fast and correct reactions from the employee, thereby increasing stress (Austria).

While other case studies in the construction sector found there has been a general intensification of work, they also highlighted the ambivalent development of new risks on the one hand, e.g. due to the quickening pace of work and new opportunities on the other, e.g. reduction of the workload through automation or monitoring of irregular work (Di Nunzio & Rugiero, 2021).

With regard to **3D printing,** effects on work intensity depend on different factors. For **IoT,** a greater work intensity during the implementation was observed, as there was a need to adjust processes. This was especially the case when there was no formal training. This greater work intensity then decreased for operational staff, while an increase in work pressure was observed for those in managerial positions who analyse large amounts of data. There was also an increase in work intensity when the technology sets the pace of work. For **AR/VR** insufficient training resulted in stress as well. (Eurofound, 2021)

Both observations show that insufficient training causes stress and that during the implementation there is an increased work intensity, which can probably be assumed to apply to other technologies as well. In one of the cases it was also highlighted that lack of experience with the new tools creates stress (Denmark).

While **AI** could have negative effects when used for scheduling work (Nurski & Hoffman, 2022), monitoring **robots** could lead to mental exhaustion (Nurski & Hoffman, 2022) and the relegation to a secondary role may result in alienation from work (Eurofound, 2018b). Past data shows an increase in work intensity (Antón et al., 2021) and that there are mixed results on stress when there is collaboration with robots (Nurski & Hoffman, 2022).

With the increase in use of digital collaboration tools in other sectors, there has been an intensification of the work pace (Green and McIntosh 2001 in Antón 2021), while other findings indicate no intensification due to increased computer use (Menon, Salvatori, & Zwysen, 2020).

However, unstructured data could increase stress (Goger et al., 2019), e.g. when data is generated by **RFID**, **sensors** and **drones,** when analysis is performed by **Big Data,** but also when workers have to get data from the **BIM** themselves.

In the case studies, it was also mentioned that if the tact is set by automated machines it can cause stress and that an increased focus on time and efficiency will also result in more pressure and stress (Denmark).

SKILLS AND DISCRETION

The changes due to new technologies will also lead to changes in the skills and competencies of workers, with increased technological and digital competencies being required (CECE, 2019; Goger et al., 2019; Oesterreich & Teuteberg, 2016a). It is argued that while limited digital skills may be still suitable for entry-level positions, advanced skills are required to progress beyond these (Carson, 2020).

The management level is no longer required for certain steps, as the labourer's knowledge allows them to prepare decisions, be involved in the design of processes and implement them. Workers can also be involved in preparing actions to be taken in case of problems. (Goger et al., 2019)

In general, people need to develop a flexible mindset to solve problems creatively, understand tools and their data and to know when to use them (CITB, 2018). While everyone needs a basic understanding of the technology, different levels of digital competency can be differentiated and linked to different organisational levels (CITB, 2018). Highly specialised, trained individuals are required, which requires time and training (Goger et al., 2019). The importance of learning and the willingness of both the organisation to provide funding and workers to participate in training is obvious (Grande et al., 2021).

IT skills and a basic knowledge of the technology being used are required to enable workers to carry out the task of controlling and monitoring machinery. Supervisors, forepersons and other management roles will require competencies in software programmes like BIM. (Goger et al., 2019)

Construction will become more standardised in factory-like spaces, followed by assembly on-site, which will also require a broader set of skills. As a result, a reduction of unskilled labourers and middle management is expected, possibly offset by a shift in responsibilities and new roles. At the same time, there will be the need for »special troops« who solve unexpected problems, require practical experience, detailed technical knowledge and problem-solving ability. (Goger et al., 2019)

Workers will increasingly collaborate digitally, requiring knowledge of processes and software. At the same time, social skills will become even more important. Labourers

can be trained to control, monitor and manage automated equipment. However, due to an increase in automation, experience and manual skills may become more difficult to obtain. (Goger et al., 2019)

3D printing will result in an adjustment of skills, depending on the context and the sector. There will be a greater emphasis on design and planning skills. Thus, workers will become more dependent on designers. Skills will be acquired on the job rather than through formal training. For managerial and engineering positions, the use of **IoT** provided greater job discretion and new digital and analytical skills. For production and assembly workers, the opposite was observed. For them, job autonomy was reduced and a task-driven work organisation with limited work autonomy was observed. For blue-collar workers, the acquisition of basic digital skills and technology-specific skills is driven by IoT. These skills are not necessarily transferable to other companies, however. At the same time, digitalisation results in upgraded job profiles if upskilling and training are provided. **VR** and **AR** can enhance workers' capabilities and skills, while there is little change in work autonomy. (Eurofound, 2021)

The use of **BIM** requires new related skills (Schober et al., 2017), as does the use of **AI** (Eurofound, 2022c). When AI is used to instruct workers, it could be used to complement skills (with visualisation devices such as AR) and support on-the-job learning (Nurski & Hoffman, 2022).

Drones, **Sensors** and **Big Data** are likely to require new skills to operate and use the data they collect.

There are mixed findings on **robot** skills. Some argue that digital skills are needed to interact and operate (Carson, 2020) and might even lead to multi-skilled roles, e.g. when one worker in off-site construction builds entire modules using automated equipment (CLC, 2019). Others show no effect (Antón et al., 2021) or even a loss of skills (Nurski & Hoffman, 2022).

One study indicates a small positive effect of computerisation on skills (Menon et al., 2020). It can therefore be assumed that more digital skills are needed to use digital collaboration tools.

The change in skills required was also mentioned in many cases. In general, digital technologies require a different skillset, and as work becomes more complex, a lot of up- and reskilling is needed (Sweden). The challenge is that workers have to be able to utilise the system, e.g. BIM, to input and extract relevant information, which requires new skills to understand data (Italy). This view was spelled out in more detail in another case where it was highlighted that workers need to be able to assess, interpret and understand data (Denmark).

There is hope for more qualified jobs, although there is a risk of losing the least skilled. It is therefore important to train workers in new trends and technologies (Spain).

Increased skill requirements for **robots** and **automation** can be seen as something positive, but this may also put additional stress on workers, as they need these skills to continue their job (Austria, Sweden, Denmark).

Due to automation, there is a larger gap between simple manual tasks and responsibility for a machine (Austria). Training makes it possible to bridge this gap (Austria). However, as there are also some individuals who cannot manage this, social solutions are needed (Sweden, Austria).

Although there is less demand for labour, at the same time there is a shortage of skilled workers. Reskilling existing workers in other trades is time-consuming and costly, and is often not carried out, instead being dealt with by means of natural outflow of labour. Reskilling was already hard, but automation has made it even more difficult. (Austria)

VR can help to integrate training of new tasks and health and safety aspects (Italy).

In the interviews **3D printing** was viewed rather critically, one argument being that it frustrates people because little is known about it (Denmark).

Regarding discretion, it was mentioned that workers have less influence on work and have less freedom, e.g. due to prefabrication. This undermines existing functions and simplifies tasks. (Netherlands)

In-depth analysis of the shift of skills and competencies in the furniture sector can be found in the Digit-Fur (Rumignani, Fuentes, & Monleón, 2019) and Sawyer (Rumignani, Fuentes, & Monleón, 2021) project summaries.

PROSPECTS AND EARNINGS

Automation opens up the possibility to replace humans with machines, at least for certain tasks (Eurofound, 2018a), which means that workers could fear losing their jobs (Oesterreich & Teuteberg, 2016b). Several studies have attempted to quantify this effect, with different results. In general, repetitive tasks are easier to automate (Baldini et al., 2019). Based on the RTI index, which measures intensity of routines, it can be assumed that »craft and trade workers« and »workers in elementary occupations« will be most affected by increased digitalisation (Baldini et al., 2019). Migrant workers in particular are potentially more vulnerable to job automation than non-migrants, as their tasks are more likely to be automated (Baldini et al., 2019). While there is a risk that jobs could be lost due to rationalisation or automation, there is also a chance that new jobs with new requirements can be created (Goger et al., 2019).

Other sources suggest that automation neither creates nor eliminates entire occupations, but rather changes the way these professions are performed and may also affect the number of people employed in an occupation. Young entry-level workers are more vulnerable, as they lack the specialised skills that will be needed even after automation. A low level of education and hence a lack of digital skills

increases this risk. Women are also more affected, possibly because they are underrepresented in higher-skilled and senior positions. (Carson, 2020)

Automation also reduces entry points and makes it more difficult to move up the career ladder, reducing opportunities for workers with low levels of education or facing other career barriers. At the same time, it restricts upward mobility into skilled positions, intensifies shortage of skilled workers and slows down diversification efforts. Lower skill levels can result in lower wages, with entry level positions being prone to elimination due to automation. (Carson, 2020)

Furthermore, there is the risk that the distribution of skills will shift, with skilled labourers being replaced with either highly skilled or unskilled workers (Sherratt et al., 2020). This view is shared by Hirsch-Kreinsen (2016) with regard to the general effects of digitalisation, but not specifically in construction or woodworking. It is argued that while there are many possibilities for work organisation, these are limited by two poles. On the one hand, there could be a highly heterogenous organisation, with a small group performing very simple tasks and a new group of highly skilled workers (above current skill levels). On the other hand, there could be a very homogeneous structure of qualified and equal workers (Hirsch-Kreinsen; Hirsch-Kreinsen, 2016). Some sources argue that the gap between high- and low-level jobs will grow in the construction sector (CECE, 2019).

Looking at specific technologies, **3D printing** skills gained on the job could create greater career opportunities, and as processes become more efficient, this could be reflected in wages (Eurofound, 2021). In a case study performed by Grande et al. (2021), an indirect increase in wages by raising qualification requirements for 3D printing was observed.

IoT improves job opportunities for engineering and managerial positions (Eurofound, 2021). While one study suggests that IoT could have an effect on wages if it is used to monitor employee performance (Eurofound, 2021), another study found that there are no direct effects of IoT on earnings, but the average wage increased by raising qualification requirements (Grande et al., 2021).

VR and **AR** have no direct impact on wages or career opportunities (Eurofound, 2021), but raising the qualification also increased the average wage (Grande et al., 2021).

