Humans in Digitalised Logistics

Towards human-centred and socially sustainable digitalised warehousing in Europe

Policy report
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HuLog

Humans in Digital Logistics

The views and opinions expressed in this report are solely those of the authors.

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List of acronyms

This list provides the full forms of acronyms used in this report.

- 3PL: Third-Party Logistics
- AGV: Automated Guided Vehicle
- AI: Artificial Intelligence
- AMR: Autonomous Mobile Robot
- ASRS: Automated Storage and Retrieval System
- ERP: Enterprise Resource Planning
- FMCG: Fast-Moving Consumer Goods
- GDPR: General Data Protection Regulation
- HR: Human Resources
- WMS: Warehouse Management System
- WPS: Workforce Planning System

Executive summary
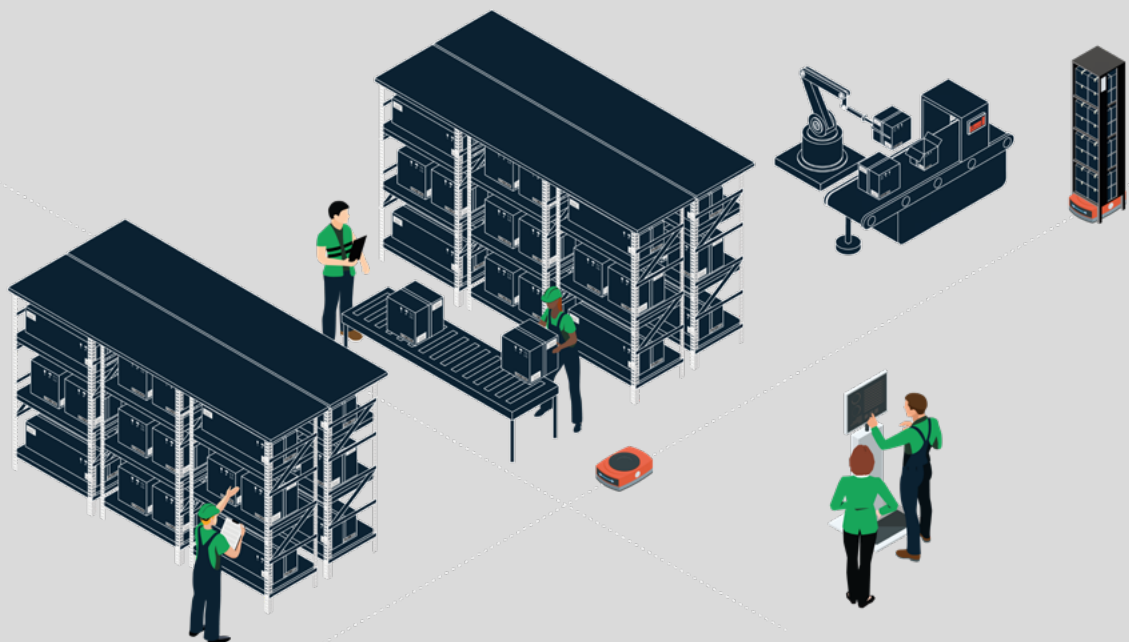
As part of expanding European logistics, warehousing is today an increasingly important source of jobs. Warehouses extensively deploy digital technologies to run operations, which are often adopted with the aim of improving efficiency, productivity, operational flexibility, reducing errors, and cutting costs to remain competitive in low-margin markets. However, these technologies – ranging from warehouse management systems to digital interface handheld scanners, pick-by-voice systems, automated storage and retrieval systems, robots, and human augmentation technologies, such as exoskeletons and smart glasses – also have a deep, lasting impact on the quality of warehousing work. While they might make some tasks physically lighter and more ergonomic, these technologies often introduce new risks by narrowing down jobs to repetitive tasks, intensifying work, and increasing surveillance and control.

As a result, across national contexts, jobs in digitalised warehousing are today unattractive, and warehouses struggle with high injury rates, high turnover, unfilled vacancies, and endemic labour shortages. Poor employment conditions are reflected in low wages and limited benefits,

structurally precarious employment, limited training and advancement opportunities, and the structural overrepresentation of vulnerable workers, such as migrants, workers with a migrant background, and workers with an impairment.

A CALL TO ACTION

Yet this trajectory is not inevitable. Digital technologies can be deployed to improve job quality, extend working lives, and strengthen the social sustainability of European warehousing – but only if policy makers, employers, trade unions and other key stakeholders put humans front and centre in the design, implementation, and governance of digital technologies. This human-centred approach aligns directly with broader European policy initiatives, such as the Quality Jobs Roadmap and the Pact to Strengthen Social Dialogue, and the overall political ambition to build a resilient, green, and digitally integrated logistics systems throughout Europe. It further supports national and regional aspirations for socially sustainable economic welfare grounded in a strong logistics sector.

OUR RESEARCH

This report presents the results of a three-year international research project on how digital technologies shape work and employment conditions in warehousing across three major logistic hubs in Belgium, Poland, and the United Kingdom. The project aimed to identify guiding policy principles for advancing a more human-centred and socially sustainable digitalised warehousing across Europe.

The studied warehouses make use of various combinations of digital technologies to organise warehouse operations and work. Workers and their representatives are often not involved or only marginally involved in decisions on technology. We found extensive evidence of the deskilling of jobs, eroding workers' autonomy and making their work less meaningful. While (semi-)automation technologies, such as robots and conveyor belts, make physically demanding tasks lighter, they also introduce new risks, as jobs often become less varied, tasks more repetitive, and work intensified, with profound implications for workers' physical and mental well-being. Warehouse management systems allocating tasks through digital interfaces also enable management to closely monitor workers' performance, increasing workers' stress levels. At the same time, work coordination through these technologies substantially reduces human interactions in the warehouse, eroding the social fabric and in some cases leading to feelings of isolation.

Digital technologies also play an important role in facilitating the fragmentation of the workforce. By semi-automating the processes of sourcing, coordinating, and controlling workers, they facilitate complex employment models that structurally rely on temporary contracts, agency work, and work through subcontractors on-site. For many workers, this translates into temporary (agency) employment, volatile hours and high flexibility requirements, wages usually just above minimum wage, limited benefits, and negligible training and career opportunities. Across contexts, this employment model results in a substantial share of workers belonging to vulnerable groups and disproportionately more often working in the least favourable jobs at the least favourable employment conditions. Overall, this study points to the predominance of a fragile, low-trust, socially unsustainable employment model in warehousing, despite the importance of logistics for the European economy.

Digital technologies can be deployed to improve job quality, extend working lives, and strengthen the social sustainability of European warehousing – but only if policy makers, employers, trade unions and other key stakeholders put humans front and centre in technology design, implementation, and governance.

SIX POLICY PRINCIPLES FOR HUMAN-CENTRED WAREHOUSING WORK

The remedy is not to oppose technological innovation, but to redirect it to foreground humans, and especially workers. Our report sets out six principles for human-centred and socially sustainable warehousing in Europe.

01 End-to-end worker involvement

Workers and their representatives must be involved in all phases of digital technology adoption including selection, design, piloting, roll-out, and ongoing use. Their participation should be anchored in legislation and organised through existing bilateral bodies where present (e.g., bilateral management-trade union representative bodies, work councils) or ad hoc bodies where bilateral bodies do not exist. Participation should be organised to include the voice of more vulnerable workers, who constitute a substantial share of the workforce (e.g., temporary workers, workers employed by subcontractors, workers with a migration background, women, workers who do not speak the local language). Workers' involvement and inclusion fosters the quality of technology-related decisions, perceptions of fairness among workers, as well as mutual trust and shared responsibility between workers and the employers in the use of digital technologies.

02 Regulated data usage and negotiated algorithms at work

There need to be clear and binding legal regulations around what kind of data employers are allowed to collect, how data can be used, and at what level (for example, team vs. individual), and with which third parties it can be shared. There must be guaranteed human involvement in Human Resource Management decisions based on collected data. There should be company-level governance structures and procedures to guarantee the rights of workers and their representatives in this area. Next to these legal provisions, company-level bilateral governance structures and procedures should be installed for the 'algorithm' – all the aspects related to advanced data-intensive digital technologies – to be collectively negotiated between the employer and workers' representatives, embedding them in employment relations. Overall, regulated and transparent data usage and a negotiated algorithm foster perceptions of fairness among workers, mutual trust between workers and the employer, and shared responsibility for the digital technology and its effects.

03 Prevention and redress of health, safety, and psychosocial harms

Maximising workers' physical and mental well-being at work is essential to make warehousing jobs socially sustainable. Legislation should impose comprehensive pre-introduction health and safety risk assessments to prevent harms as well as the continuous monitoring and evaluation of the short- and long-term effects of novel digital technologies, which are today still partially unknown. Systems of control and enforcement through labour inspectorates should be established and adequately funded. Risk assessments and redress measures should cover all dimensions of job quality, also paying attention to restoring social relations in warehouses where they have been eroded by the use of digital technologies. Such measures will enhance workers' physical and mental well-being as well as the social climate at work, decreasing instances of sick leave, absenteeism and turnover, and improving worker retention.

04 Technology use for inclusion in high-quality jobs

Digital technologies should be purposefully designed and deployed to tailor jobs to specific individual and group competences and needs. They should be used to reduce physical strain, broaden jobs in tailored ways, cut language barriers, stabilise work schedules, and overall widen access to high-quality warehousing jobs. These uses should be negotiated between the employer and workers and their representatives, with specific attention for including the voices of more vulnerable workers in negotiations. A better tailoring of warehousing jobs will make them more inclusive and sustainable, increasing overall workforce retention.

05 Stabilised employment relations

Stakeholders should work to raise the share of direct, permanent employment, extend collective bargaining and other forms of worker representation, equalise pay and protections across contract types, and ensure clarity and equity across supply chains. Legal regulation should be introduced that guarantees the alignment of the employment conditions of warehouse workers on different types of contracts and across formal employers, including workers' right to representation. The responsibility and liability of the client company for all workers, independent of the formal employer, should be strengthened. A principle of maximal stabilisation of employment should be established, and the utilisation of temporary (agency) employment and outsourcing should be collectively negotiated. By improving the terms of employment of the less protected segments of the workforce, where the most vulnerable workers are concentrated, these measures will promote long-term, inclusive and sustainable employment and employment relations, decreasing worker turnover and mitigating current labour shortages.

06 Enhanced training and career opportunities

Employers should be mandated to invest in certified training on digital technologies and establish minimal standards for re- and upskilling warehouse workers. Transparent, fair, and non-discriminatory training policies and career paths should be collectively negotiated, in view of providing workers with more career opportunities and granting access to workers on temporary contracts and/or belonging to more vulnerable groups. Digital technologies should themselves be used to develop training that is more tailored to workers' individual skills, needs, and interests. Training activities would benefit from structural collaborations among companies and other relevant local actors. These measures will make warehousing jobs more attractive, broadening the pool of potential warehouse workers and helping to retain workers, reducing shortages of qualified labour. They will allow companies to directly employ more skilled workers and to reduce their operational dependence on technology providers and the costs derived from technology.

KEY STAKEHOLDERS

The six guiding policy principles for a human-centred, socially sustainable warehousing set out in this report rely on the coordinated action of multiple stakeholders.

→ **Supra-national and national policy makers.** Including European Union institutions, international organisations such as the International Labour Organization, and national authorities (including, for instance, the ministries of employment, transport, digital, and industry, labour inspectorates, occupational-health bodies, and data protection authorities) – should legislate and enforce measures mandating minimum standards and installing participatory governance structures that guarantee the quality of jobs in digitalised warehousing.

Their role is critical in setting a level playing field between companies within and across national borders, to avoid that competitive pressures translate in poor employment conditions that externalise costs (e.g., injuries, short working careers) to the most vulnerable workers themselves, their families, local communities, and the welfare state, eroding public value and sustainable welfare. Moreover, they play a key role in providing incentives to companies and other stakeholders for good practice, such as investing in training to reskill and upskill workers in safe, tailored, and inclusive digital technologies.

→ **Companies operating warehouses are the main initiators of technology-related decisions.** They choose, buy, and configure specific combinations of digital technologies, and set the main rules for their use. Doing so, they fundamentally shape the nature of warehousing work, its coordination and allocation, as well as levels of required skills, employment models, and all employment-related decisions.

This stakeholder holds the immediate levers to redesign jobs, data governance, and employment models. Next to compliance with legislation, companies should guarantee the involvement of workers and their representatives in all phases of digital technology adoption, collectively negotiate

the algorithms with workers' representatives, adopt measures to redress health, safety and psychosocial harms caused by digital technologies, and co-develop and adopt digital technologies that tailor jobs fostering inclusion. They should offer similar protection to workers independent of contractual form and strive to maximally stabilise employment relations, and work with other stakeholders to provide maximal training to upskill and reskill workers, and transparent and fair career opportunities.

→ **Workers and worker representative organisations are key co-owners of change towards more human-centred jobs.** The improvement of job quality in warehousing is never merely a technical question of adapting existing technologies or introducing new ones. Trade union representatives, work councils, health and safety reps, workers' representatives, and bottom-up shop floor activists have indispensable, practice-based knowledge of the impact of technologies on work and are essential to ensure compliance with the law.

They should channel workers' voice and involvement to co-design technologies and shape fair, reasonable and sustainable data use boundaries, and performance norms. They should be involved in identifying and redressing physical and mental risks, training needs, and ensuring fairness among workers, independent of employment contract and demographic profile. Their involvement in technology-related decisions will foster technology acceptance among workers. At higher levels, workers' representative organisations should advocate for regulation advancing human-centred warehousing, provide knowledge and organisational support to workers' representatives in warehouses, and promote and support the inclusion of more vulnerable workers.

→ **Labour market intermediaries and subcontractors on-site play an important role in employment models currently used by warehouses.** As the formal employer of many warehouse workers, they should advocate for workers' involvement in all phases of digital technology adoption, request client companies to comply with legislation on data use, propose and

control measures to redress health, safety and psychosocial harms caused by digital technologies, and request and facilitate the co-development and adoption of digital technologies that tailor jobs fostering the work inclusion of more vulnerable workers, which are a large share of the workers they employ.

Moreover, they should strive to maximally stabilise employment relations with special attention for improving the employment conditions of vulnerable workers, and collaborate with other stakeholders to ensure their workers receive maximal training and career opportunities in transparent and fair ways.

→ **Other key stakeholders include employers' associations, education and training institutions, clients of warehousing companies, public employment services, local authorities, advocacy organisations, and public funders.** As part of the broader ecosystem in which warehouses operate, they play important roles in creating the boundary conditions for a more human-centred use of technology and improving employment conditions. Employers' associations should diffuse information and promote the adoption of human-centred, socially sustainable digital technologies in warehousing among their members to increase the attractiveness of warehousing jobs and advocate the development of more human-centred technology with technology providers.

Education and training institutions should collaborate with employers, employers' associations, trade unions, and public employment services to develop technology-related training to upskill and reskill warehouse workers, and to deploy technology to provide training in inclusive ways. Finally, the clients of third-party logistic companies, public employment services, local authorities, advocacy organisations, and public funders should advocate and support, from their specific roles, coordinated action to develop and adopt digital technologies to foster human-centred, socially sustainable warehousing and regional welfare.

01 .
Introduction
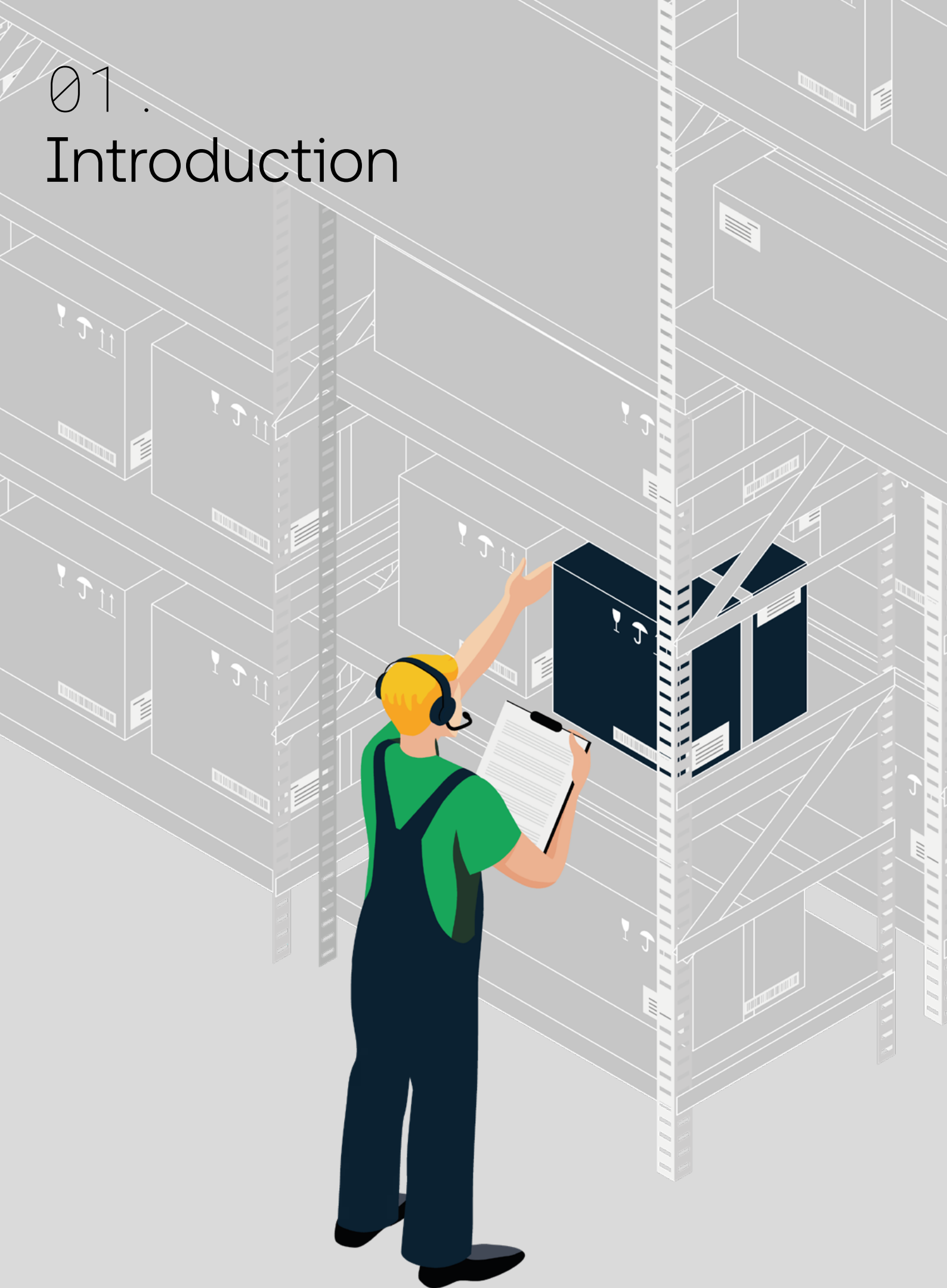
This report presents the results of a three-year international research project on digital technologies in warehousing. The project aimed to identify guiding policy principles for advancing a more human-centred and socially sustainable digitalised warehousing across Europe. This means offering work under safe conditions that: fosters workers' development, is adequately compensated, enables workers to stay in work now and for as long as reasonably possible, avoids externalising costs onto society and the welfare state, and rests on social partnerships. The report is based on an extensive evidence base collected in three logistic hubs located in Belgium (Limburg), Poland (Western Poland), and the United Kingdom (West and South Yorkshire). Such evidence documents how the adoption of a wide range of digital technologies to organise operations and work is profoundly reshaping work and employment conditions in European warehouses. The project starts from the assumption that digital technologies can play a key role in advancing a more human-centred and socially sustainable warehousing. Improving work and employment conditions – including through safe working conditions, more stable employment forms, fair compensation, workers' voice, and development opportunities – is essential to safeguard productivity and competitiveness of warehousing.