The use of **robots** is reported to have mixed effects on employment and wages (Antón et al., 2021; Nurski & Hoffman, 2022) and a potential risk of displacement when automation is combined with AI (Eurofound, 2022c). The use of **AI** in general requires digital skills (Eurofound, 2022c), which could result in higher average wages. If it is used to instruct workers, however, it puts a downward pressure on wages, devaluating them because less skills are needed (Nurski & Hoffman, 2022).

Drones are not expected to have a direct impact on wages, but there could be greater job opportunities through increased skills. **Digital collaboration** tools, **BIM**, **sensors** and **Big Data** could have an impact on wages if data is used to monitor employee performance. At the same time, it could also lead to better job opportunities.

In the interviews, the potential decline in the number of workers due to **3D printing** was mentioned, while at the same time this was qualified, as similar developments were expected with **robots**, but there might be a shift to more office workers (Netherlands). The view that the workforce could shrink due to application of 3D printing, but also other technologies, was shared in another interview (Austria). New construction methods, e.g. prefabrication, may also lead to job losses (Spain).

Also, the effects of increased efficiency vary. While in some cases this may prevent jobs from being relocated abroad (Denmark, Sweden), in other cases a risk of job losses is perceived (Sweden, Austria). In addition, improved process efficiency strengthens the economic position of the company, which in turn improves job security (Austria). Whether digitalisation helps to prevent offshoring of jobs depends of course on the sector in question. While it may be possible to relocate production facilities in woodworking and prefabrication of construction, it is obviously not possible to relocate the construction site itself.

Furthermore, the use of **sensors** and **digital collaboration and communication** can enforce fair pay and the use of contracts (Italy).

As only simple tasks need to be performed, people receive less training, which poses a risk of reduced wages (Netherlands).

Workers with higher skills are less replaceable (Austria, Sweden) and higher skillsets may also be rewarded in wages (Sweden). Higher skills and their certification also open up job opportunities outside the sector when jobs are cut (Sweden).

Using the impacts identified, a modified SWOT analysis was carried out as shown in Figure 5. This answers the following questions:

- Strength – What are the strengths of the technology for workers?
- Weakness – What are the weaknesses of the technology for workers?
- Opportunity – What are the opportunities of the technology for the trade union?
- Threat – What are the threats of the technology for the trade union?

Annex C summarises impacts in the view of the interviewees. All in all, most representatives saw technological developments as rather positive for the workers. This is in line with surveys in the literature (Voss & Riede, 2018). One of the most frequently mentioned positive impacts was reduced

Figure 5:
SWOT Analysis based on the case studies

STRENGTHS	• Reduced physical strain • Improved OSH • Increased qualification • Increased efficiency, output and quality, increased job safety • Qualified workers are less replaceable • Impact on planning and process improvement (efficiency) • create better overview and improve communication and collaboration • ensure a better flow and continuity • reduce errors and create common language across the value chain • Improved training • Better working environment • Improved ID can prevent exploitation	• Qualification creates pressure • Smaller tasks "taylorisation" • Increased gap of easy and complex tasks • Potential monitoring • Psychological stress • Job loss • Less influence on outcome, less freedom • Function hollowed out • Simpler tasks create risk of less training and therefore reduced wages • Reduction of workforce	WEAKNESSES
OPPORTUNITIES	• Ensure fair pay and the application of contracts • Increased attractiveness of the sector • Supports green transition • Improved efficiency → stop relocation abroad	• Reduction of workforce • Blurred lines of sectors make application of contracts more difficult • Trade union work gets more difficult, less people, mixed trend of decentralisation and centralisation • Changes in social partnership as people are less attached to companies	THREATS

physical strain. Despite being frequently mentioned in the literature, monitoring was less of a concern for most representatives. This may be due to the fact that regulations are in place and there are positive examples where the social dialogue has shaped these processes.

2

EXISTING POLICIES AND THE APPROACH OF THE UNIONS

This chapter provides an overview of existing agreements, laws, etc. These were for the most part identified during the interviews. The aim was to answer the following research questions:

- What is already laid down in collective agreements or other types of agreements?
- Are there any trade union policies on how to deal with these transformation processes?
- Are there any policies/experiences with these processes? If so, are there any types of agreement/procedure at the company level (participation in the implementation process; training; checks; involvement of external expertise, etc.)?

In general, policies can encourage the adoption of new technologies and further R&D (European Construction Sector Observatory, 2021; Oesterreich & Teuteberg, 2016a). The fact that legislation can have a major impact on the uptake of new technologies was also voiced in the interviews (Denmark).

In Spain, developments in the sector are influenced by developments at the European level, such as the »Declaration about digital principles and rights« of December 2022. Furthermore, at the national level, digitalisation is driven (not only, but also) by legislative changes. It is therefore a mixture of international and national policies that influence the construction and woodworking sector. (Spain)

Regarding BIM, there is an EU directive on public procurement which has been implemented in some Member States (European Construction Sector Observatory, 2021). In Denmark, such legislation was introduced in 2008, requiring all public and non-profit housing construction to use BIM and project web (an electronic document management) (Denmark). In Italy, there is also legislation from 2022 governing the use of BIM, which already increased the utilisation rate (Italy).

With regard to 3D printing in the construction sector, regulations governing its application are lacking. However, the technology itself is expected to grow as policies and some regulations are adopted to foster its application (European Construction Sector Observatory, 2019). Regarding the use of drones, regulations have been put in place to protect from abuse and at the same time foster adoption (European Construction Sector Observatory, 2021). The cases also highlighted legislative discussion on the European Level regarding Big Data and AI (Italy, Sweden).

With all technologies, there has been an increase in the availability of data and therefore an increase in privacy concerns. Data security and governance are part of the data strategy (European Construction Sector Observatory, 2021). The General Data Protection Regulation (GDPR) influences several technologies where data might be collected: construction site access cards, wearable technology, sensors, IoT, smart buildings and collection through software, e.g. BIM, digital building logbooks (European Construction Sector Observatory, 2021). The GDPR is seen as a central element to consider, as private data is often collected (Austria).

In January 2023, Denmark introduced a new regulation on sustainability which requires certain documents, where technologies can help and sustainability and digitalisation are to support each other. Additional requirements for life cycle assessments of building materials will push technologies even further. (Denmark)

At the national level, most strategies for the construction sector focus on e-government and e-public services as well as on resource and energy efficiency. Several digital construction platforms aim to promote networking, knowledge-sharing, training, etc., which is important due to the high fragmentation of the sector. (European Construction Sector Observatory, 2021)

Several initiatives have been launched to foster skill development, such as the Construction Blueprint and the European Skills Agenda (European Construction Sector Observatory, 2020, 2021). Many initiatives have been found relating to digitalisation of the sector, e.g. in the form of roadmaps as well as skills development. Such legislative requirements and initiatives promote the application of technologies above and beyond the economic interest of companies.

Whenever a new technology is introduced, it triggers a transformation process which influences work organisation and job quality. This is where worker participation and social dialogue come in, both at sectoral level, e.g. in the form of collective agreements, and at company level, e.g. in the form of company agreements.

At company level, social dialogue is particularly important, as it is needed to build trust, ensure employee involvement in the process to create acceptance, and to take into account employees' views on work organisation and job quality (Eurofound, 2021). Employee participation in the twin transition resulted in favourable conditions for both workers and companies (Bednorz, Sadauskaitė, Czarzasty, & Surdykowska, 2022).

The case studies conducted by Eurofound (2021) found that when a specific problem needed to be solved, a more top-down approach was used. Approaches were company-specific and dependent on the purpose. Regardless of the existence of a formal employee representation body, there was limited employee involvement in the transformation process. (Eurofound, 2021)

Furthermore, Bednorz et al.'s (2022) case studies of twin transition found that employees were mostly involved directly and in relation to their workplace, while their impact at company level was rather low. The involvement of employee representatives varied (Bednorz et al., 2022).

In the case studies conducted during this project, the transformation process was influenced by either a local trade union representative or a works council. This highlights the problem that smaller companies, of which there are many in the construction and woodworking sectors, often lack this form of formal employee representation.

In Denmark, employee participation is laid down in the Co-operation Agreement from 1947 as amended in 2006, which was concluded by the FH (the trade union side) and DA (the employer side). It stipulates how employers and employees are to cooperate and thus influences working conditions (Denmark).

In Italy, changes in production processes and management of workforce have to be negotiated locally with the union side (Italy).

In the Netherlands, the transformation process is regulated by works council legislation, which requires agreement on major changes and applies to changes in general. At small companies there are also small groups (PVT employee representation), but these are not covered by legislation protecting works councils. Due to the high fragmentation of the sector, there are a lot of very small SMEs as well as (bogus) self-employed flex and migrant workers who do not meet the threshold for a works council. While in the metal-working industry works councils have a strong influence, this is not the case in the construction sector. Thus, trade unions should have more influence because they have more leverage, but at the moment they are often not involved in changes at the site. (Netherlands)

In Austria, in large companies this is a topic discussed by supervisory boards (which are also made up of employer/employee representatives). It is more difficult in very small companies where there is no works council and therefore limited employee influence. Local trade union representatives also talk to companies and try to influence them. Where there is a works council at company level, there is a dialogue that leads to company agreements that also include technological aspects. Some company agreements are mandatory because they are required by higher law, e.g. monitoring of human dignity measures, as otherwise these measures cannot be implemented. These are also monitored externally. There are also voluntary agreements that are not required by higher law. In fact, most of these are mandatory because they relate to personal data. These agreements are negotiated by works councils with the employer and sent to the social partners for them to review legal aspects. These company agreements are very specific. (Austria)

In Sweden there are local company agreements in addition to collective agreements which set a national level as a lower standard. These local agreements have to be negotiated by trade union representatives at the workplace in the case of significant changes that affect employees. These are regulated by codetermination provisions in the Working Life Act and the Work Environment Act. (Sweden)

Social dialogue at the national and EU levels is important for »setting minimum requirements and standards, adjusting educational programmes, ensuring that resources and incentives are made available to support companies' upskilling, reskilling and training efforts, and guaranteeing a security net for workers at risk of losing their jobs as a result of technological change« (Eurofound, 2021, p. 36). At the EU level, there needs to be greater involvement of sectoral social dialogue committees. At the regional or/and sectoral levels, social dialogue should monitor the impact and identify good practices and challenges for companies in the specific region/sector (Eurofound, 2021). While social partners' views on the dual transition are well aligned, their involvement in policy design and implementation varies across Member States (Bednorz et al., 2022).

The importance of the social partners in governing the different types of impact of digitalisation was also highlighted by the Discus project. The case studies in the Discus project showed a lack of involvement on the part of the trade union and limited participation by employees. Therefore, the authors suggest strengthening the formal social dialogue with regard to digitalisation and to introduce a procedure for broad stakeholder participation (Di Nunzio & Rugiero, 2021).

In general, digitalisation is poorly represented in collective agreements and bargaining in the case studies. As noted in several of them, digital issues do not usually arise in the negotiation of collective agreements, as these are mainly about salary, working time, etc. (Spain, Netherlands, Austria). This is also confirmed by other case studies (Bednorz et al., 2022; Di Nunzio & Rugiero, 2021; Eurofound, 2021).

In the Danish construction sector, the social partners have made a declaration of intent to work on new technologies, yet there is nothing specific about digital technologies mentioned in collective agreements. It is expected that the

ongoing negotiations will lead to the inclusion of digitalisation. Within the second case study for the woodworking sector, it was reported that the use of technology is not currently an issue in collective bargaining. In the federation for the construction sector, unions are working together to coordinate and define new strategies to include new technologies and training. Different trades have different collective agreements and, although they keep each other informed, there are no guidelines on how to include digitalisation. (Denmark)

In Italy, different levels of contractual agreements were mentioned, namely (1) bargaining and contract, (2) general agreements and (3) international agreements. The bargaining and contract level is in turn divided into territorial levels, with each contractual agreement leaving some room for the next. Within the three levels, there are some agreements that include digital technologies. For example, those that regulate the exchange of data at the trade union level, the purchase of VR equipment for training purposes and agreements governing specific areas, e.g. recovery from earthquakes, which involves digital technologies. (Italy)

In the Netherlands, there are collective agreements that do not contain provisions on how to use technology, and the union is usually not involved in the work content, either. Function-building, which as discussed in chapter 3.2 can be influenced by technologies, has not yet taken place for new digital technologies. Currently, this is done for BIM, which highlights that agreements are lagging behind the development of the sector, as usually companies use the technology first and then unions will inspect the use and function-building more closely. With changes in processes due to prefabrication, there is also the risk that companies will not fit in the collective agreements anymore, which poses the question of how to include these changes in existing agreements, or whether new agreements are needed (which is less preferable). (Netherlands)

In Austria, there are no institutionalised agreements on the transformation process at sectoral level, although there is an established dialogue due to the social partnership. Sectoral collective agreements for the construction industry in Austria do not explicitly include aspects of technology use, although processes are discussed during collective bargaining. There is also discussion about day-to-day conditions, but no formal agreement, as this is based on the strong and well-established social partnership. There is also a sectoral collective agreement for the wood industry with different subcategories, which is negotiated by the local works council together with full-time trade unionists. Technological aspects are not fully covered in these agreements. A functional description with regard to technology is not to be found in the collective agreement for woodworking, but a description is contained in company agreements. In general, the collective agreement is quite old in terms of functions. (Austria)

The national collective agreement is the main agreement in Spain. The national collective bargaining system includes all workers in the sector. There is nothing specific with regard to digitalisation, but it does cover training aspects. In the agreements, the union wants to include a sustainability and digital worker in charge, similar to the arrangements for OSH, who must be informed about the introduction of new technologies. The agreement for the cement industry already includes digital technologies. Currently, efforts are being made to come to similar agreements in the construction and woodworking sectors. Spain was the only case study where a clear target was formulated on how the union is to manage the transition. The »European Social Partners Framework Agreement on Digitalisation«, which is not industry-specific, is seen as a guideline. (Spain)

This framework describes a circular process that can be adapted to different needs of sectors or technologies. It also describes actions that can be taken by all social partners to shape job quality and work organisation. The four topics are (»European Social Partners Framework Agreement on Digitalisation,« 2020):

- Digital skills and safeguarding employment
- Modalities of connecting and disconnecting
- Artificial Intelligence (AI) and guaranteeing the human-in-control principle
- Respect of human dignity, and surveillance

In the Swedish construction sector there is a collective agreement as well which also covers ID cards. Other than this, collective agreements relating to digital technologies regulate most things relating to information exchange, e.g. salary reporting, to make sure the workers are covered by a collective agreement and paid correctly. Job descriptions relating to digitalisation are not part of the collective agreement. There is also an ongoing dialogue between social partners, and if there is an issue concerning digitalisation that any party would like to include in the collective agreement, a request is made and the issue is discussed and negotiated. (Sweden)

In the Swedish woodworking sector, digital technologies are not included in collective agreements, either, as highly automated production and manual furniture production are covered in the same agreement. There are some clauses in the collective agreement relating to experience, but these are not specific to any technology. The wage system is also based on skills in a broader sense and therefore could be adapted to many machines. Usually companies introduce a machine first, attend to the training, and in the end the union addresses the wages affected by the change as part of the monitoring process. But on a larger scale, in terms of what can be used in the industry, the unions are not involved, even though they want to be, especially when there are major changes in the industry. (Sweden)

In the context of collective agreements, training aspects were often mentioned in the case studies. While the qualification landscape is country-specific, there is often a similarity, as contents are worked out together by employer and trade unions. Furthermore, in Denmark the authorities are part of the system, but with regards to technologies, there is nothing specific (Denmark).

In Italy, a certain amount is laid down in contractual agreements, enabling research and approaches towards new technologies and a faster response to companies' needs (Italy).

In the Netherlands, there is an educational fund for the timber industry, but not for the construction industry. Training and education are embedded in the Dutch VET system, where changes in the industry are a huge topic. The fund helps develop training programmes, which are then carried out at training centres. In the collective labour agreement, it is negotiated who is to pay how much into the fund. There are provisions to govern training, but nothing specific is laid down on digitalisation. (Netherlands)

In Spain, training aspects are discussed within the labour foundation, where training issues, the need for training as well as OSH issues are discussed. Furthermore, projects are conducted to raise public awareness and to sensitise the sector. (Spain)

All in all, the unions are aware of the various types of impact, and they highlight the need to involve employee representatives in the change process in order to influence job quality and work organisation and ensure a fair transition. Similar findings can be found in previous reports and studies (e.g. Di Nunzio & Rugiero, 2021; Voss & Riede, 2018). Many agreements have been reached at the local level in case studies, but agreements are lacking at the sectoral level, although many representatives consider these to be necessary. Regarding the topics for new or revised arrangements, some views have already been expressed in the case studies.

Different opinions were expressed regarding whether the topics of digitalisation should be included in collective agreements or whether these should be split up. In the Netherlands it is considered useful to use collective agreements to ensure broad coverage, including at smaller companies. It was also brought up whether, due to the changes in the sector, it is useful to have different chapters which specify more details as well as underlying high-level collective agreements. Such a modularisation of collective agreements or »umbrella agreements« is already taking place in the metal-working sector (Netherlands). Also, the boundaries between sectors are becoming blurred and agreements need to account for this (Netherlands). In Sweden the best approach is considered to be to govern aspects of digitalisation in collective agreements (Sweden). As topics of digitalisation usually do not make it into collective bargaining, in the case of Spain it is viewed to be more useful to negotiate digital issues apart from the collective agreement. Potential agreements should then apply to all workers (Spain).

One of the most frequently mentioned topics for additional or amended agreements is the qualifications aspect. Qualifications need to be ensured for the initial pathway to the job, e.g. whether apprentices need to know old technologies and which new ones they need to know (Denmark, Austria). But also, in the case of further training, digitalisation should be covered so that all colleagues can use new tools (Denmark, Austria). These agreements should also provide some guidelines e.g. who will participate, on whose time and what happens to those individuals who do not manage to complete the training programme, etc. (Sweden).

While there is no need for additional agreements governing daily use of digital technology, such as 3D scanning, these are definitely needed to cover aspects of data usage, e.g. in the case of Big Data or sensors for monitoring workers (Italy). Furthermore, agreements are needed for aspects relating to wages (to ensure fair pay) and working environments (Denmark). Here, the goal is always to protect workers from negative effects and it should be investigated whether there are good reasons to formulate such agreements specifically with regards to digitalisation, or whether this relates to more of a general concern (Sweden). Changes are expected to take place first at bigger companies and then spread to the entire sector, which is why trade unions should monitor those changes closely (Netherlands). One aspect here is function-building (Netherlands). Some kind of agreement is also needed here, as the transformation will drastically change a sector in which fewer workers are employed and there is a need for arrangements spelling out what will happen to those who lose their jobs (Austria).

Once again, the above-mentioned framework of the European partners can provide some non-sector-specific guidance on topics that can be included in the social dialogue. Furthermore, the trade unions can draw on some information available in the public sector. A toolkit designed by the European Public Service Union (EPSU) provides guidelines on topics and questions that can be included in the social dialogue. Voss and Bertossa (2022) analyse collective bargaining agreements and other sources and highlight shortcomings. The results are also fed into a database of exemplary sentences which can be accessed online (PSI, 2023).

3

RECOMMENDATIONS FOR ACTION

This chapter answers the question of how trade unions can build a collective bargaining agenda on the basis of findings presented in the previous chapters. In most cases, trade unions view technological development as inevitable, and most representatives welcome the positive changes that digital technologies bring. Negative aspects are seen as avoidable if appropriate measures are taken. One recurring attitude is that trade unions should influence the social impact of technological developments to ensure a positive outcome for workers.

The ongoing social dialogue, not only during times of collective bargaining, is an important tool to achieve this. In general, the challenges and approaches in the case studies are similar at a higher level and are not related to specific technologies. While there is a generally positive attitude, there are slight differences, not only in attitude, but also in approach, e.g. regarding where technological aspects should be regulated. These need to be considered, as do a different approach to adoption of technologies, and the difference may be even greater in the Eastern European countries not surveyed.