Logistics – a cornerstone of European welfare, competitiveness and security – is currently a top priority on the European agenda.[1] The EU-30 transport and storage sector not only generates an annual turnover of approximately €1.89 trillion but also holds significant strategic importance.[2] This is evident from recent events, including supply chain disruptions during the COVID-19 pandemic, surging economic and geopolitical tensions, fierce global competition for raw materials, and the rapidly growing share of e-commerce. To address these challenges, the European Union (EU) is developing the so-called "Physical Internet", an infrastructure that uses advanced digital technologies to improve the interoperability and environmental sustainability of European logistics, ensuring the smooth and efficient circulation of goods.[3] In addition, the EU recently committed to a €12 billion investment to develop the Trans-Caspian Transport Corridor. This Corridor will connect China to Europe via Kazakhstan, the Caspian Sea, the South Caucasus, and Turkey, providing a crucial alternative route bypassing Russia and Belarus.[4]

Over 12 million people work in logistics across the EU-27 (10.6 million) and the United Kingdom (1.9 million),[5] keeping goods moving and supply chains running. A significant number of these workers, approximately 699,000, are employed in warehousing within the logistics sector. This figure is however a gross underestimation, as it refers only to workers employed in the sub-sector 'Warehousing and Storage' (H521 in the Eurostat NACE classification) within the broader logistics sector of 'Transport and Storage' (H), and does not include the much larger workforce involved in in-house warehousing and storage activities in other economic sectors, on which no reliable data is available.[6] Warehousing jobs, from unloading and stowing, to order picking and loading, are today being fundamentally transformed by a wide range of readily available digital technologies, including warehouse management systems (WMS), digital interface tools (e.g., handheld scanners, pick-by-voice systems), Automated Storage and Retrieval Systems (ASRSs), robots, and human augmentation technologies (e.g., exoskeletons, smart glasses).

Digital technologies hold a great potential to improve warehousing jobs, as they can be deployed, among other reasons, to reduce physical strain,

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1   European Commission. (2024a). The future of European competitiveness: A competitiveness strategy for Europe.

2   All figures, except for the UK data, are drawn from Eurostat. (2023). Structural business statistics: Enterprises by detailed NACE Rev. 2 activity and special aggregates.

3   ALICE-ETP. (2020). Roadmap to the Physical Internet: Executive version.

4   Avdaliani, E. (2025, May 22). Europe's big bet on the Trans-Caspian Transport Corridor. Diplomatic Courier.

5   Office for National Statistics. (2025). UK workforce jobs SA: H Transport & storage.

6   In this report, the term 'logistics' is used for the broader 'Transport and Storage (H)' sector according to the Eurostat NACE classification, while 'warehousing' refers specifically to the 'Warehousing and Storage (H521)' sub-sector within logistics; Eurostat. (2023). Structural business statistics: Enterprises by detailed NACE Rev. 2 activity and special aggregates.

increase productivity and workers' remuneration, tailor jobs and training to individual skills and preferences, automate heavy and repetitive tasks, and better forecast staffing needs. This potential is of particular relevance given the mounting pressure to make jobs more sustainable, extending the working lives of an increasingly diverse and ageing European population. However, this potential remains largely unrealised today, as technology adoption decisions are made with insufficient consideration of humans, and in particular of their impact on the quality of warehousing jobs. Across national contexts, warehouse work is unattractive, and warehouses struggle with unfilled vacancies and high worker turnover rates, due to poor working conditions, relatively high injury rates, precarious employment contracts, low wages and limited benefits, and limited training and career prospects. Relatedly, workers belonging to the most vulnerable segments of the workforce – including migrant workers, workers with a migrant background, formerly incarcerated persons, sheltered workshop workers – are strongly overrepresented in the heaviest, most deskilled, and most precarious warehousing jobs.[7] Labour shortages, in turn, stimulate the adoption of additional digital technologies with the aim to reduce reliance on labour, rather than to improve job quality.

This policy report formulates six guiding principles towards human-centred, socially sustainable warehousing jobs derived from the conducted research project. This ambition is in line with the European Commission's commitment to improving work and employment, as reflected in the Pact to Strengthen Social Dialogue in Europe,[8] and in particular the Quality Jobs Roadmap, an initiative to foster fair wages, good working conditions, and inclusion in the transition to a green digital economy.[9] Recognising that quality work is essential for social justice, productivity, skills, and competitiveness,[10] this initiative acknowledges the key role of social partners and foresees wide consultations to inform new legislation and frameworks. Similarly, our policy principles have been developed based on insights from a wide variety of stakeholders, reflecting their specific roles and the diverse geographical, institutional, economic, and demographic ecosystems in which the studied warehouses are embedded.

This report is structured in six sections. The next section presents key economic and employment figures for the logistics sector and warehousing more specifically in Europe. Section three presents the study and how the evidence was collected in three key European logistic hubs. Section four details the nature of digital technologies and explains how they are changing warehousing operations and jobs. Section five shows how various digital technologies impact the quality of warehouse work in terms of workers' autonomy and the meaningfulness of work, workers' physical and mental well-being and work sustainability, workers' social environment at work, and worker participation in decisions on digital technologies. Section six shows how employment strategies in warehouses commonly rely on a multi-tier employment model, yet employment practices, in terms of work shift allocation, work allocation, wage and benefits, and training and development opportunities, distinctively reflect national legislation, the presence or absence of union representation, specific labour markets, and company strategies. In the final section, six policy principles are formulated to make digitalised warehousing more human-centred and socially sustainable.

7   Zanoni, P., & Miszczyński, M. (2023). Post-diversity, precarious work for all: Unmaking borders to govern labour in the Amazon warehouse. Organization Studies, 45(7), 987–1008; Lee, T. L., Tapia, M., Aranzaes, C. L., Sapre, S. R., Shimek, S., Pinto, S., & Bustamante, A. R. (2024). The militarization of employment relations: Racialized surveillance and worker control in Amazon fulfillment centers. Work and Occupations, 52(4), 491–528.

8   European Commission. (2025, March 5). Commission and social partners sign joint Pact to strengthen social dialogue in Europe.

9   Directorate-General for Employment, Social Affairs and Inclusion. (2025, April 16). Executive vice-president Mînzatu kicks off exchanges with social partners on the Quality Jobs Roadmap.

10 Ceemet. (2025, April 17). Ceemet emphasises the need for competitive companies and skills development at the Quality Jobs Roadmap consultation. ETUC. (2025a, June 24). ETUC demands for the Quality Jobs Roadmap.

02.
Warehousing
in Europe

2.1 THE WEIGHT OF LOGISTICS AND WAREHOUSING IN THE EUROPEAN ECONOMY

Warehousing commonly refers to the storage and handling of goods in dedicated facilities and comprises a wide range of interconnected activities, such as inventory management, stowing, order picking, packing, and goods movement, that ensure products are efficiently stored and distributed.[11] Warehousing has increasingly become a major economic activity over the last decades, reflecting the rapid expansion of supply chain logistics. In 2022, the European Union's logistic sector generated a net turnover of €1.89 trillion, with warehousing accounting for roughly 27% of that total.[12] Aside from a temporary dip during the COVID-19 pandemic, spending on logistics, including warehousing, has risen steadily, increasing by €46.3 billion between 2009 and 2023 (see Figure 1). This growth was driven primarily by the surge in e-commerce, but also reflects rising energy and transport costs and ongoing supply chain disruptions.

The warehouses in the three logistic hubs included in this study are strategically located along two of the nine main logistics corridors of the EU's Trans-European Transport Network (TEN-T): the North Sea-Baltic (Belgium and Poland) and the North Sea-Mediterranean (Belgium and the UK). These routes serve as the backbone for freight and passenger

Figure 1. Growth of European (EU-30) Logistics Spend between 2009 and 2023.
Own elaboration based on Pflaum (2024)

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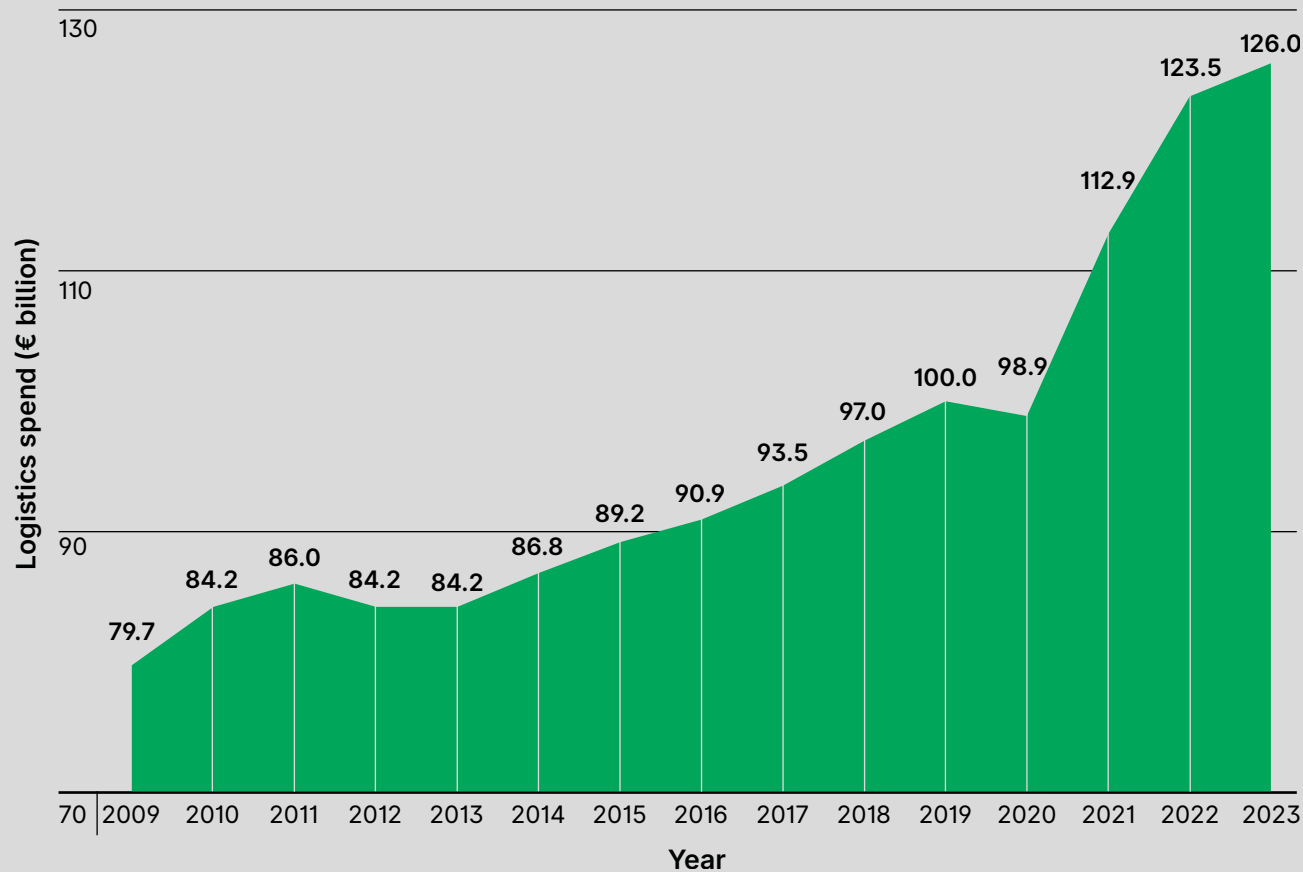
11 Hompel, M., & Schmidt, T. (2006). Warehouse management: Automation and organisation of warehouse and order picking systems. Springer Science & Business Media.

12 All figures, except for the UK data, are drawn from Eurostat. (2023). Structural business statistics: Enterprises by detailed NACE Rev. 2 activity and special aggregates. UK data have been drawn from sector specific market reports and data sources such as the IBIS World database.

transport across the continent, integrating road, rail, inland waterways, and ports.[13] The United Kingdom, Belgium, and Poland are among Europe's leaders in the warehousing market (see Figure 2). In 2023, the United Kingdom was at the forefront of Europe's warehousing with a €32.11 billion net turnover and nearly 14,000 enterprises,[14] reflecting its advanced logistics infrastructure and role as Europe's largest e-commerce market. Belgium's warehousing generated €5.84 billion with 627 enterprises. These figures reflect the country's strategic position on major European trade corridors, including its proximity to the continent's largest seaports in Antwerp and Rotterdam (in the Netherlands). With a turnover of €5.98 billion and 1,710 enterprises, Poland has emerged as a major warehousing player,

having attracted significant foreign investment due to its competitive labour cost and expanding industrial zones.

2.2 EMPLOYMENT IN LOGISTICS AND WAREHOUSING IN EUROPE

Warehousing is a major source of employment across Europe.[15] In the EU-27 and the United Kingdom, logistics employs an estimated over 12 million people, which represents approximately 6.5% of the total workforce. Of this number, warehousing alone accounts for roughly 699,000 workers, while migrant labour constitutes a sizable share of the workforce across all these national contexts.

Figure 2. Net Turnover of Warehousing and Storage in Europe by Country (€ billion).
Own elaboration based on Eurostat (2023) and IBISWorld (2025)

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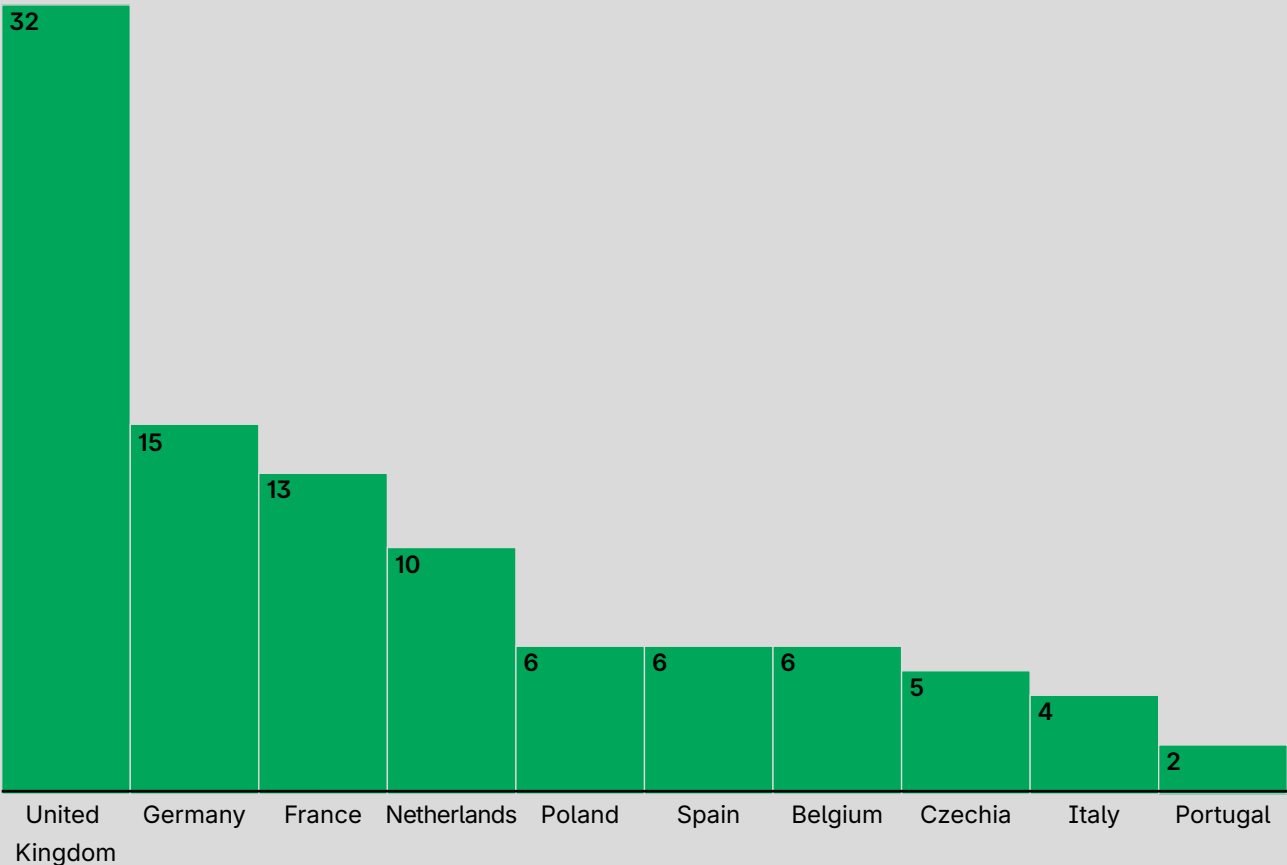
13   European Commission. (2024b). Trans-European Transport Network (TEN-T). Directorate-General for Mobility and Transport.

14   IBISWorld. (2025). Warehousing & storage in the UK – Market research report (2015–2030).

15   All figures, except for the UK data, are drawn from Eurostat. (2023). Structural business statistics: Enterprises by detailed NACE Rev. 2 activity and special aggregates. These figures should be interpreted as indicative estimates rather than precise counts.

The UK's logistic sector employs around 1.9 million people,[16] with 277,000 working in warehousing, making it the largest warehousing workforce in Europe.[17] Migrants comprise a significant portion of this workforce: 21% are EU nationals, primarily from Romania, Poland, and Bulgaria, and another 16% are from outside the EU.[18] In 2024, the average labour cost was €29.2 per hour.[19] Labour relations in the UK are characterized by relatively weak regulation and limited collective bargaining.

Poland's logistic sector has grown rapidly, employing more than 957,000 workers (6% of the total workforce), with 66,112 in warehousing. Migrant workers from Ukraine, Belarus, and Georgia, and increasingly from India, Nepal, Bangladesh, and Pakistan, have become essential to the workforce. In some regions, foreign-born workers now constitute up to 20% of the warehousing workforce.[20] With an average labour cost of €17.3 per hour in 2024, Poland recorded the lowest labour costs among the three countries. Polish employment relations are characterized by weak unions and company-level wage negotiations.

The Belgian logistic sector employs about 229,000 workers (5.5% of the total workforce), with 15,861 in warehousing. Workers migrant origins represent a large share of the warehousing workforce: 38% of workers are of foreign origin, with 22% from outside the EU (notably Morocco and Turkey) and 16% from within the EU (mainly Romania, Poland, and Bulgaria).[21] The country's average labour cost of €48.20 per hour in 2024 is substantially higher than in the other two. Belgian employment relations are characterized by a strong corporatist tradition, with collective agreements at the national, sectoral, and company levels regulating wages and working conditions.