Based on the findings, the following recommendations can be made:

(1) Trade unions should try to take a proactive approach to digitalisation issues before it takes place on a larger scale, especially in the construction sector. This is important because the level of digitalisation in the construction sector is currently low compared to cases in the woodworking sector in this study. If trade unions could get involved at an early stage, they would have more influence.

Trade union initiatives, together with the employer side, could help to build the necessary knowledge base and achieve a shared vision within the unions, but also between the social partners. On the basis of these results, trade unions can provide training for trade union representatives at all levels. Initially, the focus could be on current emerging technologies and trends such as automation, 3D printing or prefabrication. However, trade unions should keep an open mind and be aware of emerging trends. In most cases in this study, trade unions have been slow to react to digitalisation, but a faster response should be ensured.

Based on the lessons learned from the initiatives between trade unions and employers' organisations, model agreements and guidelines could be developed, specifically for the construction and woodworking sectors, to help individual trade unions. The »European Social Partners Framework Agreement on Digitalisation« could serve as a guideline. Such guidelines should still allow some individual freedom. This is particularly important in the context of different developments, e.g. for larger companies and SMEs, as they have different needs. At the policy level, solutions are needed to ensure that SMEs are not left behind when it comes to digitalisation.

These trade union initiatives could also collect best practice from other sectors and possibly even serve as cross-sectoral initiatives on specific technologies. This would allow the construction and woodworking sectors to keep pace with technological developments in other sectors and increase the influence of the trade unions.

(2) As technologies are introduced into everyday work, there is a clear need for appropriate training for workers in their initial approach to the job, but also for on-the-job training.

An important aspect of training workers is to create curiosity and a willingness to participate in changes among workers, possibly by presenting new technologies in an »experience centre«, e.g. in the form of innovation technology centres or digital hubs. Trade unions together with employers in the relevant national bodies should define content and curricula in relation to technological development so that it is recognised at national level. Adequate funding must be made available to ensure that these technologies are available in respective schools (educational bodies). Unions and employers should set frameworks setting out who is to receive training and under what conditions so that it does not have to be negotiated on an individual basis. Finally, safety mechanisms should be put in place for those who do not manage to upgrade their skills.

(3) Digitalisation should be included in the ongoing sectoral social dialogue and in collective agreements, as these can be used to shape the social parameters of technological change. The interviews demonstrated that trade unions are aware of technological change and how to shape its social impact, so now they need to use this awareness to act.

Digitalisation affects tasks, and therefore function-building in collective agreements should also reflect this, e.g. by adding new functions with regard to digitalisation. Wages should be considered in this context, either because of the direct impact of technology or because of the indirect impact of increased skills. In the process of transformation there is a risk, particularly in smaller companies, that employee participation will be lacking because there is no works council or similar body. Trade unions could publicise the advantages and provide solutions for SMEs to involve their employees in the transformation process, e.g. by offering guidelines or best practices. If small companies adopt such practices, adjustments could be made to public procurement to incentivise this behaviour. Mandatory risk and hazard analysis could be one way of protecting workers from adverse conditions, e.g. in the form of new types of stress.

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ANNEX A: INTERVIEW GUIDELINE

1. Introduction (5 minutes)

Introduction of the interviewer and the project, agreement of recording and transcribing, structure of the interview

- Please introduce yourself!

2. Digital technologies (30 minutes)
Target: degree of changes, impact on worker

- Which technology-related topics are you currently most engaged with in your daily work?
- How do you (as a union) keep up to date with technological developments; are there e.g. regular workshops?
- How aware is your union of changes and their implications for workers?
- What positive influences do the technologies you reviewed before have on workers? Think of every-day working conditions, qualification and experiences!
- What negative influences do the technologies you reviewed before have on workers? Think of everyday working conditions, qualification and experiences!
- Which technology would you like to introduce immediately?
- Which technology would you prefer never to introduce?
- What will change within the next 5 years with regards to the digital technologies at the construction site?

3. Policies on the use of technology (30 minutes)
Target: Agreements related to the use of the technology itself

- Which collective agreements or other types of agreement e.g. legal provisions are in place for the use of these new technologies at a company/union/national/international level?
- How did your union influence these?
- Which additional agreements are needed regarding the use of these technologies and for which reasons?
- How does your union influence these?
- Are there common understandings on how to influence these? Are there model agreements or guidelines?

4. Transformation policies (30 minutes)
Target: Agreements related to the transformation process towards increased digitalisation

Implementation of these technologies is part of a transformation process. During this transformation, external consultants might be involved, but also workers are involved in the transformation, e.g. by actively participating or undergoing additional training, etc.

- How is the transformation process regulated in policies or other types of agreements or legal provisions?
- Which (additional) agreements are needed and for which reasons?
- How does your union deal with agreements related to the transformation process?
- Are there common understandings on how to influence these? Are there model agreements or guidelines?
- Do you know of any agreements at the company level? What is their content?

5. Closing (5 minutes)

- Any recommended further information sources?

Acknowledgement, conclusion and next steps

ANNEX B: INTERVIEW SUMMARIES

CASE STUDY 1: DENMARK

The Interview partner was from a trade association made up of several trade union confederations and mostly contributed a **construction** perspective.

IMPACT

In general, the construction sector is slow to adapt changes, and there are huge barriers to introducing new technologies. At the moment, mostly mobile communication devices are used. Topics like robotics, 3D printing and BIM are also topics for recent trade union work. The union wants to make members aware and curious about new technologies.

The union keeps up to date through seminars, conferences, working groups, magazines and papers, and visits to construction sites to talk to people. However, it is hard to get an overview because developments are so diverse. The foundation of the construction sector has a contact lab/knowledge centre to inform members about digitalisation. Here the union has an influence as well.

Especially robots and automation are seen as having a positive influence on OSH, as they enable less uncomfortable working positions and repetitive work as well as less heavy lifting. Furthermore, technologies will have an impact on planning and improving processes (with regard to efficiency), create a better overview and improve communication and collaboration, ensure a better flow and continuity, reduce errors and create common language across the value chain. Especially technologies which improve OSH and reduce physical strain, as well as those which improve planning are welcome.

There is a risk involving surveillance of workers by new technologies, but positive experience with ID cards outweighs this fear, especially as there is an established collaboration between the social partners on these topics.

In the near future, the importance of sustainability is expected to increase further. Robots and sensors will probably be introduced, but changes in construction are still expected to be slow.

POLICIES

Legislation plays a huge role in establishing new technologies in the construction sector. In 2008, a law was introduced with regards to BIM usage. It requires all public construction and all non-profit housing construction to use BIM and project web (an electronic document management). In 2023, new regulation with regards to sustainability came in place which requires certain documentation. Here new technologies can help and sustainability and digitalisation will support each other. Requirements for lifecycle assessments for building materials will push technologies further. The Cooperation Agreement from 1947, amended in 2006, concluded by the FH (union side) and DA (employer side) stipulates how employer and employee are to collaborate and as such influence working conditions as well.

Nothing specific regarding digital technologies is laid down in collective agreements. But in these agreements the social partners have made a declaration of intent to work on new technology. Through the ongoing negotiations, digitalisation is expected to become part of the revised collective agreements.

Tripartite agreements by authorities, employers and employees mainly involve education and training. Nothing is stated with regard to digitalisation, only that workers need to be curious.

Within the federation the different parties work together to coordinate and define new strategies to include new technologies and education on these. The federation tries to influence agreements by working together with all the actors in working groups and committees, at the networking centre (run by the construction foundation) and counselling with politicians. The different trades have different collective agreements, and they keep each other informed, but there are no guidelines.

Training aspects are currently being developed between employers and employees.

Additional agreements are needed to address aspects like wages (ensure fair pay), educational training in technology (for basic education and further training) and working environments.

CASE STUDY 2: DENMARK

The interview partner is associated with a trade union federation and contributes mostly a **woodworking** and **qualification** perspective.

IMPACT IN WOODWORKING

Digitalisation is seen as closely connected to the circular economy and green sustainability. This link is expected to be even stronger in the future. Currently the most relevant topics are robots and cobots.

The union keeps up to date with workshops, analysis and development projects, all of which create, renew and monitor developments.

There will be changes in skillset requirements, for example as workers need to be able to assess, interpret and understand data.

Robots and automation can help to reduce physical strain. Due to improved efficiency, automation can also help prevent jobs from being shifted to other countries where production is cheaper. This is how digitalisation is helping the industry to maintain jobs in Denmark. With regards to organisation there are little changes – people are still working lean in teams.

At the same time, increased productivity has a negative impact, as there is a heavier focus on time, resulting in more pressure and stress. Physical stress is increased as robots dictate the tact, and there is a lack of experience with these new tools. The increased focus on up-to-date knowledge requires workers to be trained accordingly. 3D printing will disseminate in the industry, but it is frustrating for members, as the impact is unknown. This again highlights that members need to be prepared.

Many things are also related to mindset, as digitalisation does not automatically mean they will lose their jobs.

POLICIES ON WOODWORKING

Technological developments are monitored with all social partners, based on this learning activities formulated, and examination standards are set for vocational educational training. This is done at the national level. This way there is a clear view on the development, but no specific agreement. There is no influence from the European side, as there are big differences in systems, e.g. in Denmark there is a dual system. Guidelines for training and qualification are then binding.

Usage of technology is currently not an issue in collective bargaining. No policies are known on the transformation.

The national trade committee serves as the backbone for vocational educational training. There is parity between employer and employee organisations, which meet 6 times a year and also have an office backbone for analysis, etc. The two sides monitor creation and renewal of vocational educational courses, formulate learning objectives, examination standards and key competencies which are required in the industry. Duration and topics are regulated in curricula, based on the agreements in the national trade committee.

For adult vocational educational programs, the content is also nationally recognised by the stakeholders and worked out by the national trade committee. Training then has to comply with this (national standard). Vocational colleges might not quite be up to date with the progress of digitalisation, mainly due to finance issues. Commercial suppliers of adult vocational exist as well, however unions recommend using the public system, as the national standard is recognised. When adult members attend courses, they are paid for this time.