16 Office for National Statistics. (2025). UK workforce jobs SA: H Transport & storage.

17 IBISWorld. (2025). Warehousing & storage in the UK – Market research report (2015–2030).

18 Office for National Statistics. (2023). Business register and employment survey.

19 Office for National Statistics. (2024). Index of labour costs per hour, non-seasonally adjusted.

20 Property Forum. (2024, August 22). Poland records highest warehouse take-up in Europe.

21 FOD Werkgelegenheid, Arbeid en Sociaal Overleg. (2024). Rapport diversiteit 2024.

03.
The study:
Evidence from
three key European
logistics hubs

Western Poland

West and South Yorkshire, UK
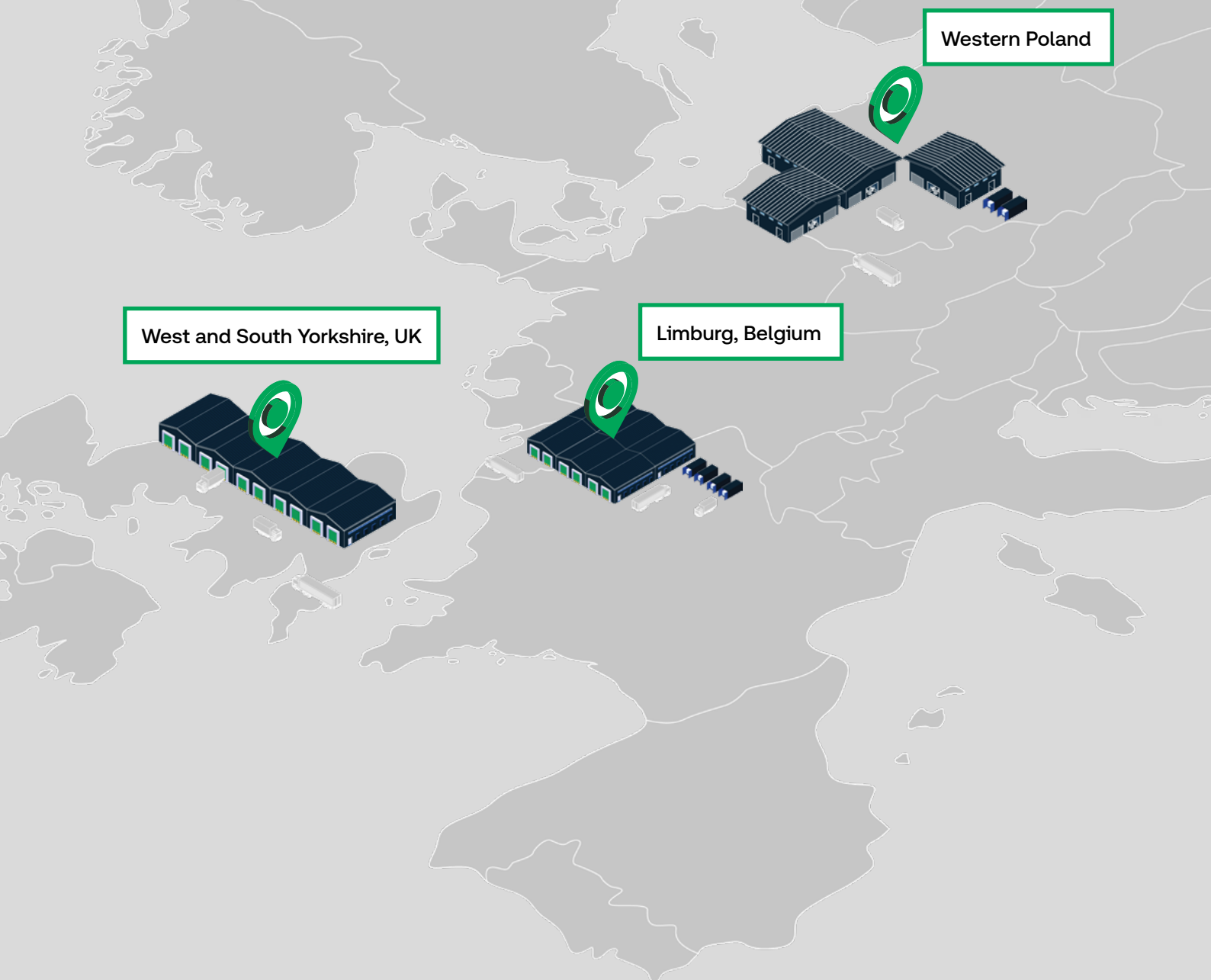
Limburg, Belgium

This research is anchored in three major European logistics hubs: Limburg (Belgium), West and South Yorkshire (United Kingdom), and Western Poland (Poland). The north-eastern Belgian province of Limburg has developed into the second-largest logistics region of the country. Today, the warehousing sector provides a significant portion of employment, after the closure of the coal mining sector and the disappearance of the manufacturing industry. Its location near the Dutch and German borders, combined with strong multimodal infrastructure and proximity to major cargo hubs, such as the port of Antwerp, the airport of Liège, Cologne, and Brussels, makes it highly attractive for logistics firms. This logistics hub operates within the institutional framework of Belgium's coordinated market economy, where multi-level collective bargaining and mandatory worker representation formally secure wages, working time, and benefits.[22] In practice, however, access to these protections is mediated through a segmented internal labour market, where different groups of workers - e.g., permanent versus temporary, native versus migrant, Dutch-speaking versus non-Dutch-speaking - have unequal access to these protections.

Similarly, West and South Yorkshire are both located in the north of England and together have become one of the largest logistics regions in the UK, second to the south-east of the country. Its central location within the country, combined with strong road transport links, and cheaper land prices and labour costs (compared to the south-east), has accelerated growth in the region in recent years. Like Limburg, West and South Yorkshire are regions marked by deindustrialisation including the closure of the mining industry and the decline of manufacturing across the past four decades. By contrast to Belgium, however, the UK has a liberal market economy with a voluntarist industrial relations system.[23] Sectoral agreements are absent, and pay and conditions are defined at firm or site-level through union recognition deals, which range from robust national frameworks that encompass the full spectrum of terms and conditions, to weaker arrangements that only cover pay. Agency workers and newer migrant groups often fall outside collective coverage, leaving large parts of the workforce dependent on employer discretion.

Western Poland, broadly understood as the regions bordering Germany and the Czech Republic, is a fast-growing warehousing hub. Often reliant on greenfield investments, subsidised with regional funds within industrial zones, this region attracts investors operating not only domestically, but especially oriented towards operations in Western Europe. Main logistics actors include an exponentially growing network of Amazon's warehouses, high activity of logistics real estate developers, as well as Third Party Logistics (3PL) operators. Reflecting the 'free market' transformation following post-socialist reform, this hub presents the most liberalised model, with relatively low worker protection, low sectoral bargaining, and low union visibility.[24] Within logistics, the employment relations are strongly tied to employment agencies and precarious work arrangements. In the last decade, this labour market has become increasingly based on migration from the former Soviet republics, a process that has intensified with the war in Ukraine.

The project adopted a qualitative, multi-sited approach across nine companies, three in each logistics hub. The sample was selected to ensure diversity in warehouse type (e.g., in-house logistics, 3PL providers), level of technological integration (ranging from low-tech environments relying mainly on manual processes to highly automated facilities), and workforce composition (variation in contract types, employment security, and degree of precarity, including the use of migrant labour) (see Table 1).

22 ETUI. (2016, December 15). Industrial relations in Belgium.

23 Brione, P., & Buchanan, I. (2024, January). Trade unions and industrial relations. House of Commons Library.

24 Unterschütz, J., & Woźniewski, K. (2011). Industrial relations within the Polish legal system – Why the CJEU judgements have little effect on Poland. In W. Warnecke & A. Bückert (Eds.), Reconciling fundamental social rights and economic freedoms after Viking, Laval and Rüffert (pp. 159–191). Nomos.

Table 1. Profile of Companies Studied and Workforce by Region.

Limburg (Belgium)

	Scope of operations	Technological integration	Workforce composition
Company 1	• Third-party logistics (3PL) • Single-client • Chemical and pharmaceutical products • 88 sites in 18 different countries - 1 included in this study	• Mainly manual work, with workers using transport vehicles to pick and transport goods • Person-to-goods picking solutions, fully integrated with WMS • Limited automation: Robotic arms and ergonomic picking devices to ease lifting	• 120 workers: 80% direct permanent workers and 20% temporary agency workers (on-site agency) • A small pool of subcontracted workers, deployed as needed through a sheltered employment provider • Generally low-skilled workers • Predominantly male, aged 20-50, 70% migrant origin with permanent residency (mainly Turkish and Moroccan background)
Company 2	• Third-party logistics (3PL) • Multiple clients • Pharmaceutical products • 3 sites - 1 included in this study	• High presence of semi-automation: goods-to-person systems, fully integrated with WMS • Advanced automation: Automated cranes, shuttles, robots for depalletising and sorting, and machines for folding cartons and labelling • Limited manual work: Truck loading/unloading and cold storage handling	• 50 workers: 60% direct permanent workers and 40% temporary agency workers (on-site agency) • A small pool of subcontracted workers, deployed as needed through a sheltered employment provider • Generally low-skilled workers • Gender balance equal, 75% under 30, over half migrant origin with permanent residency (mainly Turkish and Moroccan background)
Company 3	• In-house logistics • Automobile parts • 10 sites in 10 different countries - 1 site included in this study	• Mainly manual work, with workers using transport vehicles to pick and transport goods • Person-to-goods picking solutions, fully integrated with WMS • Limited automation: Basic automation for sealing, labelling, packaging, sorting	• 600 workers: 80% direct permanent workers, 20% temporary agency workers (on-site agency) • +/- 100 subcontracted workers, deployed as needed through a sheltered employment provider • Generally low-skilled workers • 35% women, 65% men, many over 50, increasing younger recruits, highly diverse (19 nationalities, mainly Turkish, Moroccan, Italian origins)

Western Poland (Poland)

	Scope of operations	Technological integration	Workforce composition
Company 4	• In-house logistics • Lifestyle Retailer • 1 site - included in this study	• High presence of semi-automation: Goods-to-person systems including automated conveyors, mezzanine systems, fully integrated with WMS • Advanced automation: Machines for folding cartons, labelling and sorting solutions • Limited manual work: Truck loading/unloading, forklifts	• Over 300 workers, rising to 400 during peaks, 80% direct permanent workers, 20% agency workers (half of them subcontracted and half temporary) • Majority of low-skilled workers with some mid-skilled and tech-skilled among them • 62% women, 38% men, 6% migrants (Ukrainians and Belarusians), average age: 32
Company 5	• Third-party logistics (3PL) • Single client • Home improvement and construction retailer • 12 sites - 1 included in this study	• Mainly manual work such as loading/unloading with workers using transport vehicles to pick and transport goods • Person-to-goods picking solutions, voice-picking, fully integrated with WMS • No automation	• Over 1,500 across full distribution function • 130 workers in the studied warehouse: 50% direct permanent workers, 50% agency workers (civil law contracts, 90% of them are migrants, mostly Ukrainians and Belarusians) • Generally low-skilled workers • 80% men, 20% women, average age: 35
Company 6	• In-house logistics • Fast-Moving Consumer Goods Retailer • 12 sites - 3 included in this study • Order picking and loading function subcontracted at some sites	• Mainly manual work such as loading/unloading with workers using transport vehicles to pick and transport goods • Person-to-goods picking solutions, fully integrated with WMS • No automation	• 20% direct permanent workers, 80% agency workers (civil law contracts) with growing number of subcontracted workers (15 agencies operating) • 80% of workers migrants (90% of them Ukrainians) • Generally low-skilled workers • 80% men, 20% women

West and South Yorkshire (UK)

	Scope of operations	Technological integration	Workforce composition
Company 7	• In-house logistics • Supermarket retailer • Over 40 sites - 3 included in this study • E-commerce general merchandise function subcontracted	• High presence of semi-automation: Goods-to-person systems, fully integrated with WMS • Advanced automation: Automated goods vehicles, shuttles, robots for depalletizing and sorting, and robots for transporting parcels • Limited manual work: Truck loading/unloading and cold storage handling	• Over 12,000 across full distribution function • Mostly direct permanent workers, plus 10% agency (rising to 30% during peak) • 20% female workforce across sites • Diverse age and migration background (more non-EU workers since Brexit) • Generally low skilled workers, but 60 engineers at most high-tech site
Company 8	• In-house logistics • Supermarket retailer • Over 20 sites - 1 included in this study • None of the warehousing processes are subcontracted (took all warehousing operations back in house ~10 years ago)	• Mainly manual work, with workers using transport vehicles and semi-electric palette trucks to pick and transport goods • Person-to-goods picking solutions, fully integrated with WMS	• Estimated approx. 20,000 across full distribution function • 35% agency (and growing in order to replace direct permanent workers) • 40% female workforce (mostly agency workers) • Large migrant population – majority Polish but also Romanians or Bulgarians who are more likely to be agency workers • Generally low skilled workers
Company 9	• In-house logistics • Lifestyle Retailer • Approx. 10 sites - 3 included in this study • None of the warehousing processes are subcontracted	• High presence of semi-automation: Goods-to-person systems, fully integrated with WMS • Some manual work remains: Truck loading/unloading and cold storage handling, in addition to some person-to-goods picking	• Over 7,000 across whole distribution function • Majority direct permanent workers with some use of temporary and agency during peak times (approx. 5-10%) • Generally low skilled workers, but significant in-house technology team

The project is built on a rich and diverse body of qualitative data. Semi-structured interviews were complemented by document analysis, field observation, and consultations in stakeholder workshops in different phases of the research. Document analysis covered internal company materials, policy documents, sectoral reports, and union publications, while field observations offered direct insights into warehouse layouts, workflows, and the use of technology in practice. Stakeholder meetings, in turn, created spaces for co-reflection and helped integrate practitioner perspectives.

Extensive interviews – 152 in total – were conducted inside the nine companies with warehouse workers, site managers, in addition to head office managers. Within warehouses, interviews with workers captured lived experiences of digital tools, task organisation, supervision, and well-being, while conversations with supervisors, human resource (HR) management staff, trade union representatives, on-site temporary work agencies, and higher-rank managers shed light on employment practices, technological adoption, and organisational strategies (see Table 2).

An additional 85 interviews were carried out with institutional actors with significant influence on technology adoption and working conditions in warehouses in the three logistics hubs. These included representatives of trade unions, employer associations, public employment services and private labour market intermediaries, government bodies, and technology developers and consultants (see Table 3). Many of these actors maintain direct ties with the warehouses included in this study, through service provision, regulation, advocacy, or technological implementation.

This multi-layered dataset captures the perspectives of a wide range of actors involved in warehouse operations as well as those of actors shaping the broader institutional and technological environment in which warehouses operate. Due to its international focus, the data allowed for a cross-country comparison to identify how digital technologies are implemented, negotiated, and experienced across different contexts.

Table 2. Warehouse-level Data: Research Participants (by country).

Position	UK	Poland	Belgium	Total
Head office management/professionals	5	8	14	**27**
Site-level management	6	23	15	**44**
Warehouse workers	27	29	25	**81**
Total	**38**	**60**	**54**	**152**

Table 3. Hub-level Data: Stakeholder Organizations (by country).

Organization	UK	Poland	Belgium	Total
External labour market intermediaries (e.g., recruiters, public employment services, employment support providers, charities)	11	5	4	**20**
Employers' associations	3	1	5	**9**
Trade unions	5	1	4	**10**
Local government	16	2	3	**21**
Technology providers, consultants	13	4	8	**25**
Total	**48**	**13**	**24**	**85**

04.
Digital technologies in warehousing
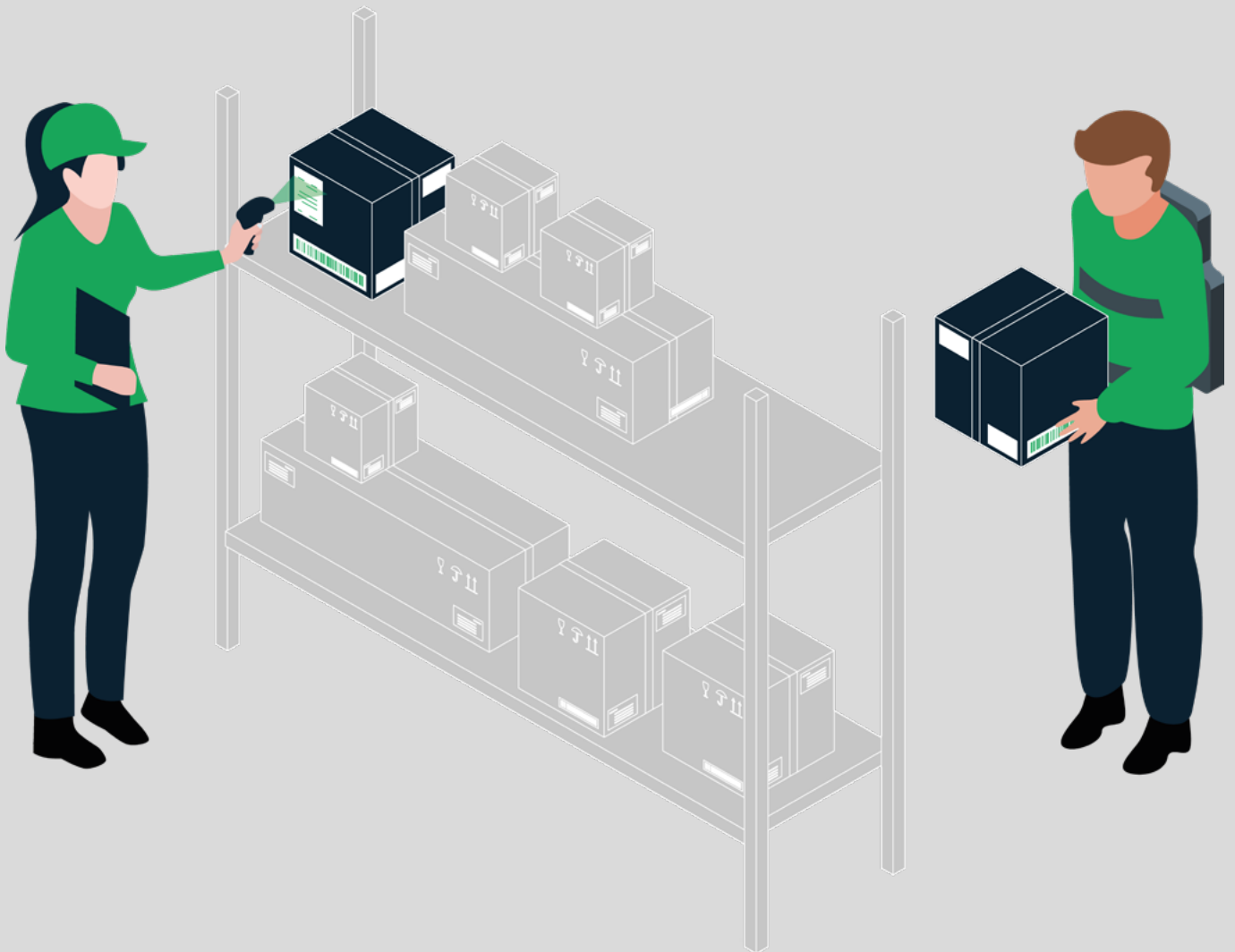
Digital technologies are increasingly integrated in all warehousing operations.[25] For the purpose of this study, digital technologies are conceptualised as socio-technical 'assemblages' that structure the organisation, coordination, and execution of logistics labour. These technologies encompass hardware, such as scanners, sensors, robots, and augmentation technologies, as well as software infrastructures including WMS, data architectures, and AI. Hereunder, a distinction is made between six main types of digital technologies focussing on their specific function in relation to work (both of management and workers), and the main drivers for adoption and diffusion (see Table 4). The section concludes by discussing the key factors affecting the uneven adoption of digital technologies in European warehousing.