CASE STUDY 3: ITALY

One interview was conducted with a member of the confederation of trade unions. The focus is **construction**.

IMPACT

The union is involved with »DURC«, which is a document to certify payments of social contributions and by virtue of this involves a massive data exchange between several institutions. There is also a digital ID card for all workers within the union. Furthermore, there is the new digital card called »CIPE« for all the workers in the construction sector. This is a card for construction professionals and certifies health and safety knowledge, the skill, the level of renumeration and whether the card-holder belongs to a certain company. All major unions and employers will use this card. It will change the way collaboration works, as the organisation has a digital picture of the workforce. BIM is a big topic for construction workers.

The union is highly aware of, and involved in, digitalisation. The union has a school at university level, where it develops courses on digital transformation, bargaining and the green economy. The union itself is also transitioning to digital and moving to paperless.

BIM can be useful, but is currently being used more from the engineer side. It includes a lot of helpful information, but workers have to be able to utilise the system and extract the relevant information. This requires that they must be able to put in place, maintain and utilise the system and also that they must be able to extract information to ensure that it is helpful. Many technologies make it possible to obtain more information, making everything clearer and easier to understand while enabling better processes.

3D Printing is currently not utilised much because it is expensive. It could be useful, especially for components and especially with regards to material shortage. A lot of research needs to be performed in this area, however.

Digitalisation can improve health and safety, fair pay and the application of contracts – by means of digital collaboration and communication systems or sensors. Teaching in VR makes possible integration of teaching and health and safety issues, so tasks are already trained in a healthy and safe way.

Automation on the construction site is seen as expensive. Given a low level of effectiveness due to the large number of small, unique jobs, it is viewed critically. The same goes for big data and data analytics, which are less useful as companies are small and specific. However, it might be useful for

big public projects, e.g. maintaining an infrastructure and using Big Data on a company base rather an employee base. There is the potential threat of the »transparent worker«, but this is less of a concern, as companies are very small. If you are doing your job, the supervisor will see you, it is not economical to put such an elaborated system in place for so few employees. Another problem is high mobility and non-continuous work (when workers alternate between employed and unemployed status). Here use of data is more about tracking for better functioning at an administrative level and to make life easier when it comes to taxes and payment. The focus here could be on how to use big data to improve the market and not just making greater profits for the company.

The green transition of the construction industry is also undergoing a digital transition. Thus, improving one with regard to research in order to maintain the other one will be probably the best choice. Here research coordination as well as coordination of focal areas is needed. In the next 5 years, however, not so much will change, as the construction sector is slow in changing.

POLICIES

In 2022, a legislative decree was put issued by the Ministry of Labour governing the mandatory use of BIM. The thresholds above which use is mandatory will be eased over the next few years. This decree also established a reward system for recovery after COVID. If BIM is used, there are reward points in public procurement. This has worked quite well, as it has increased BIM usage. At EU level, a decree has been issued on big data and AI.

There is no public institution for education in the construction sector, but the union and employer have joined forces here. They have stipulated a specific amount in the contractual agreement that is to be deducted for teaching. This is how schools are created which are managed by the union and employer acting together. The schools are for vocational training, initial onboarding to a job, switching career paths and educating migrants. This approach facilitates research and the embrace of new technologies. Schools can respond to companies's needs more quickly.

The system in general can be split into (1) bargaining and contractual agreements, which is in turn broken down into territorial levels, where each contract leaves some room for the next one, (2) general agreements and (3) international agreements. There are different parity institutions involved, one for administrative bargaining/contribution, one for teaching, one for health and safety, and each of them has local representations that report to the national one, and each one is in charge of bargaining at their respective level.

With contractual agreements (1) digitalisation has already entered the picture at different levels. At the national level, this means organisation of data exchange or purchases of new equipment for training. At the company level, it means organising work by means of digital technologies.

The most important agreements (2) currently involve the reconstruction of collapsed bridge in Genova and agreements on reconstruction in the region hit by the earthquake. These agreements involve data utilisation for different reasons, e.g. preventing jobs from infiltration by the mob or the organisation of work, a reservation list to enter the area, or managing the workforce when they have to enter a problematic area. For example, in the earthquake zone work is being done to bring about a transparent construction site, where all information such as projects, transition of work and machine utilisation is put into a common database. This manages everything from the calculation of contributions, entrance into the workforce, etc. Agreements in the earthquake area and bridge area are legally binding. An elected commission manages the infrastructure. Specific legislation (emergency legislation) is drafted and applied in this area, while normal legislation for such kinds of jobs is not applied in this area. Experiences gathered are now also being considered in new regulations for general public procurement. There is a new digital system for public procurement from January 2023 which manages information on company and workers, making it possible to intelligently use information. Parity organisations are involved in agreements to manage information.

There are international agreements (3) with similar entities in Germany, Austria or France. These regulate the exchange of information relating to workers and companies in case workers want to work internationally in order to facilitate greater mobility.

All agreements are bargained with the union. For the earthquake area, the union bargains with the Ministry of the Interior, together drafting a protocol, the regulation and they are also part of an »observatory«. These observatories also allow influence to be exercised, agreements to be revised and so on. The observatory is constituted by the public and union. The task here is to maintain the agreements, identify the problems, report the problems and solve them by means of such agreements.

There are plenty more agreements, with a host of agreements focusing on managing information, cooperation with the state and cooperation between unions. There are a lot of agreements devoted to managing the relation system, maintaining agreements and spelling out specifics.

On the contractual side, a decision needs to be made on what technology is supposed to be used, and decisions are then based on this. But with regard to the public side, this also depends on the willingness of the state. Often it is not about specific tools here, but rather about the data. So, if data is used, there will be an agreement. Within the union and together with the employer, it is then decided what data can be provided for these agreements.

If a contract is just at the territory level, it is negotiated with the union at that territorial level. If it implies the use of a fund which is established by the contract, e.g. creating a digital environment for OSH, then a committee is put in place.

This committee then needs to introduce an arrangement to be applied at the national level. There are committees on several topics, apprenticeship, maternal leave, but also for managing information, like »CIPE«, and purchase of VR environments for training purposes. The committee is formed with members from both the employer and union sides, and if need be other parties are involved. These agreements are needed when data or funds are used. When using a digital technology for an everyday job like 3D scan, there is no need for additional agreements. Data agreements come into play when big data analytics or sensors are used to monitor the workforce.

The contractual agreements are specifically for wood, the cement sector, etc., and on the other hand for construction. In factories there are contractual agreements for big companies as well as company-specific contracts. In construction there is one big contractual agreement at the national level and then small adjustments at the 2nd level and each different level. Changes in production and management of the workforce have to be bargained with the union side. New contracts or agreement are needed to define what is useful, what is safe and how to prepare the workforce for the transition. Here the influence of the unions is very useful, as they can provide insight into how to manage the transformation, e.g. in case of a green transition at a company, the union will protect the workforce but also support networking, providing insight into the new skills required. Here stationary trades have more opportunities for digitalisation than construction, as here it is very difficult and expensive.

The power comes from the local trade union. It is done e.g. by preparing members to actively participate in changes by sending them to their own union school at the university level. It is managed by the union, while the curriculum and environment are set by the union.

Then there are also parity schools for the workers, these are managed by employers and the union in the form of a committee. The national school sets up courses and rules and then offers a direction for individual schools. This is now changing through the new contract from 2022, as there are specific paths for basic, green and digital transition and also specialised courses to create a common curriculum at the national level. This also regulates increases in wages following successful completion of training programmes. This is currently still in the process of negotiation.

CASE STUDY 4: SPAIN

One interview was conducted with two representatives of the trade union covering, among other sectors, construction and woodworking, while the focus was mainly on **construction**.

IMPACT

There are some differences between construction and woodworking, and technology is introduced differently as well. In construction, a dialogue is better established and it is more developed than in woodworking. In construction there is a labour foundation which is a parity organization at which training and OSH programmes are developed and workers are trained. In woodworking, the social dialogue is weaker, as in the past there was only one main organisation, but now there are two smaller organisations, which makes the dialogue more difficult.

Still construction is slow to establish new technologies. BIM, drones, digitalised applications for different processes and prefabrication are current topics. Big companies are more prepared to introduce technologies; there is a problem regarding how to digitise the many small companies to ensure their competitiveness.

For the union it is important to analyse the impact of the twin transitions on the worker. To this end, the union is gathering information at all levels, e.g. an international project at the European level, across initiatives and studies sponsored by the European Parliament. Also, at the national Spanish level in the form of an initiative by the Spanish government, e.g. digital Spanish agenda 2026. The goal is to be informed about changes at the European level as well as at the Spanish level to influence the government about what is important for workers. As the union is present at the companies, it listens to workers and tries to influence developments there. For the union, there are two important aspects. (1) Adopting a proactive perspective on digitalisation and sustainability e.g. in collective bargaining. (2) Influencing aspects of the right to ask information, contract and firing, training and OSH, treatment of personal data, new digital risk and other issues related to the impact of sustainability like energy efficiency, the circular economy, etc.

As sustainability and energy-related issues are becoming more important, digitalisation can provide support here. OSH can be improved, especially thanks to prefabrication. Sensors can also improve OSH, but at the same time are associated with a risk of surveillance. New ways of construction e.g. prefabrication, can result in the loss of jobs. Technologies are a fact; implementation has to go hand in hand with workers. It is not about preventing introduction of a technology, but this has to be done together with the workers. All in all, the transition needs to be just and fair and unions need to prepare workers for technological issues, e.g. by upskilling. It is important that the trade unions are involved.

In the future it is expected that digitalisation will attract new workers, and more young people and women will be involved. Digitalisation will be increased thanks to the spirit of the workers behind it. There is hope that there will be more qualified jobs, although there is a risk of losing those jobs with the lowest qualifications. Therefore, it is important to train workers e.g. with regards to energy efficiency and renewable energies, but also in technology-specific aspects, like drone usage to screen for asbestos.

POLICIES

Developments are being influenced at a European level, e.g. by the declaration regarding digital principles and rights from December 2022. Also, at a national level digitalisation is also being pushed because of legislative changes (not only but

also). Therefore, it is a mixture between where the government wants to go and where the EU is heading.

Within collective bargaining, an effort is being made to include new aspects, but currently it is mainly about training and qualification and identifying the need for additional training. Vocational training is needed to improve the capacity of the workers to deal with technology.

In this context, the labour foundation is worth mentioning. It is run by the union as well as employers and discusses three main issues while carrying out studies on them: (1) First of all, training issues and how to identify a need for training. (2) OSH issues are also discussed and (3) projects to raise public awareness and sensitise the sector are conducted. It is a long-established approach to social dialogue and ensures a social dialogue not only during collective bargaining. The labour foundation conducts the training itself in schools across the country or hires and supervises other training centres. A working group develops a roadmap for training by anticipating what is happening in the sector and trying to react in advance. It first conducts training for the job and provides several fresheners and specialisations. There are also special courses on new technologies, e.g. nano-technologies in construction. At the labour foundation there is special group on digitalisation and sustainability. At the labour foundation level there are two committees made up of workers and employers. One is the OSH committee, the other the training/skill committee. These two issues are discussed there at a sectoral level (instead of in a collective agreement).

The national collective agreement is the main agreement. The national collective bargaining system covers all workers in the sector. There is nothing especially relating to digitalisation, but it does cover training aspects. Here the union wants to provide for a worker to be in charge of sustainability as well as a digital worker in charge, similar to the case with OSH. In the cement sector, this is already in place, so now the union wants to include it in other sectors as well. Whenever a company wants to implement a new technology, it must inform this person in charge. In the cement sector, this officer must be informed, but it is not the same in the construction sector. In other sectors, the works council has to be informed, but the works council is sometimes not trained in issues involving digitalisation.

The collective agreement for the cement sector is a good example and it does address digital technologies. But this is very special to the cement industry. Aspects like rights of information in case of changes and how to achieve the qualification for these technologies are laid down in the agreement.

There is the European social partner framework agreement on Digitalisation. This is a general agreement that is not specific for construction sector, but it is a good example. The framework is seen as a guideline for use at the national level, while having one agreement for each sector (as they are a confederation).

The union is trying to influence developments in the area of collective bargaining and voluntary additional agreements (like the one for the cement industry). Usually if one negotiates collective agreement, digital issues fall by the wayside, as the agreement mainly covers items like salary and working hours. Therefore, it is considered to be more useful to negotiate digital issues separately from the bargaining of collective agreements. The agreement for the cement sector is voluntary, while the one for construction sector is compulsory, but both affect all workers. These constitute different agreements because of the level of specialisation.

It would be important to have such an additional agreement soon. Currently there is a low degree of digitalisation. Therefore, it would be beneficial to have the agreement in place before all the digitalisation efforts impact the workers. The additional agreement should also be binding on small companies. It is difficult, however, and small companies need to be supported in finding a way to do this, e.g. by a fund or other means. The agreement should ideally also provide them this help.

If bigger companies apply for a fund to increase digitalisation, they cannot make workers redundant within a specific time frame. Small companies need help too, but the conditions should be different here, e.g. a shorter time. For big companies this has already been implemented in law.

CASE STUDY 5: NETHERLANDS

There was one interview with two participants from the trade union. The area of one expert was **wooden furniture**, the area of the other the **construction** sector.

IMPACT

BIM is still an important topic. It has been in use for 10 years and is very common. The other technologies are currently being investigated.

In woodworking big changes are and have been taking place due to the higher degree of prefabrication in factories. This is a trend which is accelerating at a fast pace. The consequences are still being investigated and there is no coherent view yet. There has definitely been an increase in robots and automation.

The union collects information by talking to the members, visiting construction sites and going to congresses, etc. But at congresses the discussion is often only about technology and not about the people, e.g. education, which plays a big role.

Of this the union is aware, so now the next step is to act on it. This step has not yet been taken. The pace of development is very rapid and the union is behind a little bit. Digitalisation has a lot of implication on how workers work, how unions work, and how collective agreements work.

The increased pace of digitalisation could improve the attractiveness of the sector for young people, which is a positive development, as there are not enough young people

interested in working in construction. As prefabrication often takes place indoors, there is better environment, as these aims are easier to achieve in such a controlled environment. Work in general is getting less heavy and easier as well as safer. Developments will change the way of work, e.g. parametric design will change how architects are working. Especially those technologies which make work lighter and safer are welcome.

One negative aspect is that workers have less influence on the work, can put »less from themselves« in it and have less freedom. This function is being undermined. There are more of the same simple tasks to do. Especially older workers do not like the change. This is especially taking place in prefabrication, as it is »factory work and not carpentry any more«. As the workload gets smaller, the job gets less interesting. The quality of work is declining. Because only simple tasks need to be performed, people receive less training, which poses a danger of reduced wages. There is a threat that existing functions will be undermined.

3D printing is viewed critically, as it highly reduces the need for workers. The same was said 30 years ago about robots, however. Perhaps the same number of people will work in the sector in the future, but fewer at building sites and more in offices.

In the future there will probably be a higher degree of prefabrications and even more factories in the same connection. This development is being accelerated by new carbon laws which promote prefabrication. The construction sector as a whole is very traditional. This might lead to greater differences, because some factories are introducing this technology very quickly and some very slowly. Construction with wood will be on a much greater scale in the future. At the same time, construction and general urban development will become more closely related.

POLICIES

There are no new collective labour agreements relating to technology. Existing ones are being used. However, nothing is regulated on how to use technology. Technology also creates new functions. But these are not being addressed by the union right now. Function-building in collective agreements is not taking place for new digital technologies. Right now, BIM functions are being introduced (10 years later). Here agreements are running behind technologies. For example, data analysts from another sector with a different background are entering into the sector, which is a positive trend. Usually a technology is first used, then the union will look at how companies use it, how they build functions, and what causes them to lag behind. The company makes the decision on function-building. Trade unions ought to be closer to this function-building, e.g. with regards to wage levels, as there is a danger of tasks not matching the wage for the function. At construction sites, trade unions are often not involved in changes. Companies introduce the technology, but nobody reviews whether they need to be involved in the collective labour agreement.

The greater amount of prefabrication poses a new problem, namely that companies do not fit into the collective agreement anymore, as they are changing the way work is performed. To obtain a universally applicable collective bargaining agreement (CBA), in The Netherlands the companies involved in CBA negotiations need to account for more than 50% of all the workers in that sector. The question (challenge) is how to fit them into existing CBAs (which include high working standards and good labour clauses) or is there a need to develop new CBAs for these (new) activities, which is less preferable. For example, the agreement in construction covers work on the construction site, however it is unclear whether the factory is part of it. As employers tend to not want to involve the trade union, they argue it is not. Potentially they will not apply the collective agreement anymore, which they should. If there is no CBA in place, the workers will revert to the Dutch statutory minimum wage, which is less than the CBA wage (for construction or timber sector). Sometimes they want to apply the collective timber agreement, but it has a lower standard than construction. Sometimes companies also try to negotiate an agreement with the works council instead.

Sectoral, universally applicable CBAs are best suited for workers (these fit best into the Dutch labour system), especially those at smaller companies, as these agreements cover many companies, and trade unions cannot be everywhere. Additional agreements are perhaps needed for bigger companies, as these are introducing new technologies at the fastest pace. The trade union needs to be there, as they are setting the pace for the entire industry.

Changes in the sector might require different chapters to specify the high-level collective agreement, so to say an ›umbrella CBA‹ for construction (and construction-related subsectors/activities) – customised for the subsector. This is already being done in the metalworking sector. Also, within the union, sectors are split along very strict lines. This has developed historically, but does not align with modern reality anymore, where companies work across sectors in the building environment, e.g. construction and metalworking. Workers and employers' organisations (because they are together responsible for the sectoral social dialogue) need to work more closely together to move forward from this very ›outdated‹ system.

There are no guidelines or model agreements. Some discussions are taking place between different sectors, but nothing has been completed.

There is a strong focus on pay increase and pensions, etc., within collective bargaining, but technologies are not a big topic. The union is not involved in the content of work. Traditionally unions (including FNV) are strongly focused on pay increase and pension schemes. Discussions about new technologies in the sector are very ›highbrow‹ and take place between: employers, government and scientific institutes. There are also different views within the unions, as some prefer to focus on pensions, etc., while others think technologies should be part of it in order to have some influence

over these; otherwise the trade unions are always lagging behind developments.

The transformational process is regulated by works council law. If something big changes, an agreement is needed. The provisions governing this do not prescribe how it is supposed to work, but rather related to changes in general. At small companies there is also a small group (PVT staff representation), but they do not have the protection of the works council law. And even where works councils are required, often there is no work council. In metalworking works councils are strong, but in construction they are less strong. The Dutch construction sector is very fragmented: more than 50% of all the work in a construction process is subcontracted. As there is an average number of 9 workers at a company, these companies do not meet the threshold for a works council. Thus, a host of (very small) SMEs, (bogus) self-employed flex and migrant workers entered the sector after the financial crisis of 2010. Therefore the unions tend to campaign for lesser subcontracting and the introduction of the ›BouwplaatsID‹ (Construction ID pass). The unions should have more influence, as they have more leverage.

Privacy and cyber security are very important issues. Examples include the building site ID, which includes skill and company affiliation, and cameras, which are not to be used to monitor behaviour of workers. Within the framework of the building site ID, these topics are discussed by the union, but the question is whether the IDs are used according to the rules. In the case of cameras, the works council has to be involved and find out what the cameras are to be used for and what they are not allowed to be used for. National laws are in place governing privacy issues.

There is a building digitisation board constituted by employer and knowledge centres, but the trade union is not involved in it. Also at a higher level: employers, government, and scientific institutes, which form the new ›tri-partite‹ in The Netherlands – and this is not a positive development for workers' rights.

Besides the collective labour agreement, there is also an educational fund at the national level which develops new training programmes and develops new courses for new functions. Unions and employers control this fund on a parity basis. These funds try to adapt to the changes. The timber sector has a fund, while construction does not have any fund. Therefore, this topic is partly missing in the construction sector. All training and education is embedded in the Dutch VET system. So, although no parity fund is (directly) applicable, changes in the industry are a huge topic in the national VET system (in the construction/tech pillar of this system). The fund develops training programmes, which are then conducted at educational centres. In the collective labour agreement, it is negotiated who is to pay how much into the fund. Training is regulated, but there is nothing specific on digitalisation.