Table 4. Digital Technologies in Warehousing Classified by Work Function, Main Drivers for Adoption and Diffusion.

Digital technology types	Work function	Main drivers for adoption	Diffusion
Warehouse Management Systems (WMS)	(Semi-)automating managerial tasks: Task sequencing, work allocation, coordination and control	Operational efficiency, flexibility, transparency, and traceability	High: Prerequisite for implementing other digital technologies
Digital interface tools: Handheld scanners, tablets, pick-by-voice, pick-by-light	Assigning tasks to workers and collecting performance data	Higher productivity, standardised workflows, and performance monitoring	High: Required to operate WMS, relatively low cost, can be adopted in brownfield sites
Goods-to-person systems: Automated Storage and Retrieval Systems (ASRSs), conveyor belts, automated sorting systems, goods-to-person workstations	Eliminating human walking from the work process	Significant efficiency gains from reducing walking time and physical handling	Low: High investment cost, but increasingly adopted in greenfield sites
Robotics: Automated Guided Vehicles (AGVs), Autonomous Mobile Robots (AMRs), robotic palletisers, sorting robots	Automating specific operational tasks	Flexible, scalable automation to increase throughput without additional labour	Low/Medium: Adoption increasing with falling costs and modularity
Human augmentation technologies: Exoskeletons, heads-up displays, smart glasses, bionic devices	Semi-automating specific operational tasks	Higher productivity without compromising ergonomics and worker health	Very low: Mainly in pilot phases or niche use cases
Wearables monitoring movements and biometrics	Measuring (and correcting) workers' movements and biometrics	Injury prevention, safety monitoring, and performance control	Very low: Only experimental pilots

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25   MHI, & Deloitte. (2025). 2025 The digital supply ecosystem: Orchestrating end-to-end solutions.

4.1 WAREHOUSE MANAGEMENT SYSTEMS

WMS[26] refers to the complex software infrastructure that collects and integrates information across multiple domains to automate managerial functions in warehouses. It typically includes systems for operational optimisation, workforce planning, and HR management, which are often interconnected. WMS have fundamentally changed how warehouses are managed by leveraging increasingly available and affordable computing to process massive amounts of data. They have almost completely replaced prior, more error-prone, paper-based systems and the piecemeal use of basic digital tools such as Excel. Used in all investigated warehouses, WMS represent the digital 'backbone' of operations, continuously processing information about stored items and their location, matching it with data on workers, their location, and tasks to efficiently organise wSarehousing operations. In larger warehouses, WMS are integrated within broader enterprise resource planning systems (ERPs) or connected to specialised modules such as workforce planning systems (WPSs), which focus on scheduling and managing the workforce.

By processing vast amounts of real-time operational data, a WMS can flexibly plan operations, predict the demand of labour, and optimally allocate tasks, boosting overall labour productivity. This not only improves accurate stock tracking and transparency, but also allows for continuous optimisation, making operations more efficient and reliable.

"The Warehouse Management System manages goods in the warehouse. It knows where everything is located, how long it has been there, in what quantity, with what expiration date, and in

which batch. It supports warehouse processes, for example by indicating which locations need to be replenished from stock."

WMS, Consultant, Technology Provider, Poland

Beyond inventory control, WMSs also profoundly reshape the organisation, tightening managerial control while enhancing the efficient deployment of labour. By continuously processing data on items and their location, the system sequences tasks, assigning them to operators, and monitors their completion, generating granular data on workers' performance and enabling rapid reallocations when needed:

"Because everything is digital, management can quickly see where the bottlenecks are and reallocate people. That makes a huge difference in planning."

WMS, Warehouse Worker, 3PL Warehouse, Belgium

4.2 DIGITAL INTERFACE TOOLS

Digital interface tools – such as handheld scanners, tablets, voice-picking systems, and pick-by-light systems – communicate tasks to workers in real time and, conversely, continuously feed back data on their work into the WMS. By communicating single tasks defined by the WMS in real time in a relatively simple, standard yet customisable way (e.g., in different languages), digital interface tools do not only reduce mistakes and increase the productivity of labour, but also substantially simplify warehousing jobs, expanding the pool of workers that can potentially perform the job:

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26 In this report, WMS is used to denote this broader, interlinked software environment, and specify particular functions or modules where relevant. See Barthold, J. J., & Hackman, S. T. (2019). Warehouse & distribution science (Release 0.98.1).

"A WMS that, in quite a rigid way, requires warehouse workers to perform certain actions: scan here, confirm there, click there."

WMS, Consultant, Technology Provider, Poland

This simplification leads to an increased emphasis on 'soft' skills, such as motivation and flexibility, and basic digital literacy skills:

"What's most important are people who are motivated. If they can follow instructions, they can do the job."

Warehouse Manager, Lifestyle Retailer Warehouse, Poland

Various types of these interface tools were used in the studied warehouses. In many cases, they were stand-alone, i.e., carried or worn by workers walking around in the warehouse to retrieve goods. In other cases, they were integrated into fork lifts and reach trucks, or in automated goods-to-person systems. Warehouses' choice for a specific digital interface tool depends, next to cost, on how it is embedded in the work process, including other technologies, and how it is experienced by workers:

"When we tested [handheld] scanners instead of voice picking [systems], quality and productivity both dropped, and safety suffered because workers were looking at the device while driving. With a headset [pick-by-voice system], you can keep your eyes on the path and stay in the flow to deliver better results."

Digital Interface Tools, Warehouse Manager, Automobile Warehouse, Belgium

At the same time, digital interface tools improve operations by continuously collecting data on workers' pace, errors, and output, to monitor individual and team performance.

"Once you've beeped something [with your scanner], they can see on the screen where you've beeped. So if you have been doing something else for 15/20 minutes, they will ask what you've been doing. Some [managers] do use it as a tracker."

Handheld Scanner, Warehouse Worker, Lifestyle Retailer Warehouse, UK

4.3 GOODS-TO-PERSON SYSTEMS

Goods-to-person systems, such as Automated Storage and Retrieval Systems (ASRSs), conveyor belts and automated sorting systems, are automated systems that transport goods directly to workers at designated workstations. The most common types are ASRSs, computer-controlled installations of high-bay racking grids. In an ASRS, items are typically fed onto a conveyor belt that determines storage and retrieval. When items are needed, automated lifts fetch the items and deliver them directly to workers. Goods-to-person systems are valued for maximising storage density, and substantially decreasing or completely eliminating walking time, which is one of the most labour-intensive aspects of traditional person-to-goods operations.

Cutting out walking significantly reduces labour needs, enabling firms to expand operations capacity without hiring proportionally more workers, a particularly valuable prospect amid labour shortages:

"Before [implementing the ASRS], you were constantly walking. So, today, my average steps on a day, when working at a [goods-to-person] station, hits 1-2,000 steps, whereas before you are talking 20,000 steps. So its cut that aspect of it down."

Goods-to-person Systems, Warehouse Worker, Supermarket Retailer Warehouse, UK

Labour productivity is moreover increased because ASRSs directly set the pace of work:

"The blue bins arrive [through the ASRS at the goods-to-person station]. [...] The screen says: on top it shows six, from the right bin, and now 21 from the left bin, which she has to pick into the box on the far right. [...] And there is also a certain pace they have to keep up with..."

Goods-to-person Systems, Warehouse Worker, 3PL Warehouse, Belgium

Four warehouses in our study used this type of goods-to-person technology. While increasingly adopted, they still remain relatively rare because they require substantial capital investment, which many small and medium firms do not have. Goods-to-person technologies cannot easily be implemented in brownfield sites and they are less flexible than other technologies. Some managers pointed to shortcomings of ASRSs including their complexity, long return-on-investment period, and non-customable standardisation:

"Goods-to-person systems are challenging. In our warehouse, we work with ten to fifteen different picking strategies, compared to just three in a manual warehouse. Certain customers also simply don't fit into our automated flow, as efficiency depends heavily on sticking to a standardised process."

Goods-to-Person Systems, Warehouse Worker, 3PL Warehouse, Belgium

4.4 ROBOTS FULLY AUTOMATING TASKS
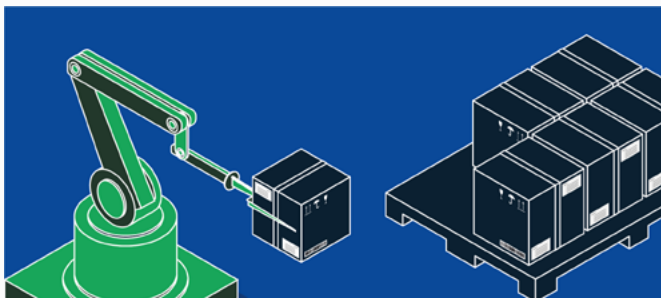
Robots can be deployed to perform tasks traditionally carried out by human labour, such as to move goods, store, pick, sort, and package items, as well as to palletise, depalletise, and count inventory. Common examples include Automated Guided Vehicles (AGVs), Autonomous Mobile Robots (AMRs), robotic arms, and automated palletisers. Automated loading and unloading of trucks remains, on the contrary, rare due to technical and compatibility issues. Three of the studied warehouses used robots in their operations. With costs gradually decreasing, they are becoming more common, particularly in e-commerce, where a high volume of standardised items is handled. Robotics increasingly rely on AI for functions such as navigation, object recognition, and path optimisation.[27]

Compared to ASRSs, robots offer greater flexibility and scalability, as units can be added or removed during seasonal peaks or unexpected surges in demand, without shutting down operations. Their advantages became visible during the COVID-19 pandemic:

"COVID taught people that you need to be flexible and resilient, and I think that's why more companies are interested in robotics. It gives them that extra capacity for peak days like Black Friday."

Robotics, Warehouse Manager, Supermarket Retailer Warehouse, UK

Full automation of specific tasks through robots greatly reduces the need for labour, reducing labour shortages, and can eliminate the most physically demanding and least ergonomic jobs:

"Next year, we will have a fully automated inbound process, with a scanner directing boxes to the right robot and the robot palletising them [...] It's not always easy because the investments are large, but it's also about ergonomics and making the work less physically demanding."

Automated Palletising System, Warehouse Manager, 3PL Warehouse, Belgium

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27 In the warehouses included in this study, the quality of work and employment was not prominently affected by AI technology. However, AI is expected to be increasingly integrated in some of the digital technologies we observed, such as management software, robotics and augmentation technologies.

4.5 HUMAN AUGMENTATION TECHNOLOGIES
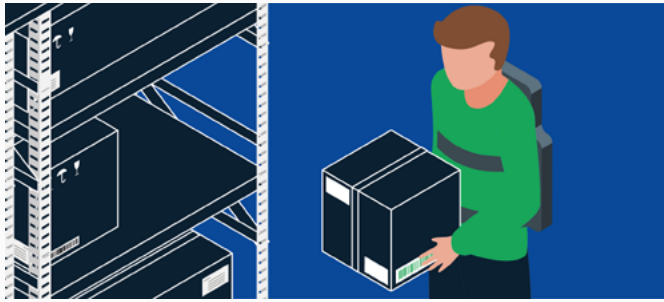
Human augmentation technologies are digital technologies that enhance workers' physical, cognitive, or sensory capabilities, 'augmenting' them. Examples include exoskeletons, heads-up displays (HUD), augmented reality (AR) overlays, bionic arms, and powered gloves. These technologies promise to improve labour productivity, accuracy and efficiency, without compromising workers' health and safety.[28] Overall, their use in warehousing remains, to date, limited.

While highly visible in media and marketing campaigns, exoskeletons, for instance, are still rare, and were not present in any of our warehouses. By augmenting the capabilities of human bodies, they have the potential to make tasks, such as lifting heavy items, more ergonomic and can also expand the pool of workers able to perform such tasks. However, they remain costly.

"We ran tests, and only a very small group, literally just a few individuals, decided to use it... After some time, the exoskeletons were lying around unused, so we examined again why that happened. It turned out they were uncomfortable."

Exoskeletons, Regional Director, Food Retail Warehouse, Poland

Heads-up displays, which guide workers directly to picking locations while keeping their hands

free, were also not found in our cases, due to their relatively high cost and fragility:

"Google Glasses could be useful in warehouses, but they are far too fragile. A pair costs £240. In an industrial setting, people handle them with gloves, put them down at lunch, and things get placed on top of them. [...] Break just one pair every two weeks, and you've probably lost all your savings."

Smart Glasses, Warehouse Manager, Lifestyle Retailer Warehouse, UK

4.6 WEARABLES MONITORING WORKERS' MOVEMENTS AND BIOMETRICS

This type of digital technologies monitors workers' movements and biometrics by collecting and analysing physiological and behavioural data via wearable devices, sensors, and advanced, AI-powered data analytics platforms. Currently in a very early, piloting phase, these technologies were not found in any of the studied warehouses. They are included in this overview because of their potentially far-reaching implications for workers if they become more adopted in the future. These technologies are promoted by developers and scholars as a means to prevent workplace injuries by detecting fatigue or improper posture, monitoring safety compliance, and predicting health risks.[29]

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28 However, the long-term effects of these technologies on workers remain largely unknown. See Kranenborg, S. E., Greve, C., Reneman, M. F., & Roossien, C. C. (2023). Side-effects and adverse events of a shoulder- and back-support exoskeleton in workers: A systematic review. Applied Ergonomics, 111, 104042; Herold, R., Gevorgyan, H., Damerau, L. S., Hartmann, U., Friemert, D., Ellegast, R., Schiefer, C., Karamanidis, K., Harth, V., & Terschüren, C. (2024). Effects of smart glasses on the visual acuity and eye strain of employees in logistics and picking: A six-month observational study. Sensors, 24(20), 6515.

29 Aloini, D., Fronzetti Colladon, A., Gloor, P., Guerrazzi, E., & Stefanini, A. (2022). Enhancing operations management through smart sensors: Measuring and improving well-being, interaction and performance of logistics workers. The TQM Journal, 34(2), 303–329; Di Pasquale, V., De Simone, V., Radano, M., & Miranda, S. (2022). Wearable devices for health and safety in production systems: A literature review. IFAC-PapersOnLine, 55(10), 341–346.

However, they also pose risks in terms of workers' health data privacy and for enabling far-reaching forms of worker surveillance.[30]

4.7 CONCLUSION

Warehouses combine a wide variety of digital technologies to organise their operations, with important implications – both risks and possibilities – for the quality of warehouse work and the relations between management and workers. Importantly, the scientific and popular literature alike tend to emphasise the rapid diffusion of advanced technologies in warehousing and logistics more broadly, due to a disproportionate focus on large companies playing a pioneering role in digital technology adoption, such as Amazon.[31] Together, our cases reveal a relatively limited and uneven adoption of digital technologies, and limited labour substitution through technologies. In our interviews and workshops, top management, warehouse managers, technology providers and consultants, sectoral employers' associations, and trade unions in the different logistics hubs pointed to multiple factors shaping technology decisions beyond the characteristics of the technology itself.

Economic considerations include the high investment costs of technologies and their technical support and maintenance, leading to long payback periods and higher operational costs, which are at odds with prevalent short-term contracts with clients and overall harsh competition. A second important factor is the lack of internal knowledge and increased dependence on external providers. Such dependence considerably increases the financial and operational risks of adopting new technology. Additionally, companies might not adopt new technology due to the constraints posed by legacy infrastructure, the fact that they run operations in rented premises, and resistance from workers and their representatives.

> Warehouses combine a wide variety of digital technologies to organise their operations, with important implications – both risks and possibilities – for the quality of warehouse work and the relations between management and workers.

30 Moore, P. V., Upchurch, M., & Whittaker, X. (2018). Humans and machines at work: Monitoring, surveillance and automation in contemporary capitalism. Palgrave Macmillan.

31 Miszczyński, M., & Zanoni, P. (2025). Coercion and consent under techno-economic despotism: Workers' alienation and 'liberation' in the Amazon warehouse. Work, Employment and Society, 0(0); Zanoni, P., & Miszczyński, M. (2023). Post-diversity, precarious work for all: Unmaking borders to govern labour in the Amazon warehouse. Organization Studies, 45(7), 987–1008.

05.
Digital technologies shaping the quality of warehouse work

The adopted combinations of digital technologies profoundly shape warehouse work – both the quality of jobs and the required skill profiles needed to undertake them – in complex and lasting ways. This section analyses the effects of these technologies on the quality of warehouse work around three broad themes:[32] workers' autonomy and work meaningfulness; workers' physical and mental well-being, and work sustainability; and workers' social relations at work. To contextualize these effects, the section concludes by examining how decisions about digital technologies are made in companies.

5.1 WORKERS' AUTONOMY AND WORK MEANINGFULNESS

Overall, digital technologies are introduced in warehouses to increase operational efficiency by breaking work down into a pre-set sequence of standardised tasks and distributing them optimally across the workforce in real time through easy instructions. Referred to in the scientific literature as 'digital Taylorism,'[33] this organisation of work greatly deskills jobs and limits workers' autonomy.

"Automation is meant to remove knowledge-dependence from warehousing. In the past, operators needed to know the products. With digitalisation, the system guides them directly. They no longer need to be experts."

Automation Technology General, CEO, Technology Provider, Belgium

Various combinations of a WMS, digital interface tools, and storage and retrieving systems create more standardised workflows imposing the work pace and reducing the scope for human error. While this 'algorithmic management'[34] of the workforce greatly increases labour productivity, it leaves little room for workers' initiative or autonomous problem-solving in day-to-day work.

"Starters don't need any experience anymore. The system tells them exactly where to go, when to stop, what to do. Management prefers that, they don't want skilled workers, they want people who follow instructions, like robots."

WMS, Warehouse Worker, Lifestyle Retailer Warehouse, UK

Work autonomy is particularly limited in goods-to-person systems, where workers remain at their workstation and handle the goods that are delivered to them:

"You stop thinking after a while [when working at the goods-to-person station]. [...] you just follow the instructions from the machine."

Goods-to-Person Workstation, Warehouse Worker, 3PL Warehouse, Belgium

Work standardisation reduces the need for workers to plan ahead or make autonomous decisions. Simple, multi-lingual, easy-to-learn digital interfaces further lower qualification requirements and remove language barriers. Together, these features greatly broaden the labour pool from which warehouses can temporarily draw when needed.