In public procurement, tenders could also be a way to influence the company, e.g. by stipulating that a certain amount of money needs to go towards training of the employees or a certain percentage of the company's personnel to be directly employed, which will lead to better education and training of the construction workforce overall.

Most of the time companies try out new technologies, but do not subject these to an agreement. This is also because technologies are often not completely adopted.

CASE STUDY 6: SWEDEN

The interview was conducted with a representative of the trade union in charge of **construction**.

IMPACT

Currently the union, together with major construction companies, is most engaged when it comes to making the existing ID card more secure and representing workers' interests. The system called ID06 is in place and used for access control, ascertaining the training status of workers, information about the employer and workers, but not connected to the tax authorities. It would be desirable for this to be used at all sites, though this is not the reality. Currently the union is working on preventing misuse by using face recognition at the entry terminal. Here the union represents the interests of workers, e.g. insisting that cameras are not to be used at other places on the site. The ID card is seen as a measure to ensure safe use of the system and prevent exploitation of workers, e.g. control of working time, and it would therefore be a positive development to implement this as soon as possible. This also serves as a measure for occupational safety and health, ensuring that only educated workers are present at the construction site.

Besides this, there are smaller projects at companies, where the possibilities of a technology are tested. Although the union is not involved, unionists are aware of these topics and discuss them, mainly at the EU level. The union had a project regarding the green transition to remedy some of the negative views workers had on the topic. That project adopted a positive outlook, showed the possibilities, e.g. renovating, changing way of building and creating a safer workplace. There might be a need for the same approach for digitalisation, although it is a little late, as there are also some fears on the part of workers e.g. job loss due to automation. On the other hand, very few young people want to work in the sector and an increased digitalisation could help with this.

Besides this, digitalisation could reduce physical strain and dangerous tasks, e.g. when working with asbestos. On the flip side, there is a risk that jobs will no longer be performed by humans, thereby causing a loss of jobs in the sector. The exact effect is hard to assess at the moment. Work is becoming more complex, which requires a lot of up- and reskilling. On the one hand, this is viewed as positive, as learning new things is an advantage. On the other hand, however, it might prove to be very difficult and cause some stress, especially if workers have already been doing a task for a long time. Additionally, there is a risk of monitoring, although this can be mitigated by measures, as shown in the ID card example.

In the future, there will be more digital technology. Currently several small-scale tests are taking place and some of them will be probably be implemented on a bigger scale.

POLICIES

Usage of the ID card is not subject to any legal provisions. However, this is included in collective agreements. Currently an effort is being made to extend it in collective agreements to make sure the new biometric approach is GDPR-compliant. Also, the union is trying to influence agencies to add the ID as a requirement in public procurement.

There is the collective agreement, but it mostly governs things relating to information exchange, e.g. salary reporting, to make sure the workers covered by collective agreement are paid correctly. Job descriptions with regard to digitalisation are not part of the collective agreement. If a collective agreement is needed with the employer, then all workers at companies are covered. Collective agreements are the result of social dialogue and negotiation between union and counterpart. To facilitate a bottom-up approach, meetings are held in different regions, where suggestions for inclusion in collective bargaining can be made. These are then screened and might be included.

Besides collective agreement there is a constant dialogue with the counterpart. If there is an issue with regards to digitalisation that any party would like to include in the collective agreement, the demand is forwarded and then it is discussed and negotiated.

There are no other agreements at the national level where the trade union is involved. Nor is there anything at the regional/company level. Legislation exists at EU level, e.g. a discussion regarding the AI Directive and Data Protection Directive. If you are looking for legislation with regard to digitalisation, you have to look at the EU level, as nothing is to be found at the national level. However, it is important to keep an eye on the EU level, as it affects the national level. In case of any new legislation at the national level, the unions or their confederation are involved as experts in the process of analysis.

There is no need for additional agreements, but some aspects with regard to digitalisation should be included in the collective agreement. These aspects should be put down in collective agreements and not any other agreement outside of this. The goal is always to protect construction workers from negative effects of changes. Here it should be analysed whether there are reasons to formulate these in specific terms with regards to digitalisation or whether it is more of a general concern.

Co-determination under the Workplace Act requires an employer to have a social dialogue with the union in case of any substantial changes to the workplace which will affect the workers. These dialogues are then carried out with representatives of the trade union at the company. This legislation is binding on all companies, regardless of size and not specifically relating to construction. The provisions work quite well with regards to involvement of the unions in the process. But on a larger scale, i.e. what is allowed to be applied in the construction industry, unions are not involved in this. They would like to be involved especially in the case of major changes affecting the sector.

CASE STUDY 7: SWEDEN

The interview was conducted with two representatives from the trade union for **woodworking** (among other sectors).

IMPACT ON WOODWORKING

Digitalisation of the working environment and the skills of the workers are current topics, although workers have been coping with automation for many years. Often, it is not about a specific technology, but about making the processes more efficient, where automation is a big part of it. This is the case, for example, at sawmills, where workers had to have a high level of qualification in the past. Now many things are done by computer, e.g. calculating how many parts, how to cut and, in combination with 3D scan, quality control as well. These forms of automation are already being widely implemented and require a different skillset. Sawmills are involved in developing a framework for training and determine where there is the need for training, etc. It is important to train and have highly qualified people so workers can adapt to new technologies and systems. Although they are aware of the changes, it is hard to have an impact.

Digitalisation can create a better working environment, alleviate physical strain due to automation & robots and thereby reduce repetition as well as move workers away from the machines, which makes work safer. The better environment makes it easier to attract young people. The worker has a higher value and cannot be replaced so easily with a higher technological competence e.g. by training. This higher value will also be reflected in higher wages. There is a risk of job loss, due to efficiency increases. But on the other hand, this increase in efficiency ensures they are still competitive, which is also important, otherwise production will move elsewhere. The evaluation of skills with certificates also enables workers to switch to jobs to other sectors if there is a decrease in demand for woodworking. Regarding the risk of monitoring, this is simply viewed as a shift from physical monitoring to digital control, which might be of concern to white collar workers, but less so for blue collar workers. Also, if there is a strong union there is a low risk of negative consequences. All in all, workers are accepting the changes, as there are safety mechanisms in place for them and at the societal level gains are evident. Especially all technologies that lessen the need for heavy repetitive work are welcome, while others like AI are more frightening.

One needs to have a good knowledge of processes, including with a higher degree of automation.

Something to keep an eye on is this: Don't taylorise work organisation. Instead increase skills of blue collar workers and don't have an expert make sure that blue collar workers are only performing very simple tasks.

In the future it is expected that the factories will be more alike, e.g. if one could scale up housing, factories would be more along the lines of highly automated furniture production. There will probably be more prefabrication of housing, which results in moving the construction from on-site to a factory, in turn enabling a better working environment that is more effective and more sustainable. State and municipal buildings already have high sustainability demands which are creating a trend toward construction using wood.

POLICIES IN WOODWORKING

Collective agreements »are totally blind for technical solutions«. These highly automated forms of production and furniture production by hand are included under the same agreement. However, these technologies are accepted by workers, as they generally improve work. There are some clauses related to experience in the collective agreement, but not specifically for one technology. The wage system is also built around skills in a broader sense and could be adapted to many machines. Usually companies first introduce a machine, attend to training and in the end the union performing its supervisory tasks will address wages affected by the change.

There is some common understanding about what it takes to be a skilled tradesman. This also includes some digital technologies, like CNC user and finishing machinery. The trade union and employer agree on the competencies needed. There is an evaluation system, which is still being built, in which newer technologies like drones and 3D scan are not included at present. Level 5 is attained in the European qualification framework.

Collective bargaining sets a national level as a lower standard and around 90% of workers are covered. Then there are some local company agreements on top of this. These are negotiated by union representatives in the factory and the results have to be better than the national level. This is laid down in the Working Environmental Act and in the Information Consultation Act. Here it is stipulated where and when one party needs to inform the other one and where and when a party needs to negotiate. The Working Environment Act stipulates that representatives be included when a plan is changed. For example, in case of a new camera, there are always local agreements on e.g. who is allowed to view the data. Thus there is a framework before implementation. Local representatives who negotiate every major change with the employer are supported by an ombudsman from the central union. Sometimes it is difficult to interpret what constitutes a change.

It is good practice to include workers in the change, e.g. when choosing a new machine, as they have to use it later on. But this depends on the owner of the company.

Training in the case of a new machinery is usually done in-house, by the supplier of the machine. There is a framework for who is eligible, what happens to those who do not manage, etc., which is determined as well by local representatives.

Broader skills for people already working can be acquired by taking courses at the vocal training centre. Here the employer pays for the training and the salary, but this has to be negotiated by the employer and employee, who often did not work during training, as often people cannot get money from the employer. This worked for the unemployed, as they had other sources of income (e.g. unemployment benefits). Now there is a new agreement in place to improve possibilities to leave the job to undergo up- and reskilling. Here up to 80% of the salary is paid for as long as one year and workers can decide which educational training they would like to receive. The educational training is meant to strengthen workers' positions in the labour market and the government helps to finance it.

It would be good to have some additional guidelines for education e.g. covering who will participate, at whose expense, what happens with those who are not able to cope, etc.

CASE STUDY 8: AUSTRIA

The interview was conducted with a member of the trade union in charge of construction and woodworking and focused on **construction**.

IMPACT

The degree of digitalisation differs in Austria and production facilities of Austrian companies abroad, especially in Eastern Europe. In Austria there is a higher degree of digitalisation. BIM is widely used. The trade union is characterised by sceptical views regarding certain aspects of digital technologies, but trade unions know that technologies will be introduced more and more. The trade unions have to step in to shape how digitalisation is implemented, and especially social aspects of these technologies. There is not only one technology, but rather the individual economical considerations on the part of companies, in which all technological possibilities are open.