"With a WMS system and good visual identification in the warehouse, an employee can actually start working after just an hour of device training and a warehouse tour. They should achieve a reasonably efficient performance within a week."

WMS, Consultant, Technology Provider, Poland.

New workers can be quickly onboarded, by providing short training on essential safety procedures,

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32 These themes are derived from the seven dimensions of job quality identified by the European Parliament: workers' autonomy and control over tasks; the physical working conditions and exposure to risk; physical and psychological health effects; work intensity and pace; the social work environment, including both social relations and organisational culture; the meaningfulness of work; and workers' opportunities for learning, on-the-job training, and career development.; European Parliament's Committee on Employment and Social Affairs. (2009). Indicators of job quality in the European Union.

33 Delfanti, A. (2021). The warehouse: Workers and robots at Amazon. Pluto Press; Miszczyński, M., & Zanoni, P. (2025). Coercion and consent under techno-economic despotism: Workers' alienation and 'liberation' in the Amazon warehouse. Work, Employment and Society, 0(0).

34 Wood, A. J. (2021). Algorithmic management: Consequences for work organization and working conditions. European Commission.

equipment operation, and the digital tools that guide everyday tasks. Lacking autonomy, and long-term work prospects, warehouse workers often feel interchangeable, detached and alienated from work.

"[Loading] is really the same thing over and over, and sometimes you just get fed up with this work."

Warehouse Worker, 3PL Warehouse, Poland

"After some time, I started feeling a kind of burnout and had thoughts about changing jobs."

Warehouse Worker, 3PL Warehouse, Poland

Omnipresent monotony also contributes to the limited attractiveness of warehouse jobs, which managers referred to when explaining the difficulties of recruiting and retaining good workers. At the same time, some workers appreciated the clarity and predictability of their jobs involving low responsibility.

"Some people love a factory line: [picking and packing is] uniform and consistent. You come in, do what they tell you, and you're gone."

Warehouse Worker, Supermarket Retailer Warehouse, UK

"When it comes to folding clothes [in the return department], I like it. I just feel fulfilled doing it. I simply enjoy folding clothes. This job suits me."

Warehouse Worker, Lifestyle Retailer Warehouse, Poland

This was particularly the case of workers on temporary contracts, who did not intend to stay, such as students:

"It's very clear, order picking. On the first day they explained everything well. […] There's not too much pressure, you just keep going until the end of the day. […] It's fine work as a student, but I wouldn't do it as a career."

Warehouse Worker, Student, 3PL Warehouse, Belgium

Beyond operator jobs, the adoption of digital technologies also creates a few new skilled, specialised jobs, for instance in maintenance and quality control. These jobs are often filled by hiring highly qualified personnel, and only in a few cases by allowing particularly competent workers to upskill and reskill to grow into these new roles:

"It's not automatic that people advance, but I moved up from warehouse worker to team coach and then to a technical role. Opportunities like this are rare."

Warehouse Worker, Young Dutch-Speaking Man without Migration Background, 3PL Warehouse, Belgium

5.2 WORKERS' PHYSICAL AND MENTAL WELL-BEING AND WORK SUSTAINABILITY

One of the main drivers of technological adoption in warehouses is the improvement of physical working conditions with positive effects on productivity. Conveyor belts and automated retrieval systems are designed to eliminate or limit workers' heavy lifting and repetitive motions, enhancing ergonomics. They can also be deployed to make warehouse environments quieter and less crowded.

"The 'Ergo Picker' [referring to a mechanical arm that lifts and moves heavy goods] lightens the work. It picks the heavy items, so workers only handle lighter ones."

Human Augmentation Technology, Warehouse Worker, 3PL Warehouse, Belgium

Reducing wear on the body does not only potentially make jobs more sustainable over the longer term, it can also make warehouse jobs accessible to a wider range of workers who might otherwise struggle with physically demanding jobs, such as workers with lower muscular mass, ageing workers, and workers with prior injuries:

"With an ageing workforce, automation has meant that some colleagues have been able to keep working longer or more easily than they otherwise might have."

Automation Technology General, National Officer, Trade Union, UK

However, (semi-)automation technology does not eliminate strain entirely. For instance, goods-to-person stations reduce walking yet require workers

to work statically for long periods, standing up, and to carry out the same few movements at an imposed pace, which can cause injuries. Poorly designed, non-adjustable working stations can also create new ergonomic problems:

"At the picking station you're standing still in front of two screens. Some people get back problems because the setup is too high or too low. It's not always ergonomic."

Goods-to-Person Workstation, Warehouse Manager, 3PL Warehouse, Belgium

Indeed, digital interface devices, with which workers need to continuously interact, can add to the physical burden. Wearing headsets or smart glasses for entire shifts causes discomfort and can even produce physical pain:

"Wearing the [voice-picking] headset eight hours a day was exhausting, and I even got a sore spot on my head. [...] Google Glass made me cross-eyed from switching focus all the time."

Digital Interface Tools, Warehouse Worker, Automobile Warehouse, Belgium

Moreover, some jobs remain highly straining despite the presence of the technology, with cost considerations often outweighing ergonomic improvements:

"The goods receiving area, despite having automation, automatic conveyors, and optimising the process to the maximum extent possible, remains a physically demanding work environment. There is still a lot of heavy lifting involved, and the workforce there consists mainly of men."

Automation Technology General, HR manager, Lifestyle Retail Warehouse, Poland

Some workers pointed out how WMS optimisation models themselves create new strains. For instance, in person-to-goods systems, they often optimise routes to increase workers' speed, which might, however, unintentionally lead to physically more straining sequences or heavier lifts:

"The [warehouse management] system tells you what to pick and where to go [through the

handheld scanner], but it doesn't consider the weight. You end up lifting heavier loads because the route is optimised for speed, not for sense."

WMS, Warehouse Worker, Automobile Warehouse, Belgium

Moreover, workers might still end up walking very long distances because the gains of optimisation are offset by high productivity targets and insufficient rest and recovery times, making these jobs unsustainable over the longer term:

"It's alright when you are in your 20s or 30s, but when you're older you can't work that fast anymore."

Algorithmic Pace-Setting through WMS, Warehouse Worker, Supermarket Retailer Warehouse, UK

Workers with injuries are often forced to leave the sector, as there are not enough jobs suitable for them. Some of the warehouses, however, used job rotation to reduce boredom and injuries. This was mainly the case with workers that demonstrated the interest and ability to learn and that could then be more flexibly deployed in operations.

"Having one extra person on shift gives opportunities for job rotation which is good, because picking on the picking station day in, day out, is suicidal to some extent."

Goods-to-Person Workstation, Warehouse Worker, Supermarket Retailer Warehouse, UK

Next to the physical fatigue, many workers mention the mental toll of being constantly monitored, and the possibility that poor performance might lead to warnings, disciplinary measures, and even dismissal. While the actual degree of surveillance varies greatly among warehouses, workers were very aware that management had the data to monitor them, since each interaction with the technology is logged, and that it could potentially be used for performance management purposes:

"Management knows exactly what you're doing [through WMS]: how many order lines you've processed, how fast you're moving, even if you're standing still."

WMS, Warehouse Worker, 3PL Warehouse, Belgium

Where performance metrics were actually closely monitored and underperformance could lead to dismissal, workers reported feelings of anxiety. They felt compelled to maintain speed regardless of fatigue or personal circumstances, as there was no human to take their personal circumstances into account:

"These algorithms [WMS] dictate exactly how many items I should process per hour. But the algorithm doesn't care if my pet has died, if I'm unwell, or if I've just gone through a breakup. Nobody cares. I still have to meet that hourly target."

WMS, Trade Union Representative, E-Commerce Fulfilment Warehouse, Poland

Relatedly, the use of bonuses based on individual performance can put workers in competition with each other, leaving many frustrated. In one of our cases, productivity was measured at the team level, reducing the threat of sanctions, encouraging collaboration, and improving work quality. Workers there reported lower stress, greater willingness to help co-workers, and lower turnover. Team-based rather than individual targets fostered a sense of shared responsibility:

"The agreement is that every individual can only really be expected to do their best, and again that's where as long as everyone's doing their bit, it is more of a collective target."

Trade Union Representative, Supermarket Retailer Warehouse, UK

5.3 WORKERS' SOCIAL ENVIRONMENT

By allocating tasks directly to individual workers and algorithmically coordinating them, without human intervention and face-to-face communication, digital technologies profoundly impact the social fabric in warehouses. There are fewer supervisors on the shop floor and, as workers are not required to communicate with supervisors or co-workers to carry out their work, there are structurally fewer opportunities for interaction and socialisation. Furthermore, individual tasks and targets and the absence of a shared language among the workforce in some warehouse further tend to fragment the social environment:

"Contact with other employees happens in the cafeteria or during breaks, but during work, everyone is busy with their own tasks. It's just that you pass by each other in the aisles, exchange a few words, and then continue working."

Warehouse Worker, 3PL Warehouse, Poland

"Some people here speak English, but I don't. I just speak Dutch, I mean, we're in Belgium, right? They should learn Dutch, or at least make an effort. I'm not going to start speaking English at work."

Warehouse Worker, Dutch-speaking Man without Migration Background, 3PL Warehouse, Belgium

Picking stations in goods-to-person automated systems are particularly isolating for workers, as they often remain in one place for long periods, having little opportunity to interact and socialise with others, increasing the monotony of performing a very narrow set of actions.

"The work [in an automated warehouse] can feel more boring. When you're walking around, you pass people and there's some interaction. At the pick station, you're just standing there, staring at a screen for long periods. There's a lot less human contact."

Goods-to-Person Workstation, Warehouse Engineer, 3PL Warehouse, Belgium

In one warehouse, working in pairs at conveyor stations was introduced to foster social contact between workers and mitigate isolation. Human interaction was also very limited when driving in the warehouse during night shifts with limited staffing:

"I spent the whole night on my own, operating the reach truck for eight hours. You do run into people sometimes, but mostly everyone is just working alone."

Transport Equipment, Warehouse Worker, 3PL Warehouse, Belgium

Individualised bonus systems also exacerbate the risk of social fragmentation, as helping a co-worker may reduce one's own output and lower the chance of meeting performance targets, creating an environment where workers prioritise personal

results over social relations and mutual support:

"They basically said like you can ask each other for help, but what we found is people don't like to stop other people on productive bonus and ask them to help lift that, because you're taking their hour limit away from them while they're helping you."

Warehouse Worker, Lifestyle Retailer Warehouse, UK

In some cases, workers even reported that social interactions were discouraged by management, as they were seen as distractions that might lead to lower performance or mistakes. To counter these isolating effects, some workers told us how they actively sought contacts with co-workers by arriving early to secure a workstation next to a friend, or by briefly chatting while performing repetitive tasks:

"You're working at one [goods-to-person] station, and while doing your tasks you usually chat a bit about your day, your kids, football, whatever. So generally you show up early to get a spot next to your friend."

Goods-to-Person Workstation, Warehouse Worker, Supermarket Retailer Warehouse, UK

These small acts helped them preserve a sense of belonging and made monotonous work and long shifts more bearable.

5.4 WORKER PARTICIPATION IN DECISIONS ON DIGITAL TECHNOLOGIES

Despite the important implications of digital technologies for the quality of warehouse work, the participation of workers and workers' representatives in technology-related decisions was overall limited. Such decisions are generally made by management and technology departments in collaboration with technology providers, generally not even involving the HR management department. Technology providers do not only develop technologies, but often also provide

ongoing maintenance, operational support, and data management after their implementation:

"The WMS, which is developed and maintained by our external partner, that's a black box for us... We can say that we want this or that to happen, but we don't know if it's possible or how it actually works. It's all a black box."

WMS, Warehouse Manager, 3PL Warehouse, Belgium

"Automation is not equipment that you build yourself. It's equipment that is almost unique, tailored to fit your business needs. You also need someone to provide maintenance and it's really expensive."

Automation Technology General, Process Expert, FMCG Company, Poland

Technology developers and consultants promote new digital technologies by pointing to improved efficiency, productivity, operational flexibility, as well as ergonomics and safety. Together, these gains are presented not only as making warehousing less labour intensive, but also as making jobs more attractive for the workforce, helping to address labour shortages. In the Belgian logistics hub, the sectoral employers' association also played an important role in promoting technological innovation to raise productivity and sustain the competitiveness of the whole industry in the region.

In the three countries studied, national legal provisions impose the duty to inform and consult workers when new technology introduces substantial changes in the organisation of work.[35] However, such provisions do not give workers the right to participate in the decisions and were in practice applied in quite uneven ways. In the UK and Poland, where workers' representation is less institutionalised and overall weaker, only two of the six companies involved workers in these decisions. In a company located in South Yorkshire, trade union representatives had negotiated a company-

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35 Directive 2002/14/EC of the European Parliament and of the Council of 11 March 2002 establishing a general framework for informing and consulting employees in the European Community - Joint declaration of the European Parliament, the Council and the Commission on employee representation https://eur-lex.europa.eu/eli/dir/2002/14/oj/eng

level collective agreement that included the principle that the introduction of new technology should be "used to benefit the workforce" (Trade Union Representative, Supermarket Retailer Warehouse, UK) and foresaw the involvement of the trade union in decisions concerning technology. This involvement had led to the non-adoption of automation technology:

"If you engage with [workers] early in the journey, the outcomes are much better. You need solutions for how this is going to work [in reality]… so I went down with [the workers] to look at [the robotic picking arm], and you know what, they had the confidence to say, 'it works okay, but it's still not what we need', so we walked away from that one. As a collective, we agreed it was good, but not what we really wanted. So the next opportunity […] they are going to be involved from step one in the process as well."

Operations Manager, Supermarket Retailer Warehouse, UK

In one of the retail companies in Western Poland, the organisational culture fostered informal, organic forms of communication with workers, largely employed directly on a permanent basis, which included technology-related aspects of their work:

"Warehouse workers can suggest improvements and they actually do. When you work directly in a given process, you can clearly see its flaws. For us in management, it's sometimes difficult, because even though I try to go and see the processes myself, I obviously don't spend 8 hours a day there. So I rely on them to come forward and report issues, and they really do, it happens quite often."

Warehouse Manager, Lifestyle Retail Warehouse, Poland

Despite these positive examples, workers' involvement in these countries differs significantly across companies, and their influence on technology-related decisions remains overall very limited.

In Belgium, where work councils and trade union representation at the company level are most institutionalised, companies need to provide justification for the introduction of new technology. However, also in this context, workers' representatives cannot veto it. Overall, workers'

involvement is more guaranteed, although a trade union representative mentioned instances in which regulations are not correctly applied. In one of the cases, the planned introduction of a handheld scanner-based picking system (to replace voice picking) was halted after workers had tested it and raised complaints about neck strain:

"We once stopped a system [handheld scanner picking system] because it was too straining for the neck."

Handheld Scanner, Trade Union Representative, Automobile Warehouse, Belgium

Such examples of involvement remain the exception, as in many warehouses, decision-making around digital technologies is top-down, excluding workers from design, implementation, and evaluation.

"They never ask us anything, we are never involved… we just get informed that something is coming in, like with the new scanners. When they arrived, they were given to certain people with the instruction 'I want you to try these, and then give us some feedback'. So, the union wouldn't be involved."

Handheld Scanner, Warehouse Worker, Lifestyle Retailer Warehouse, UK

This lack of involvement does not only reduce the possibility of deploying technology to enhance the quality of work and workers' well-being, making work more sustainable, but it can even lead to operational problems and, ultimately, abandoning acquired technology:

"They brought in this new robot that's supposed to deal with waste, probably just for the sake of innovation. I don't believe it will stay with us in the long run or that it will actually be functional. There are already problems, it often stops working and people have to keep going to fix it."

Waste-Handling Robot, Warehouse Worker, 3PL Warehouse, Poland

It should be noted that, in all three institutional contexts, workers on temporary (agency) contracts or employed by subcontractors on-site remain excluded from more or less formalised channels

05.Digital technologies shaping the quality of warehouse work

of worker participation on technology-related decisions. Agency workers are often reluctant to exert their voice, as they fear they might no longer be offered work.

"We have to be careful when we are representing [agency workers] because if you push too hard then you are doing them out of work. Because that's what they will do, it's easy to say that you've got no work for them."

Trade Union Representative, Supermarket Retailer Warehouse, UK

As more vulnerable workers, such as migrant and migrant background workers (particularly those that are female and/or young), workers with an impairment, and formerly incarcerated workers, are strongly overrepresented among more precarious workers, these groups have particularly limited voice in the technologies that fundamentally shape their working conditions.
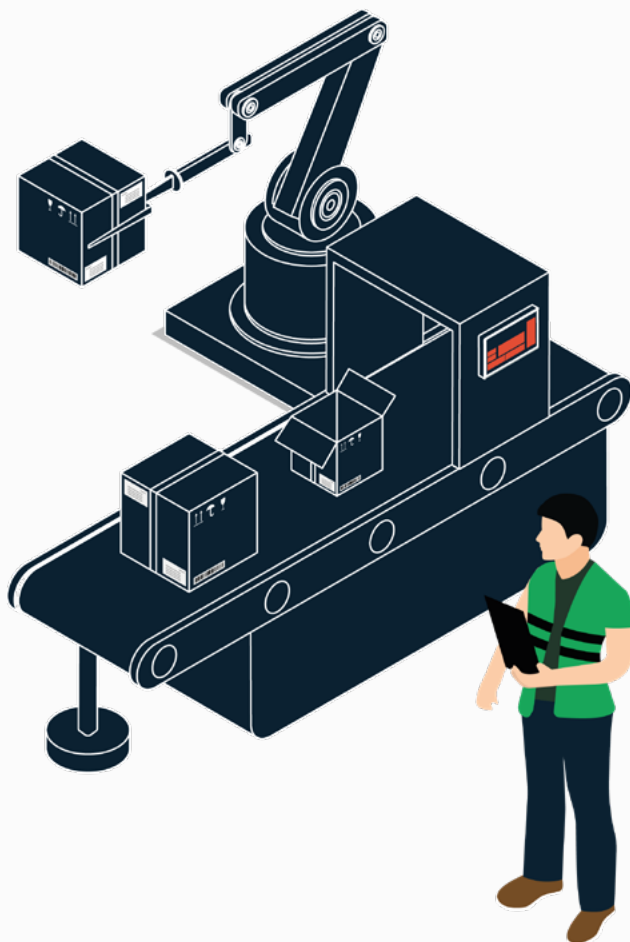
5.5 CONCLUSION

The studied warehouses deploy various combinations of digital technologies. As workers and their representatives are seldom involved in technology-related decisions, such technologies are mainly introduced to increase operational efficiency and labour productivity in the short-term, for warehouses to contain costs and remain competitive. Variously combined, they tend to digitally reorganise work according to Tayloristic principles, eroding workers' autonomy, deskilling work and emptying it from any meaning. While the increased deployment of (semi-)automation technologies, such as robots and conveyor belts, makes physically burdening tasks lighter, these technologies themselves introduce new risks due to repetitive tasks, the intensification of work, and standardised, non-ergonomic technology design. The technology-mediated allocation and coordination of work furthermore enables management to closely monitor workers' performance and reduces human interactions in the warehouse, increasing workers' isolation from co-workers and supervisors.

While (semi-)automation technologies, such as robots and conveyor belts, make physically burdening tasks lighter for workers, they also introduce new risks including more repetitive tasks, intensified work pace, and non-ergonomic technology design.

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Digital technologies and the quality of employment in warehouse work
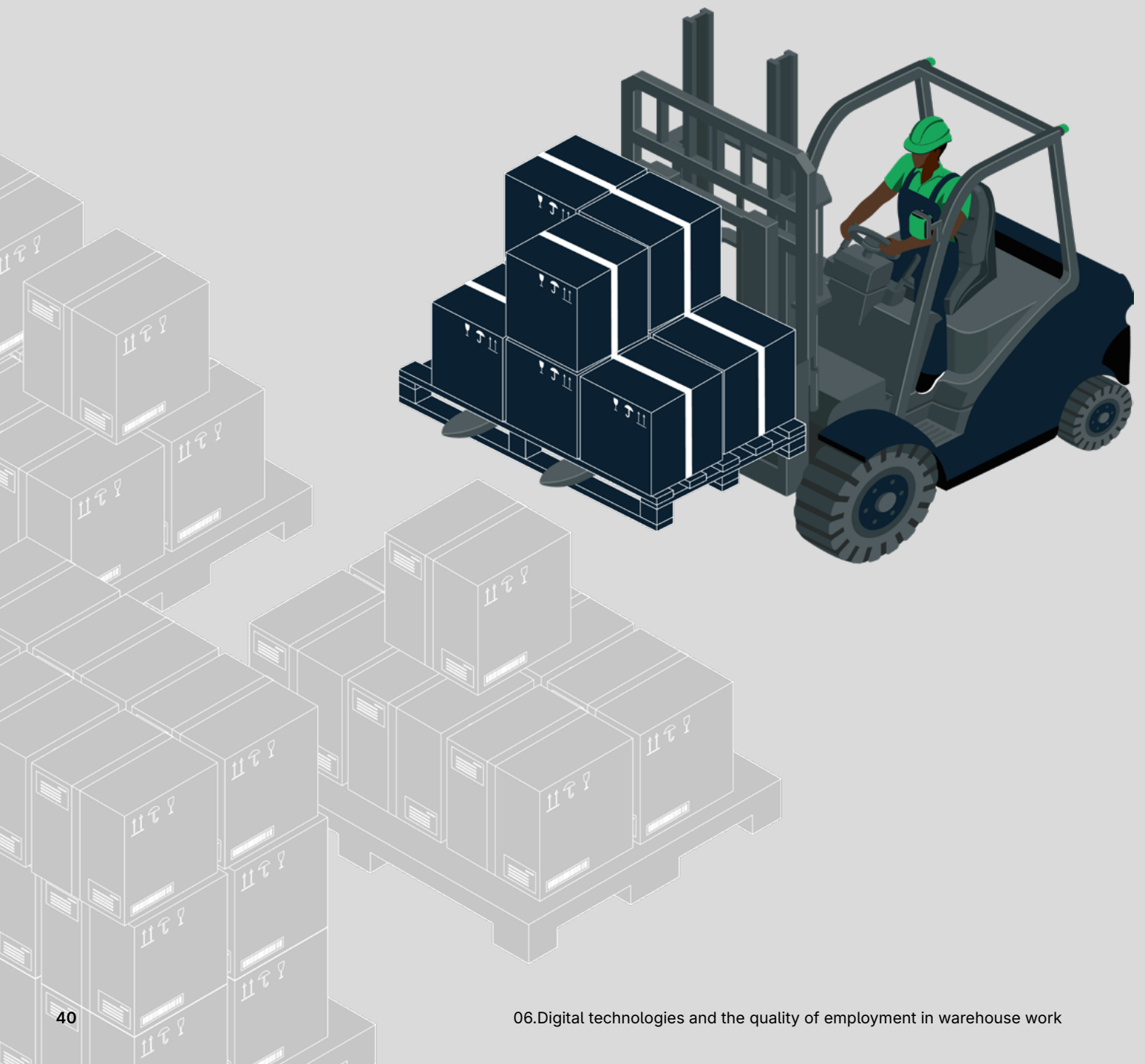
In addition to allowing companies to fundamentally reorganise the warehouse work process, the quality of work, and workers' skill profiles, digital technologies also open the way for more precarious forms of employment. This section examines how the widespread use of a multi-tier employment model affects the quality of employment in warehouses. After presenting the distinct forms employment takes in the different national, regional and company contexts, the text presents how they shape the allocation of working time, of work, wages and benefits, and training and development.[36] For each theme, the analysis points to how multi-tier employment practices fragment the warehousing workforce in specific ways. They produce distinct and unequal employment conditions for distinct groups, defined on the basis of their employer, the type of contract, as well as their socio-demographic profile.

6. 1 A MULTI-TIER EMPLOYMENT MODEL AND FLEXIBILITY STRATEGIES

Across the three logistic hubs, digital technologies make it possible for companies to adopt a multi-tier employment model by enabling the deskilling of warehouse jobs that allows to source workers with little knowledge and experience, facilitating workforce planning across multiple employers, and automating workers' coordination and control in the warehouse. This employment model variously combines a core permanent workforce made up of: a) workers employed directly by the warehouse on open-ended contracts, b) directly employed workers on temporary contracts, c) workers employed by work agencies and sourced on a temporary basis, d) and, to a more limited extent, workers employed by subcontractors on-site.[37] Companies commonly justify the use of a multi-tier employment model by referring to flexibility needs, for instance, fluctuating order volumes, seasonal peaks, unpredictable customer demand, and absenteeism.

"We have two key peaks in the year. You have Black Friday like most of the retailers… You have to increase your headcount just to try and combat a four week period where you're going to be busy."

Operations Manager, Supermarket Retailer Warehouse, UK

"We plan our temporary headcount weekly or monthly: we tell the in-house staffing agency how many people we need to cover, for example, absences and sickness. We keep a pool of temporary workers who already know our site, and they can come for one day a week, two days, or a full week, whatever the operations require. Especially for pickers, when volume spikes and we're short of hands, we simply scale up from that pool."

HR Manager, 3PL Warehouse, Belgium

However, different employment practices among companies included in this study were observed. This was the case even within each logistics hub, despite common legal regulations, available labour force, and the ecosystem of actors shaping the labour market.

In the West and South Yorkshire hub, two of the three retailers make minimal use of temporary work agency workers, usually around 10% and up to a maximum of 30% during peak times, but directly employ part of their own workers on a temporary basis. The third retailer increasingly relies on agency workers and seeks to replace directly employed permanent workers with a more flexible workforce. The companies in the Western Poland hub deploy extremely different employment practices. One retailer company employs almost all workers (90%) on regular contracts, only using temporary agency workers in peak times. A second company, a single-client 3PL company, employs half of the workforce on a permanent basis and half through temporary agency workers. The last company, a fast-moving consumer goods retailer, employs only about 20% of

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36 These themes are informed by the dimensions of quality of employment identified by the European Parliament: employment contracts and job stability; working hours, including scheduling, flexibility, and work-life boundaries; wage levels and income adequacy; access to social protection and benefits; participation and voice in workplace decision-making; and opportunities for training and career progression; European Parliament's Committee on Employment and Social Affairs. (2009). Indicators of job quality in the European Union.

37 While subcontracting is widely spread in last-mile delivery, it is less common in warehousing. See Gualandi, S., & De Micheli, B. (2023). TeamHub! Delivering sustainability to the e-commerce supply chain: Background report.

the workforce permanently and the remaining 80% through 15 temporary agencies. In the Limburg hub, two companies predominantly rely on a core of direct permanent workers, around 80% of the workforce, while a third company employs 60% of permanent workers. The rest of the workforce consists mainly of temporary agency workers, supplied through a few on-site temporary work agencies. Companies indicate that part of these agency workers form a flexible buffer of on-call workers, students, and retirees. Additionally, in all three companies, a small share of work is subcontracted to sheltered employment providers, mainly for repetitive or less desirable tasks.

Across the nine companies in the three logistics hubs, the proportion between permanent and non-permanent jobs thus varies substantially, from 90% permanent staff to 80% temporary agency workers. These figures however do not include additional flexibility through the on-site subcontracting of part of the operations to other companies, which occurs in some of the warehouses. This indicates that companies' specific employment practices cannot be solely derived from the institutional setting, but rather reflect specific markets, strategic choices, and legacies. The most extreme differences are found in the Western Poland hub, where each of the three studied companies adopts radically different employment practices. In the UK and Belgian hubs, two of the three studied companies make a more limited use of temporary (agency) jobs compared to the third one.

Despite differences in workforce composition, in all nine cases, workers with a more vulnerable position on the labour market – including young and female workers, migrant workers, workers with a migrant background, workers with a disability, and formerly incarcerated workers – were structurally overrepresented in temporary jobs, both direct and through agencies, and in outsourced jobs.[38]

"In warehousing, sheltered workshops often handle tasks like transferring goods from one truck to another, or repalletising, very repetitive and straightforward tasks. [...] We could hire people ourselves to do that work, but it's simply easier for a company like ours to collaborate with sheltered workshops who already employ these groups and have the structures in place to support them."

HR Manager, 3PL Warehouse, Belgium

"The percentage of women, from the warehouse [Supermarket Warehouse] and the agency alike, is kind of...is 60-40, somewhere around there. Most of the women are with the agency."

Warehouse Worker, Supermarket Retailer Warehouse, UK

"We have two employees from Ukraine with direct employment contracts. The rest of the Ukrainian workers are employed through agencies."

HR Manager, Lifestyle Retail Warehouse, Poland

The concentration of these workers in the most precarious jobs points to how warehouses provide jobs to workers who receive fewer opportunities on the labour market, yet do so on less favourable employment conditions in terms of stability, rewards, social protection, and clearer career prospects.

Independent of the specific employment strategy, digital technologies always play a key role in making multi-tier employment possible. On the one hand, digital technologies can be used to broaden the pool of potential workers, facilitating the use of temporary employment.

"We invest in technology to address labour shortages. It makes it possible to employ people who couldn't have done the job before. The ergonomic lift, for instance, allows us to assign women to tasks that were physically too demanding in the past."

Human Augmentation technology, Warehouse Manager, 3PL Warehouse, Belgium

38 Briken, K., & Taylor, P. (2018). Fulfilling the "British way": Beyond constrained choice - Amazon workers' lived experiences of workfare. Industrial Relations Journal, 49(5–6), 438–458; Knappert, L., Ortlieb, R., Kornau, A., de García, M. M., & van Dijk, H. (2023). The ecosystem of managing refugee employment: Complementarity and its microfoundations. Academy of Management Discoveries, 9, 339–362.

> **"We have implemented voice picking [for Ukrainian workers] in Ukrainian. They also have all the labels in their native language. Recently, we also introduced it in Spanish for Colombians."**

Pick-by-Voice System, Regional Director, Food Retail Warehouse, Poland

On the other hand, the algorithmic management of workers allows companies to make decisions about which workers should be retained based on the collection and processing of extensive data measuring their performance. It allows managers to identify which temporary (agency) workers should receive more work hours, but also which ones should be offered a permanent job with the company:

> **"If someone starts through an agency, we track their performance [through WMS]. The team leaders' evaluations go to HR, and that helps decide whether they become permanent."**

WMS, Warehouse Manager, 3PL Warehouse, Belgium

In one of the warehouses in the UK, only temporary workers had productivity targets, while permanent workers did not.

Algorithmic surveillance and evaluation – whether only potentially or actually used – also affect workers directly employed on a permanent contract, as it puts them under constant pressure to keep performing to retain their jobs. In the most extreme case, data indicating underperformance automatically initiated a disciplinary procedure with limited room for managerial discretion:

> **"If I underperform for two weeks, the [warehouse management] system sends an automatic email. My manager has to forward it, and dismissal can follow. Before, managers could take personal circumstances into account, now decisions are triggered by the system."**

WMS, Trade Union Representative, Lifestyle Retailer Warehouse, UK

Although this is the only case observed in the study, it points to the real risk that employment decisions are solely made based on performance as it is quantified by the technology, without

any consideration for qualitative, contextual and personal elements.

Finally, full automation technologies are adopted when fluctuations in operations are so large that peaks cannot be addressed with additional temporary (agency) labour. This was the case of one of the supermarket retailers in the South Yorkshire area, which had introduced an AMR system:

> **"[AMRs] do protect you from things like labour shortages and the cost of resource going up… our peak seasons double our volume in a matter of weeks and it's very, very difficult for any organisation to bring in temporary resources to do that, particularly in the incredibly competitive market."**

AMR, Operations Manager, Supermarket Retailer Warehouse, UK

6.2 WORKING TIME ALLOCATION

A multi-tier employment model, enabled by technology, has important consequences for how working time is allocated between workers on different types of contracts. Working time allocation is key to sustaining warehousing operations that ensure the 'swift' circulation of goods. Warehouses thus often require workers to work beyond the typical working day, into nights, weekends and official holidays. Work schedules may be particularly complex, including multiple types of shifts occurring simultaneously, such as fixed and rotating shifts, extended 10- to 12-hour shifts, night shifts, and weekend shifts. Combined, these various shifts produce diverse working time regimes for different segments of the workforce:

> **"There are many different shifts: 6:30 to 14:30, 8:00 to 16:30, 13:54 to 22:00, 22:00 to 6:00. There's even someone who works from 7:30 to 15:30. It's really a mix of everything."**

Warehouse Worker, 3PL Warehouse, Belgium

In larger companies, this complexity is managed through a workforce planning system (WPS) connected to the WMS or integrated in the broader ERPs. This system forecasts labour demand by shift and task, identifies gaps, and matches temporary workers to open slots via online portals. These portals are either internal company platforms or integrated with the systems of temporary work agencies, allowing automated contract generation to adjust headcount in near real time.

"We recently introduced a new HR system with an overtime availability calendar. Workers can sign up for extra hours. But with over 600 shift patterns at one site, keeping it compliant with regulations is complex. That's why we keep developing new technologies to improve performance and productivity."

WPS, Warehouse Manager, Lifestyle Retailer Warehouse, UK

Different shifts are therefore filled by workers on different types of contracts, both with the company and through work agencies and subcontracting.

Workers on permanent contracts generally enjoy earlier access to desirable shifts and more predictable schedules, while temporary (agency) workers are more likely to receive late notices, irregular start and end times, and nights or weekend shifts.

"Temporary workers put their availability in the [workforce planning] system. I first schedule permanent staff, then assign temps through the system."

WPS, Warehouse Manager, 3PL Warehouse, Belgium

Different contractual forms provide varying degrees of flexibility for the employer – be it the company or the temporary work agency. The greatest flexibility was observed in Poland, where workers on civil law contracts work up to 12, 14, or even 16 hours, as they are not considered employees, and thus are not subject to legal working-hours limits or overtime bonuses:

"My colleague has a permanent contract and I'm on a service contract [a type of civil law contract]. He can only work 8 hours, but I can work more – usually 12, though not 13 or 14 anymore. In the past people could even work 14 or, in my case, up to 16 hours."

Warehouse Worker on Civil Law Contract, Ukrainian Man, Food Retail Warehouse, Poland

Structurally paid less and much more flexible, these workers are incentivised to extend their working hours to maximise their earnings.

The lowest flexibility was observed in Belgium, which has, to date, quite strict regulations on working time, protecting workers from night and weekend shifts, guaranteeing minimum worktime each week and establishing the conditions of overtime.

"In the logistics sector, everything is already very well regulated: shifts, working hours, even the wage scales are clearly established. […] Every two years the framework is agreed: first the 'top ten' [the national group of ten representatives from trade unions and employers' federations], then sector talks, then company-level implementation, and it's set for two years."

Logistics Sector Representative, Trade Union, Belgium

In this context, conflicts are often about the employer's non-compliance with existing regulation:

"Conflicts are often about implementing agreed rules, e.g. the weekend-shift agreement that representatives say the employer doesn't respect. […] Agency work is widespread, and although day-to-day contracts aren't supposed to be used systematically, they still are."

Logistics Sector Representative, Trade Union, Belgium

Moreover, as of January 1st, 2026, current regulations will be softened to increase labour flexibility and reduce labour cost, with the aim of guaranteeing the competitiveness of the Belgian logistics industry.[39]

Part-time, flexible employment in warehousing might be a convenient source of income to students, individuals with caring responsibilities, and those needing additional social security contributions to access retirement benefits. However, extremely unpredictable schedules and incomes can also push individuals to work unhealthy long hours and rhythms, whenever they have the possibility to. Extended shifts, no resting days, and rotating nights heighten fatigue and can severely disrupt lives.

"I sometimes worked 15 days almost in a row, with only one day off. Then four days off, then three on, then two off. The schedule was extremely hectic."

Warehouse Worker, EU Male Migrant with Mental Health Condition, Supermarket Retailer Warehouse, UK

Workers' availability for extremely long working hours and less desirable shifts increases during periods of inflation or economic downturns, when lost purchasing power needs to be compensated by extending worked hours:

"At first, most people preferred the two-shift system without weekends [morning and afternoon shifts]. But when inflation hit in 2023, many asked for nights and weekends because it was the only way to earn extra."

Warehouse Manager, Lifestyle Retail Warehouse, Poland

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39 The prior general ban of night work, which could only be carried out in specific cases, will be lifted. For new employment contracts in distribution and e-commerce, night work rates will be limited to work carried out between 00:00 and 5:00, rather than the prior 20:00 to 6:00. Workers will be allowed up to 360 hours of voluntary overtime hours per year, and of these 240 hours will be exempt from social security contributions and taxation. Part-time contracts will moreover no longer have to include a minimum of one-third of the hours of a full-time weekly schedule. L&A Global. (2025). Belgium: Upcoming Act on Key Amendments to Labour Law https://leglobal.law/2025/09/23/belgium-upcoming-act-on-key-amendments-to-labour-law/

6.3 WORK ALLOCATION

A multi-tier employment model enabled by technology also impacts to whom jobs are allocated in the warehouse. Temporary (agency) workers are more likely to be assigned the most deskilled, physically heavy, monotonous, and closely surveilled jobs. This work allocation is not solely determined by the different knowledge and skill required by jobs, but also by more or less informal internal rules, negotiated between the multiple actors present in the warehouse – the employer, temporary agencies, workers, and workers' representatives where they are present – about fairness.

"When you're new, you basically have to work as an order picker for the first weeks or months. Until you hit your performance targets. Then you'll get training for another role."

Warehouse Worker on Direct Permanent Contract, 3PL Warehouse, Belgium

"In the picking area, most workers are agency staff, since the agency is not allowed to operate in either the unloading or loading areas - those jobs can only be performed by directly employed workers. This warehouse also has a freezer section, where products are stored at –31°C, and there, agency workers are allowed to work. [...] Management and the union have agreed to restrict agency workers from the loading and goods-in/out areas."

Warehouse Worker on Direct Permanent Contract, Supermarket Retail Warehouse, UK

As temporary (agency) workers might be offered a permanent contract later on, their work as temporary workers is considered a probational time. Their motivation, capacities and flexibility are tested to determine whether they deserve to be hired on a permanent contract.