Besides company visits, the Chamber of Labour (AK) is an important information source. Membership is compulsory and it is financed by all employees. In the Chamber of Labour, there are many experts in the fields of social affairs, law, technology and economics. Therefore, it also has a great deal of expertise in the field of technology assessment. The Chamber also performs research on the influence of technologies e.g. legal aspects, safety aspects and psychological effects. In addition, it has a regular exchange of knowledge with other research institutes like Vienna University of Applied Science.

While the positive aspects are sometimes neglected by the unions, there certainly are several. Jobs become easier, there is less physical strain, better environmental conditions, better health and safety, jobs become less dangerous. Better ergonomics makes possible better health, including at older ages. There are differences within Europe, however. Especially technologies like exoskeletons are viewed as positive, as they greatly reduce physical strain. But implementation remains a challenge, especially for economic reasons.

One negative aspect is that fewer people are required. Also, trade union tasks are becoming more difficult. Fewer workers means fewer members, which may translate into less influence. The same can be said in the case of central prefabrication, which also means fewer people. At the same time, a more widely distributed workforce – between factory, construction site, offices and homes – means that the trade union cannot reach everyone all at once, which changes how campaigns can be performed. 3D printing is viewed critically, as it reduces the number of workers, while there is low additional value for the worker.

Changes are also affecting social partnerships, as employees are more loosely attached to their company.

In the next 5 years prefabrication will be playing a more important role. Also, the social aspect of fewer people working at the construction site will become more important.

POLICIES

There are sectoral collective agreements, which are usually valid for one year and binding on employees. These are negotiated by the two social partners (labour and employers). These agreements do not explicitly include aspects of technology, although processes are discussed during the bargaining process. Collective agreements focus on an increase in wages, but also include tasks for apprentices, days off, etc. Everyday working conditions are also discussed, but no formal agreement is framed for these, as these are based on the strong and established social partnership. At the end of the year, trade unions ask members about urgent topics, e.g. what to do with old workers who are not capable of working on site anymore. Discussions take place throughout the year on e.g. on training schemes for apprentices in which technological aspects are included.

At the General Accident Insurance Fund (Allgemeine Unfallversicherungsanstalt AUVA), discussions take place on OSH and what can be done to improve its various aspects.

Different facilities are available for training purposes. Some academies are run solely by trade unions and some academies are established by big companies solely for their own workers. In both cases the sponsors run their respective academies. Furthermore, there are nine decentral academies (Bau-Akademien) distributed in each province that are established and financed by the employers. Here unions have access and influence to a certain extent. In addition, financial support is provided by the AK.

Local agreements are concluded with specific companies. In these, the employer negotiates with the works council, which is supported by local trade union representatives, about rights and duties. Technological aspects are covered in these negotiations. The AUVA may also be included and provides some guidance, usually on prevention of accidents.

The GDPR can be used as a guideline for data usage. At present, no agreements exist at the European level. If any agreements are concluded, however, it would be advantageous to highlight the Austrian perspective to preclude any »not invented here« effect at other levels.

Additional agreements are needed to ensure training and qualifications of apprentices, e.g. whether they need to know old technologies and which new ones they need to know. This also needs to be intensified in the area of further training so that all colleagues can use technologies.

There are no institutionalised agreements on the transformational process. There is an established dialogue based on the social partnership (the employer on one side, labour on the other). At the company level, when a works council exists, then there is also a dialogue at that level. At big companies, issues are also discussed in a supervisory board (which also has employer and employee representatives). This is more difficult at very small companies where there is no works council and employees therefore have limited influence. Local trade union representatives also talk with companies and try to exert an influence.

All local trade union representatives undergo training once a year by the trade union in order to ensure a general understanding about how changes will be impacting construction. Local trade unionists are sensitised to screen changes and inform themselves.

Some kind of agreement is needed, as transformation drastically changes the sector in that fewer workers are simply employed. Arrangements need to be established on how to support other workers, e.g. by establishing a fund. There is little trust and confidence in the market to find a solution.

CASE STUDY 9: AUSTRIA

The interview was conducted with a central works council of a multinational **woodworking** company.

IMPACT

Data protection is currently the most salient topic in daily work. A lot of data is saved, e.g. on company smartphones or machines in production, like forklifts. Therefore, it is a daily task to prevent the data being used in a manner that is disadvantageous for colleagues.

Most information is obtained through »self-informing«, e.g. at suppliers. It is important to know about changes at the company early on, so that detailed discussions can be held with the respective project team. This allows more specific information to be obtained. This is not always received quickly enough, however, as developments take place at an incredibly fast pace.

There is a high level of awareness in some works councils. But the level of awareness at some other works councils is lower. This is also due to personal interests and engagement.

Digitalisation can have a positive impact by reducing physical strain, e.g. thanks to less repetitive movements and improved OSH, e.g. by checking in with a camera before performing a task. This can also be measurable e.g. in terms of fewer

visits to the occupational physician, less sickness leave, fewer accidents and fewer serious accidents. The training and qualification of workers is improved, which is not only a positive factor, as it imposes greater pressure to train and obtain qualifications, otherwise workers are perhaps not allowed to use a certain machine anymore. Digitalisation increases output and quality, thereby improving the financial standing of the company, in turn improving workplace safety. Workers with higher qualifications are also less replaceable.

There is an enhanced danger of taylorisation due to small repetitive tasks, but this can be minimised through changes in working positions/job rotation, although this also depends on what the workers want. Very easy manual tasks are being significantly scaled down – nearly no such tasks exist anymore. Nowadays we are witnessing a major leap from easy manual tasks to being in charge of a machine. Automation widens this gap, but it can be managed with suitable training and qualifications. Some workers are unable to bridge this gap, however. Increased productivity, e.g. due to better logistics reducing the number of empty trips, reduces the number of workers needed. But at the same time there is a shortage of skilled labour. Reskilling of existing workers to work in other trades requires considerable effort in terms of time and money and often does not take place, with this dilemma being coped with by the natural outflow of labour. While reskilling was already difficult before, automation increases this difficulty. While the physical strain is reduced, the psychological strain increases, as everything takes place at a faster pace, e.g. when incidents occur, workers have to react quickly and correctly. This makes things more difficult for workers and puts greater pressure on them. Monitoring of workers is a potential threat. At the same time, workers use technologies extensively in their private lives. Here an awareness can be created regarding what data is used for the machine so as to mitigate fears and reduce potential negative effects of data usage on workers, e.g. by means of company agreements.

Most technologies have a positive and a negative side. Most negative aspects can be addressed in the form of measures laid down in agreements.

In the future there will be fewer workers due to increasing efficiency. Output and quality will be improved and environmental protection will gain in importance.

POLICIES

With regard to the use of technology, there are three main policies: (1) The GDPR, which is a central element for many applications, as personal data is often collected. (2) Then there are sectoral collective agreements for the wood industry with a subcategory: the particle board industry, with this agreement being bargained by a local works council with the support of full-time trade unionists. Although technological aspects are not really covered in these agreements, one small example would be as follows: an employee works on a piece-rate pay basis, and an automated machine is introduced that increases output, thereby increasing the wage. But nothing is done about data usage, e.g. installation of a camera. This is where (3) company agreements come into play. Some of these are mandatory, as required by higher law, e.g. surveillance measures needed to monitor human dignity, otherwise these measures cannot be implemented properly. These are also checked externally. Then there are also voluntary agreements which are not required by higher law. Most of these are de facto mandatory, as they relate to personal data, e.g. each camera is subject to approval, especially if recordings are made. These agreements are negotiated by a works council with the employer and sent to a social partner for a review of the legal aspects. Company agreements are highly specific, e.g. a new system for vehicles, where personal IDs with an RFID are used to unlock cars. This agreement covers aspects like what the employer is allowed to do, what it is not allowed to do, when it is allowed to do this, whether supervision is required and so on. The trade unions are supported with legal advice from a lawyer here.

There are rough guidelines on what a company agreement should cover, but companies' needs are too specific for these guidelines to be spelled out in any detail. These guidelines are available at AK or directly from the trade unions. There is an exchange within the network of other works councils as well.

There are no agreements specifically regarding the transformation, as this is highly company-specific as well and therefore laid down in company agreements. Some legislative requirements are in place governing use e.g. of special equipment like large tanks.

No functional description is provided for in collective agreements, with this being provided in company agreements. In general, collective agreements are rather obsolete with regard to functions. They need to be more up to date and technological change needs to be addressed, e.g. in job descriptions.

Any agreements should be concluded at the highest level possible. These are most rare at the company level and from a worker's perspective also the most difficult to influence, as leverage is limited. In collective agreement this leverage is already greater, and this is even more the case at a legislative level. This would even be desirable at the European level, e.g. with regard to worker protection and qualification profiles, as it would promote standardisation across Europe (e.g. France-Austria-Rumania), although this seems highly unlikely.

ANNEX C: IMPACTS IDENTIFIED IN THE CASE STUDIES

Case	Positive Impacts	Negative Impacts
Austria	– Reduced physical strain – OSH – Increased qualification – Increased output and quality, increasing job safety – Workers are less replaceable	– Downsizing of workforce – Qualification creates pressure – Taylorisation – Increased gap between easy and complex tasks – Potential monitoring – Psychological stress
Denmark	– OSH – Reduced physical strain – Impact on planning and improving processes (with regard to efficiency), create better overview and improve communication and collaboration, ensure a better flow and continuity, reduce errors and create common language across the value chain – Improved efficiency -> halt to offshoring	– Surveillance – Psychological stress
Italy	– Improve health and safety issues – Fair pay and the application of contracts – Improved training	– Automation and Big Data are not negative, but seen as less useful
Netherlands	– Increased attractiveness of the sector – Better working environment – Reduced physical strain – OSH	– Less influence on outcomes, less freedom – Functions undermined – Simpler tasks create risk of less training and therefore reduced wages – Reduction of workforce
Spain	– OSH – Supports green transition – Increased attractiveness of the sector	– Potential monitoring – Reduction of workforce
Sweden	– Improved ID can prevent exploitation – Reduced physical strain – Improved qualification – Increased attractiveness of the sector – Workers less replaceable – Improved efficiency → halt to offshoring	– Reduction of workforce – Potential monitoring – Qualification creates pressure

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