"Temporary workers always have to work harder. That's normal in every warehouse. [...] When you start somewhere, you have to prove yourself."

Warehouse worker on Direct Permanent Contract, 3PL Warehouse, Belgium

Conversely, better jobs are considered a form of reward to workers with longer tenure and who have already proven their commitment to the company over time, and/or a way to spare older workers from jobs involving too much heavy lifting.

"They try to spare the older ones, like me... but I still sometimes have to do order picking. I feel it in my back or my joints when I go home."

Warehouse Worker on Direct Permanent Contract, 56 Years, Man, 3PL Warehouse, Belgium

"Once you get a permanent contract, it's different. [The work] is getting easier then."

Warehouse worker on Direct Permanent Contract, 3PL Warehouse, Belgium

In some warehouses, certain parts of the operations are subcontracted to external organisations on-site. In two of the studied companies, packaging and picking work was outsourced:

"The idea [of on-site subcontracting] is that we place orders for a specific quantity of goods, which the agency is supposed to handle for us, providing services such as picking and packing per shipment."

Regional Director, Food Retail Warehouse, Poland

"On our site, the sheltered workshop partner runs a dedicated facility with over a hundred colleagues. They handle the pre-packaging of parts into our branded packaging and assemble service kits for specific repairs."

Operations Manager, Automobile Warehouse, Belgium

In practice, the allocation of work along the distinction between permanent and temporary (agency) workers and between operations run by the company or outsourced on-site often also entails the concentration and segregation of workers with specific profiles in specific jobs.

"In this warehouse, Belgians are definitely in the minority. I think people of Turkish origin are the most represented here [also in permanent contracts]. Also among the supervisors, definitely."

Warehouse Worker on Direct Permanent Contract, Dutch-speaking Man without Migration Background, 3PL Warehouse, Belgium

"The problem is that they [Polish workers] simply aren't available. Anyone who comes here says, 'I won't do this for any money,' because it involves heavy lifting. The second factor is the unattractive working hours."

Regional Director, Food Retail Warehouse, Poland

6.4 WAGES AND BENEFITS

Across the three logistics hubs, wages in warehousing are overall low, with the vast majority of workers earning just above the minimum wage. Employers often justify low wage levels by pointing to the need to keep costs low to remain competitive and rising energy and transport costs.

"When we make decisions, it often starts from the need to save costs. Cost-efficiency and cost savings are the two main drivers."

Warehouse Manager, 3PL Warehouse, Belgium

"We're seeing increasing competition between warehouses. […] At the same time, rising costs, energy prices in particular, but also business rates, are becoming a serious challenge for our members."

Representative, Employers Association, UK

Companies rarely use higher wages as a deliberate retention strategy. Most apply sectoral scales and cost-control policies, paying above median only to retain specific, scarce skilled profiles. As a result, warehouse workers might change employer for only slightly higher wages, leading to high turnover rates:

"Many warehouses are clustered on business parks, all offering similar jobs. Workers move from one building to another for as little as 25 or 30p more per hour. It creates a kind of wage arms race."

Warehouse Manager, Lifestyle Retailer Warehouse, UK

The structure of wage and benefit determination varies considerably across countries and companies. In Belgium, wages largely follow national and sectoral collective agreements, resulting in relatively similar pay structures for permanent and temporary workers, who often receive the same base pay and basic social security coverage, and benefits such as higher pay for night and weekend shifts, meal vouchers, subsidised means, and the (partial) reimbursement of commuting costs. Night and weekend shifts are paid at a higher rate. Individual bonus systems are not so frequent to avoid conflicts among workers and with the trade unions. Agency workers have access to benefits, unless they are based on tenure (e.g., additional leave days, productivity bonuses or presenteeism incentives) or they are offered by the employing work agency (e.g., retirement package, hospitalisation insurance). Workers employed by subcontractors are, on the contrary, excluded and usually employed at worse conditions. They might in some cases fall under other – less favourable – sectoral collective agreements, depending on the activity they carry out.

"We are legally required to pay [temporary workers] exactly the same as for a direct hire, from the hourly wage to meal vouchers and everything that comes with it, it's identical."

Business Manager, On-Site Temporary Work Agency, 3PL Warehouse, Belgium

In this relatively protected context, employers might use individual incentives, such as additional leave, for 100% attendance:

"They also get a bonus if they are not sick for a whole year… That translates into three extra days of leave the following year."

Warehouse Manager, 3PL Warehouse, Belgium

The recently agreed labour market reform will, however, likely change the observed employment practices, as it makes night work and overtime substantially less expensive for employers and lifts the minimum amount of work hours per week, allowing workers to be employed for only a few hours a week.

In Poland and the UK, where workers are much less unionised and often not covered by collective agreements, wages include more often a variable part. This wage structure is facilitated by the real-time monitoring of productivity and accuracy enabled by digital technologies. In Poland, individual performance bonuses are often used and can exceed 20% of base pay:

"The key is a well-designed piecework system where higher productivity leads to higher pay. But it must be fair, because the company is investing and expects a return."

WMS and Performance Tracking, Warehouse Manager, Food Retail Warehouse, Poland

Agency workers on civil law contracts are excluded from overtime rates and bonuses linked to regular employment. However, their actual wages depend on a number of factors, including the use of piece-rate systems and the possibility to extend working time through additional hours, which are not considered overtime:

"When it comes to overtime, agency workers are considered first. The company chooses agency workers first because they are cheaper. They have to pay me double time [on the weekend], while agency workers get the same hourly rate as during the week."

Warehouse Worker on Direct Permanent Contract, Food Retail Warehouse, Poland

Workers sourced through civil law contracts are excluded from paid sick leave and holiday pay, as they are formally not employees. However, as they are not covered by labour legislation, they can extend their working hours to increase their income:

"There is still a group of people who, despite our continuous offers, see greater benefits in staying on civil law contracts, as it allows them to work more - sometimes 12, even 16 hours."

HR Specialist, 3PL Warehouse, Poland

In one of the cases, next to bonuses, also penalties for mistakes were applied:

"We use the carrot-and-stick method. That means employees receive bonuses, and in our case – also compared to the market – these bonuses can be really high. But we also impose fairly severe penalties, primarily for health and safety violations, and additionally for quality issues."

Operations Manager, 3PL Warehouse, Poland

In the UK, wage determination is usually employer-driven, with only firms where unions are formally recognised by employers are able to engage in collective bargaining over terms and conditions. Labour legislation imposes equal pay for agency workers after 12 weeks, yet access to benefits depends on employer policy or company-level agreements. For workers, the combination of low wages and fragmented benefits makes warehousing unattractive and fuels high turnover. Entry-level jobs often exclude benefits until after probation or contract conversion, offering little incentive to stay. Piece-rate pay may boost short-term income, but encourages workers to overwork, increasing injury rates. Also, importantly, it is affected by technology failures which are outside workers' control, raising doubts about its fairness:

"They said whoever hits 1,700 items in a shift gets an extra holiday. The machine broke down for half an hour. I think it was on purpose to get our numbers higher."

Digital Interface Tools, Warehouse Worker, Lifestyle Retailer Warehouse, UK

In other cases, workers claimed that initial information about pay which led them to take the job proved inaccurate, since it was based on meeting unrealistic performance targets.

"Jobs are advertised with higher pay, but once you start you only get the basic rate. Nobody explains the conditions for the extra £5. People feel misled."

Trade Union Representative, Lifestyle Retailer Warehouse, UK

Moreover, as performance calculation are carried out by the employer, trade union representatives argue that they are calculated incorrectly to keep costs down:

"If too many people reach the top bonus, management simply raises the standards. They want only a small group to qualify, otherwise they think we're not being pushed hard enough."

Performance Tracking WMS, Trade Union Representative, Lifestyle Retailer Warehouse, UK

6.5 TRAINING AND DEVELOPMENT

Warehouse workers receive overall very limited opportunities for formal training and advancement. Initial onboarding usually covers workplace safety, ergonomic practices, and how to use basic equipment and digital tools such as scanners or voice-picking systems. After probation, workers may receive some additional instruction, but this is typically informal and job-specific, delivered by supervisors or experienced colleagues. Workers are expected to learn on-the-job, at best with the support from supervisors or more experienced co-workers:

"When I started, I had about 15 minutes of training and was left to figure it out. But picking is simple, the scanner guides you through everything. If someone learns quickly, two hours is enough to get the hang of it."

Handheld Scanner, Warehouse Worker, E-commerce Lifestyle Retailer Warehouse, Poland

Opportunities for certified training are rare. In some warehouses, workers can obtain forklift or reach truck certificates, but these are often valid only inside the company and not transferable to other employers. Employers justify the lack of investment in worker training to build transferable skills or long-term career prospects by pointing to high turnover and the related risk that trained workers might leave the company once they have acquired new transferable skills. One of the Belgian cases, a large 3PL company, has an internal training academy that was launched with the aim of addressing labour shortages.

"Here [at the training academy] everyone starts with an order-picker training. Only after three months, if they've proved themselves on the floor, do they get the forklift or reach-truck course. It's unusual in our sector and a real added value because it lets us bring in people with no prior experience and grow them step by step."

Business Manager, On-Site Temporary Work Agency, 3PL Warehouse, Belgium

However, even in this positive case of investment into workers' skill development, the offered training certificates have no formal recognition outside the firm, limiting their value in the broader labour market.

A limited number of workers are able to make career progress inside the companies. Workers who demonstrate commitment or flexibility may advance into roles such as quality control, dispatch, or team coach:

"I've just started a course in industrial electricity with company support. I also get educational leave. [...] I've moved to this position, partly because I had system knowledge and some technical skills."

Warehouse Worker on Direct Permanent Contract, Young Dutch-Speaking Man without Migration Background, 3PL Warehouse, Belgium

"I didn't expect to stay this long, but the job has developed me so much and the career path offers opportunities, that I've already gone through several stages in this company. I started 9 years ago in the lowest position, unloading containers."

Warehouse Manager, Lifestyle Retail Warehouse, Poland

However, in many cases, promotion criteria are not transparent and rather at managers' discretion. Moreover, these steps are not always linked to wage increases or formal promotion. In one of the UK cases, a worker mentioned being employed for 16 years, taking on additional responsibilities during that time, yet still earning just above national minimum wage. Some respondents also mentioned that progression opportunities had narrowed over time. Steps towards supervisory positions were reduced or removed, and wage differentials between workers and managers have decreased, lowering incentives to upward mobility.

"A decent worker on a bonus can earn as much as a team manager, with far less responsibility. So I don't see the point of becoming one."

Trade Union Representative, Lifestyle Retailer Warehouse, UK

Temporary (agency) workers, in which migrant and migrant background workers are overrepresented, have less or no access to training and career opportunities.

In Belgium, some employers offered language courses, but in the UK and Poland such initiatives were absent, reinforcing barriers. Gendered patterns are visible as well: while women are increasingly present in operative jobs, they remain largely underrepresented in supervisory and managerial positions.

"In our warehouse, up to 70% of workers are women, but 60-70% of managers are men. We've tried to change this by more often selecting women as team leaders."

HR Manager, Lifestyle Retail Warehouse, Poland

Individual workers' digital competence can, in some cases, open new pathways for recognition. In the UK, some workers were offered secondments to support the rollout of new WMS, under the assumption that those using the system daily were best placed to explain it to colleagues. These opportunities, however, were mostly offered to younger male workers, who are believed to be 'digital natives,' 'naturally' possessing digital skills.

"We've got workers in the operations room who know the WMS better than some managers. We pull them off the shop floor to help. These are young guys straight out of school who've learned the tech and are now moving into other roles."

Warehouse Manager, Supermarket Retailer Warehouse, UK

Such digital pathways yield opportunities that are not always open to everyone equally. In the most automated sites, high-skill maintenance roles are often outsourced to specialised providers rather than offered to warehouse personnel, reinforcing the divide between workers in deskilled jobs. In one of the most automated companies in the study, a UK food retailer, over 50 engineers worked on site, but all were employed directly by the ASRS provider, rather than the company itself. This means that while automation can raise skill requirements overall, the benefits of upskilling often accrue to subcontracted specialists rather than warehouse workers.

"We simply can't find enough technicians. It's very difficult to get a good one, so we work with a company that supplies them."

Operations Manager, 3PL, Belgium

6.6 CONCLUSION

The digital technologies deployed in the companies in this study provide a core infrastructure that enables the use of a multi-tier employment model to source their warehouse workforce flexibly and in cost-effective ways. WMS help forecast fluctuating staffing needs, connect these needs with internal and external (agency) staffing databases, and automate or semi-automate the generation of temporary contracts. Furthermore, combined with other technologies, they enable algorithmic management of temporary workers by assigning them the most deskilled and monotonous jobs, and more closely monitoring them and evaluating their performance in order to make HR management decisions (e.g., contract extension, offer of a permanent one). By deskilling a substantial amount of warehousing jobs, technologies keep wages and benefits low and reduce the need for companies to train workers, limiting opportunities to upskill and reskill, and provide career advancements only to a few, against the potentials that digitalisation could bring for the whole of the workforce.

Across contexts, this model results in highly fragmented warehouse workforces, in which the most vulnerable workers are disproportionally more often working at less favourable employment conditions.[40] Despite differences across logistics hubs and companies, the employment conditions produced by this multi-tier employment model make warehouse jobs overall unattractive, as a substantial share of the jobs is through temporary work agencies or subcontractors on-site, wage levels are usually just above minimum wages, a share of the wage is often variable, and the flexibility expected from workers is high. As a result, companies face high turnover rates and labour shortages.

Across logistics hubs and companies, digital technologies facilitate employment conditions that make warehouse jobs overall unattractive. A substantial share of the jobs are with temporary work agencies or subcontractors on-site, wage levels are usually just above minimum wages, a share of the wage is often variable, and the flexibility expected from workers is high. As a result, companies face high turnover rates and labour shortages.

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40 Schaupp, S. (2021). Algorithmic integration and precarious (dis)obedience: On the co-constitution of migration regime and workplace regime in digitalised manufacturing and logistics. Work, Employment and Society, 36(2), 310–327.

07.
Six policy principles towards human-centred and socially sustainable digitalised warehousing

Digital technologies have profoundly reshaped work and employment conditions in European warehouses. While these technologies have a clear potential to improve such conditions, this potential remains largely unmet, as they are generally adopted to increase operational efficiency, increase labour productivity, broaden recruitment pools, and reduce overall costs. Today, decisions about digital technologies in warehousing insufficiently consider their lasting impact on workers. As a result, they tend to have a negative impact on the quality of work and employment in warehouses, making warehousing jobs less attractive and exacerbating labour shortages and worker turnover.

In this section, we propose a human-centred and socially sustainable approach to the use of technology in warehousing. We start from the premise that the potential benefits of technological innovation should be shared with workers, to make warehousing jobs in Europe more human-centred and socially sustainable. Increasing the attractiveness of warehousing jobs is not only in line with the commitment of the European Commission to foster fair wages, good working conditions, and inclusion, as formulated in The Pact to Strengthen Social Dialogue in Europe,[41] it is also an essential condition to sustain the long-term competitiveness of European logistics.

Based on the collected evidence, we outline six guiding principles for policy-making at company, national and European level, that supports human-centred and socially sustainable warehousing. For each principle, we advance concrete initiatives that should be taken by the main stakeholders, in forms adapted to the specific institutional and business context. Different national employment relations systems, with different roles to the legislator, workers' representatives and companies, might require partially different paths to achieve more human-centred and socially sustainable warehousing. As warehousing is often regarded as a testing ground for digital transformation and the future of work,[42] these principles may be of inspiration for policy adoption in other sectors and workplaces.

01 PRINCIPLE 1: WORKERS INVOLVED IN ALL PHASES OF DIGITAL TECHNOLOGY ADOPTION

As digital technologies fundamentally transform warehousing jobs and job quality, workers and their representatives should be systematically involved in decisions concerning their design, adoption, implementation, and evaluation. As shown by this study, at present, technology-related decisions are typically considered business or operational matters and handled by managers and technology departments in consultation with providers, with little or no involvement of workers, their representatives, or even HR management departments. Moreover, companies seldom share their experiences with the introduction of new digital technologies to protect business intelligence under conditions of high competition.

Workers should be involved in all phases of digital technology adoption. Their participation should be anchored in legislation and organised through existing bilateral bodies where present (e.g., bilateral management-trade union representative bodies, work councils) or ad hoc bodies where these bilateral bodies do not exist. Importantly, participation should be organised to include the voice of more vulnerable workers, who constitute a substantial share of the workforce (e.g., temporary workers, women, workers employed by subcontractors, workers with a migration background, workers who do not speak the local language). Workers' involvement and inclusion fosters the quality of technology-related decisions, perceptions of fairness among workers, as well as mutual trust and shared responsibility between workers and the employer for the digital technology.[43]

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41 European Commission. (2025, March 5). Commission and social partners sign joint Pact to strengthen social dialogue in Europe.

42 Gutelius, B., & Theodore, N. (2019). The future of warehouse work: Technological change in the US logistics industry. UC Berkeley Center for Labor Research and Education and Working Partnerships USA.

43 Trust-building is especially important in low-trust contexts, such as post-socialist European countries, see Miszczyński, M. (2025). Ethical and methodological implications of social media for participant recruitment: Amazon's workforce in Poland. Journal of Organizational Ethnography.

02 PRINCIPLE 2: REGULATED USE OF WORKERS' DATA AND NEGOTIATED ALGORITHMS

The organisation of warehousing through digital technologies relies on the continuous collection and processing of large amounts of data. Data captures individual workers' actions, such as interactions with the goods, as they are registered by the technology through a digital interface tool (e.g., a scanner, tablet, voice-picking set). This data does not only enhance management's oversight and control over operations, but also enables it to closely monitor and control workers, with important implications for performance evaluations and all employment-related decisions.[44] Data is commonly shared with other parties, such as temporary work agencies. Surveillance through the constant collection of worker-related data, independent of the actual use of that data by the company, negatively affects workers' mental well-being, increasing their stress.

Putting workers front and centre requires clear and binding legal regulations of what type of data organisations are allowed to collect, how it can be processed and used by management,[45] and which company-level governance structures and procedures need to be developed to guarantee the rights of workers and their representatives in this area. Such regulatory framework should include the following:

• Legal regulations and their applications should be in line with existing European General Data Protection Regulation (GDPR), legislation on AI use at work on data transparency and privacy, and non-discrimination legislation, all of which aim to prevent harm, protect individuals, and mandate human oversight over key employment decisions.[46]

• Next to these provisions, legal regulations should require company-level bilateral governance structures and procedures for the collective 'negotiation of the algorithm' between the employer and workers' representatives, embedding digital technologies in employment relations.[47]

• Negotiations might aim, among other things, at establishing agreed performance norms for specific technologies, performance parameters, levels of aggregation (e.g., individual, team, shift, warehouse) of data, and how the data can legitimately be used by the employer and third parties involved (e.g., on-site temporary work agencies).

• Particular attention should be paid to the sharing of workers' data with third parties, feeding into broader data architectures with potentially far-reaching effects in workers' lives (e.g., future employment prospects and access to welfare services and benefits).

Overall, regulated and transparent data use and a negotiated algorithm foster perceptions of fairness among workers, mutual trust between workers and the employer, and shared responsibility for the digital technology and its effects.

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44 Xavier, P.-R., & Parker, S. K. (2022). Algorithms as work designers: How algorithmic management influences the design of jobs. Human Resource Management Review, 32(3), 100838.

45 Eurocadres. (2025, May 6). Quality jobs must be underpinned by legislation.

46 Molè, M. (2025). Lost in translation: Is data protection labour law protection? Comparative Labor Law and Policy Journal, 45(3). The recently adopted EU AI Act has the main objective of ensuring that AI systems in the EU are safe, transparent, traceable, non-discriminatory and environmentally friendly. It classifies uses of AI technology in decisions concerning recruitment and selection, task allocation, monitoring, performance evaluation, promotions, dismissals as 'high risk' and explicitly forbids biometric categorisation inferring protected characteristics, emotion recognition and social scoring at work. Regulation (EU) 2024/1689 - Artificial Intelligence Act (AI Act) - adopted by the co-legislators on 13 June 2024, laying down harmonised rules on artificial intelligence. It introduces amendments to Regulation (EC) No 300/2008, Regulation (EU) No 167/2013, Regulation (EU) 2018/858, Regulation (EU) 2019/2144, Directive 2014/90/EU, Directive (EU) 2016/797 and Directive (EU) 2020/1828. https://www.europeansources.info/record/proposal-for-a-regulation-laying-down-harmonised-rules-on-artificial-intelligence-artificial-intelligence-act-and-amending-certain-union-legislative-acts/

47 De Stefano, V. (2019). Negotiating the algorithm: Automation, artificial intelligence, and labour protection. Comparative Labor Law and Policy Journal, 41(1), 15-46; UNI Global Union (2023). Algorithmic Management: Opportunities for collective action; ETUC. (2025b). Negotiating the algorithm: Trade union manual.

PRINCIPLE 3: PREVENTED AND REDRESSED HEALTH, SAFETY AND PSYCHOSOCIAL HARMS OF DIGITAL TECHNOLOGIES

Current health and safety regulations are grounded in EU law, which mandates employers to carry out risk assessments, take preventive measures, provide training, and consult workers on health matters.[48] The evidence of this study indicates that digital technologies can have important, contradictory consequences on warehouse workers' physical and mental well-being. While such technologies can reduce the physical strain of tasks such as heavy lifting, making them more ergonomic and safer, and help better tailor jobs to individuals, they can also create new health risks, including hollowing out work, intensifying it, increasing monotony and stress, increasing strain and injuries due to repetitive movements and non-ergonomic designs, and socially isolating individual workers.

- Legislation should be passed imposing on employers' mandatory, comprehensive health and safety pre-introduction risk assessments to prevent harms, as well as the continuous monitoring and evaluation of the short- and long-term effects of novel digital technologies, which are today still partially unknown.

- Systems of control and enforcement, involving the labour inspectorates, including fines for non-compliant warehouses should be established.[49] Such risk assessments and joint monitoring systems should take into consideration the combined use of multiple types of technologies, as well as the specific vulnerabilities of distinct segments of the workforce. Such assessments should not be limited to ergonomics, physical health and injuries, but rather cover all dimensions

of job quality as identified in the definition of the European Parliament.[50]

- In particular, measures should be mandated to redress the psychosocial harms caused by digital technologies, which have received, to date, relatively little attention. They should counter the erosion of the social fabric and restore a sense of community among the workforce and shop floor management. This could, for instance, be done by introducing: teams on the shop floor; anti-harassment and anti-bullying policies; provision of support personnel; initiatives fostering social integration and supporting communication sociability; inter-cultural dialogue, and open forums.

Such measures will enhance workers' physical and mental well-being as well as the social climate at work, decreasing the amount of sick leave, absenteeism and turnover, and improve worker retention.[51]

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48 Current national legislation is grounded in Framework Directive 89/391/EEC that sets out general principles for improving health and safety at work for all EU member states. It establishes a foundation for workplace safety based on prevention and requires employers to integrate health and safety into their management policies.

49 Eurocadres. (2025, May 6). Quality jobs must be underpinned by legislation; Ceemet. (2025, April 17). Ceemet emphasises the need for competitive companies and skills development at the Quality Jobs Roadmap consultation.

50 European Parliament's Committee on Employment and Social Affairs. (2009). Indicators of job quality in the European Union.

51 Miszczyński, M., & Zanoni, P. (2025). Coercion and Consent under Techno-Economic Despotism: Workers' Alienation and 'Liberation' in the Amazon Warehouse. Work, Employment and Society, 0(0).

04 PRINCIPLE 4: USE OF DIGITAL TECHNOLOGIES TO FOSTER INCLUSION IN HIGH-QUALITY JOBS

Digital technologies are often deployed to simplify warehouse jobs and make them less physically taxing and more accessible. Technologies enable tasks to be broken down into smaller units, making jobs accessible to a wider range of workers, including those with fewer formal qualifications, limited experience, without proficiency in the local language, or less physical strength. As a result, warehouses across Europe today employ highly diverse workforces, including migrants, women, formerly incarcerated persons, and people with disabilities, yet largely in deskilled jobs.[52]

- However, digital technologies should also be used more deliberately to tailor jobs to specific individual and group competences and needs, rather than to deskill them. Public support should be provided to stimulate the co-development and adoption of digital technologies that tailor jobs and foster inclusion, involving workers and their representatives, and including workers belonging to more vulnerable groups.

- Employers could require technology providers to adapt WMS to offer individual workers some degree of choice on the type of goods, routes or locations allocated to them through the digital tool, restoring some degree of autonomy.[53]

- Assistive and adaptive robotics, such as exoskeletons, can be used to reduce strain and make jobs healthier and more sustainable, lengthening working lives, and offering opportunities to a larger group of women and people with a disability.[54]

- Multilingual interfaces and translation applications can help reduce language barriers, while AI-powered WPSs can better forecast staffing needs and help plan workers' scheduling more effectively, potentially reducing work-life conflict.

- Data-driven analyses can allow companies to identify warehouse locations well connected by public transport, making jobs geographically more accessible to a broader pool of workers.

Such uses of digital technologies will allow jobs to be more tailored to individual workers, decreasing injuries and enhancing their physical and mental well-being. Better tailored jobs will increase the sustainability of warehousing jobs and overall workforce retention.

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52 Zanoni, P., & Miszczyński, M. (2023). Post-diversity, precarious work for all: Unmaking borders to govern labour in the Amazon warehouse. Organization Studies, 45(7), 987–1008.

53 De Lombaert, T., Braekers, K., De Koster, R., & Ramaekers, K. (2023). In pursuit of humanised order picking planning: Methodological review, literature classification and input from practice. International Journal of Production Research, 61(10), 3300–3330.

54 EASPD. (2025, August 19). The EU's next big step on employment and EASPD's position on it.

05 PRINCIPLE 5: STABILISED EMPLOYMENT RELATIONS AMIDST DIGITAL TECHNOLOGIES

Employment in digitalised warehouses is characterised by the combination of multiple types of contracts and involving multiple employers. Warehouse workers can be employed as permanent staff, temporary workers, temporary agency workers, and, to a lesser extent, subcontracted labour. This complex multi-tier employment model crucially rests on digital technologies that deskill warehouse jobs, allowing employers to source workers with little knowledge and experience, facilitate workforce planning across multiple employers, and automate workers' coordination and control in the warehouse. It is not only used to address operation peaks, but often also to extend workers' legal probation terms, and put pressure on both temporary and permanent workers. Across national, regional and company contexts, different segments of the workforce also align with different demographic profiles, with workers belonging to vulnerable groups overrepresented in the most precarious forms of employment. This deep fragmentation of the workforce weakens workers' representation, voice and collective bargaining and hampers effective labour inspection.

- Legal regulation should be introduced that guarantees the alignment of the employment conditions of warehouse workers on different types of contracts and across formal employers, including workers' right to representation.

- The responsibility and liability of the client company for all workers, independent of the formal employer, should be strengthened in recognition of its direct control of workers enabled by the digital technologies it deploys in the warehouse.[55]

- A principle of maximal stabilisation of employment should be established by law. The degree and modalities of the utilisation of temporary (agency) employment and outsourcing of operations should make the object of collective negotiation between the company and representatives of all workers, independent of contract type or employer, and with the objective of maximally stabilising employment.[56]

By improving the terms of employment of the less protected segments of the workforce, where the most vulnerable workers are concentrated, these measures will promote long-term, sustainable employment and employment relations, decreasing worker turnover and mitigating current labour shortages.[57]

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55 See Borrelli, S., Loffredo, A., Marzo, C., & Walser, M. (2025). Sorry we subcontracted you! ETF/ETUI.

56 ETUC. (2025a, June 24). ETUC demands for the Quality Jobs Roadmap.

57 Vanderleyden, J., Van Aerden, K., & Vanroelen, C. (2025). Cross-national relationships between employment quality and mental well-being: The role of organized labour strength. European Journal of Industrial Relations, 31(3), 313–343.

06 PRINCIPLE 6: ENHANCED TRAINING AND CAREER OPPORTUNITIES

While the adoption of digital technologies in warehousing is often presented as opening up novel opportunities, most warehouse workers today receive limited training and few or no opportunities for career advancement. Reliance on temporary (agency) employment and high turnover rates make companies' return on investment in training overly risky. When training is provided, it is often on-the-job and task-specific, and does not lead to certified, transferable skills sustaining workers' employability. As a result, most workers remain locked in the least skilled, repetitive, physically most straining jobs on temporary employment contracts. At the same time, the digital skills that are required to operate digital technologies used in warehouses commonly remain unrecognised. While the adoption of digital technologies also creates high-skill jobs, most of these jobs are with technology providers rather than in-house. This increases companies' dependence on technology providers and deepens the divide between the majority of warehouse workers who have little access to training and career advancement prospects and a smaller group of high-skilled workers permanently employed by technology providers.

- Legal regulations should be adopted that mandate employers to invest in certified training on digital technologies and establish minimal floors for re- and upskilling warehouse workers.

- Transparent, fair and non-discriminatory training policies and career paths should be negotiated by the employer and workers' representatives, in view of providing workers with more career opportunities in warehousing and beyond, and with particular care to ensuring equal access for more vulnerable workers.

- The new possibilities opened up by digital technologies should be used to offer training that is more tailored to workers' individual skills, needs and interests. Training activities would benefit

from structural collaborations among companies in the same region and other relevant local actors that are part of the company's ecosystem, including, for instance, public educational and training institutions, technology providers, sectoral employer associations, public employment services, labour market intermediaries, local authorities, and other relevant grassroots advocacy organisations and associations. Overall, these measures will make warehousing jobs more attractive, broadening the pool of potential warehouse workers and helping to retain workers, reducing shortages of qualified labour.[58] They will allow companies to directly employ more skilled workers and to reduce their operational dependence on technology providers and costs derived from technology.

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58 Ceemet. (2025, April 17). Ceemet emphasises the need for competitive companies and skills development at the Quality Jobs Roadmap consultation.

CONCLUSION

The proposed six policy principles require coordinated actions of key stakeholders to advance human-centred, socially sustainable warehousing. To conclude, below we outline the role of each stakeholder: supranational policy makers, national policy makers, companies operating warehouses, workers' representatives including trade unions, technology developers and service providers, labour market intermediaries, and other key local stakeholders (e.g., education and training institutions, local authorities, local public funders, etc.).

Supranational and national policy makers should work towards passing legislation establishing standards and mechanisms of governance that:

1. Guarantee the involvement of workers and their representatives in all phases of digital technology adoption;

2. Regulate the usage and control of workers' data by the employer, foreseeing collective negotiations over the algorithms used to manage the workforce;

3. Mandate employers to take measures to redress health, safety and psycho-social harms caused by digital technologies;

4. Provide financial stimuli for the co-development and adoption of digital technologies that support tailoring of jobs to foster inclusion;

5. Protect workers independent of contractual form and stabilise employment relations; and

6. Provide training and career opportunities for all workers.

Companies operating warehouses should comply with supranational and national legislation and install company-level mechanisms that:

1. Guarantee the involvement of workers and their representatives in all phases of digital technology adoption;

2. Comply with legislation on data usage and collectively discuss and negotiate the rules and outcomes of operating algorithms in the workplace with workers' representatives to establish agreed norms;

3. Adopt measures to redress health, safety and psychosocial harms caused by digital technologies;

4. Co-develop and adopt digital technologies that tailor jobs fostering inclusion;

5. Protect workers independent of contractual form and strive to maximally stabilise employment relations; and

6. Work with other stakeholders to provide training and career opportunities in transparent and fair ways.

Worker and worker representative organisations, including trade union representatives should request and participate in company-level mechanisms that:

1. Guarantee workers' involvement in all phases of digital technology adoption;

2. Ensure legal compliance, especially in regards to data usage, and collectively negotiate the rules and outcomes of operating algorithms in the workplace with the employer;

3. Propose and participate in measures to redress health, safety and psychosocial harms caused by digital technologies;

4. Participate in the co-development and adoption of digital technologies that tailor jobs fostering inclusion;

5. Represent and protect workers independent of contractual form and demographic profile and strive to maximally stabilise employment relations; and

6. Support training workers on issues relevant to workplace technology with the employer and other stakeholders to ensure workers receive training and career opportunities in transparent and fair ways.

Trade union organisations at higher levels (sectoral, regional, national, and supranational) should advocate for legal regulation advancing human-centred and socially sustainable work in digitalised warehouses, where possible negotiate human-centred technologies with employers' representatives, support workers' representatives in their work in warehouses, provide training to workers' representatives in warehouses on technologies, and promote and support the inclusion of more vulnerable workers.

**Technology and technology service providers should:**

1. Involve workers in the design, development and adoption of technology;

2. Comply with legislation on data usage and technically implement and support the algorithm collectively negotiated by the employer and the workers' representatives;

3. Develop solutions to reduce and redress the health, safety and psychosocial harms caused by digital technologies in collaboration with the employer and the workers' representatives; and

4. Co-design digital technologies that tailor jobs fostering inclusion; 5) work with other stakeholders to identify training needs and develop training on technology.

Labour market intermediaries, including temporary (on-site) work agencies should advocate for the rights of temporary agency workers:

1. Ensure temporary workers' involvement in all phases of digital technology adoption;

2. Comply with legislation on data usage;

3. Propose and participate in measures to redress health, safety and psychosocial harms caused by digital technologies;

4. Ensure temporary workers' involvement in the co-development and adoption of digital technologies that tailor jobs fostering inclusion;

5. Represent and protect workers independent of contractual form and demographic profile and strive to maximally stabilise employment relations; and

6. Work with other stakeholders to ensure workers receive training and career opportunities in transparent and fair ways.

Other key local stakeholders should also promote action along the six policy principles. Employers' associations should diffuse information and promote the adoption of human-centred, socially sustainable digital technologies in warehousing among their members to increase the attractiveness of warehousing jobs and advocate the development of more human-centred technology with technology providers. Education and training institutions should collaborate with employers, employers' associations, trade unions, and public employment services to develop technology-related training and to deploy technology to provide training in inclusive ways. Finally, the clients of warehousing companies, public employment services, local authorities, advocacy organisations, and public funders should advocate and support, from their specific roles, coordinated action to develop and adopt digital technologies fostering human-centred warehousing to ensure socially sustainable warehousing and regional welfare.
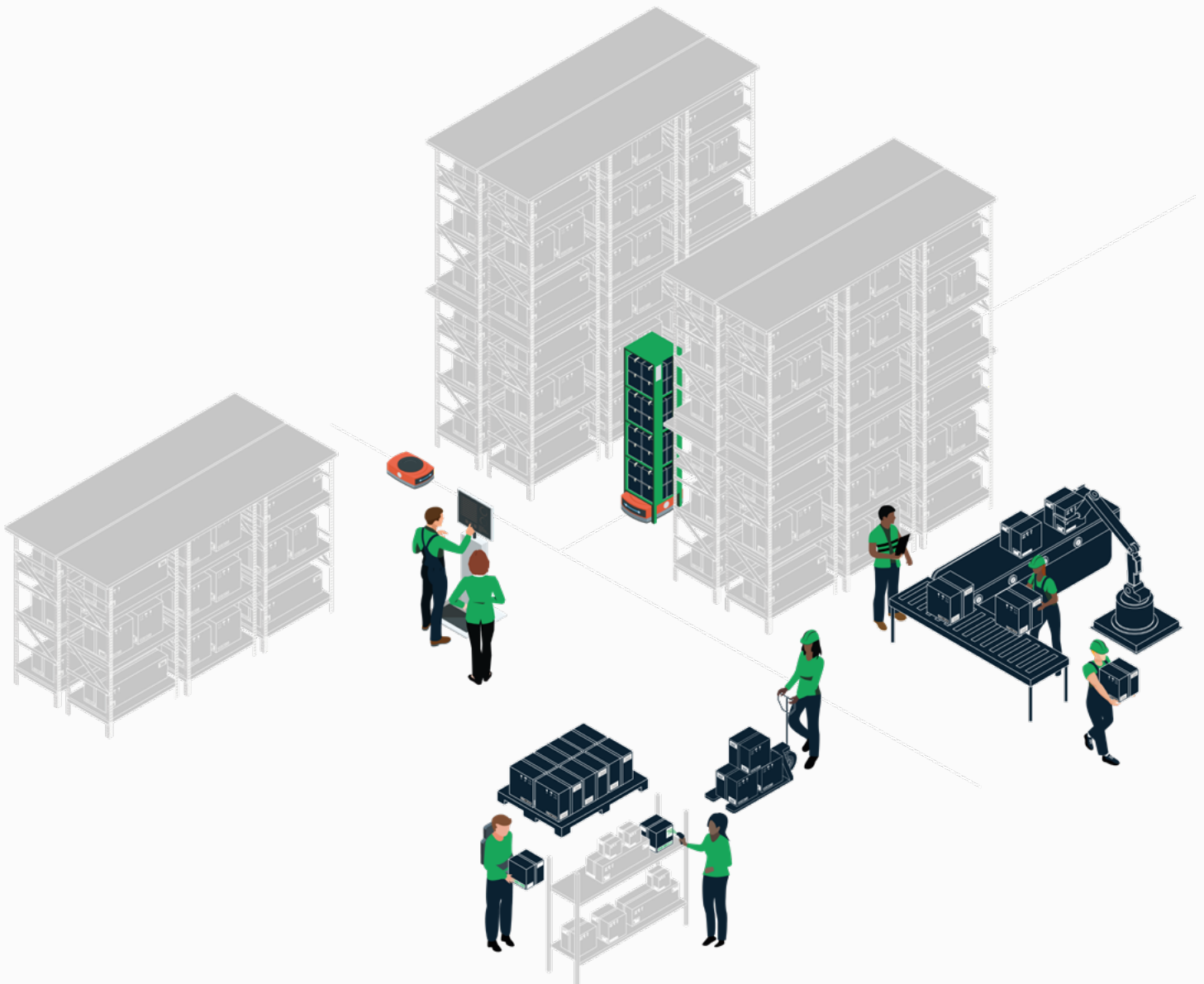
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