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Understanding the application of Industry 5.0 companies' practices (Part I)

WP3 Data retrieval and AI-analysis of vacancies and Industry 5.0 organisational practices

Deliverable D3.1 - Analysis vacancies and skills requirements. Part I

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Document description

This document contains an empirical examination of Industry 5.0 using unstructured data. Its primary objective is to establish a methodological framework that bridges the gap between theoretical concepts and practical applications in the analysis of Industry 5.0. It reports on the execution of WP3, Tasks 3.1, 3.2 and 3.3. and lays the empirical and methodological foundations for the BRIDGES 5.0 project to analyse unstructured data.

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List of abbreviations

BRIDGES	Bridging Risks to an Inclusive Digital and Green future by Enhancing workforce Skills for industry 5.0
WP	Work Package
I4.0	Industry 4.0
I5.0	Industry 5.0
GPT-3	Generative Pre-trained Transformer 3
LLM	Large Language Models
Llama	Large Language Model Meta AI

Contents

Executive Summary.

This report presents a comprehensive analysis of Industry 5.0 companies' practices in Austria, France, the UK and the Netherlands using non-traditional data sources and innovative techniques. The study aims to bridge the gap between theoretical concepts and practical applications by exploring how companies' practices are aligned with Industry 5.0.

We collected and analysed diverse data sources, including professional platforms, online job portals (for company profiles and job postings), YouTube videos, academic journal articles (Scopus), and others. To overcome the challenges associated with measuring Industry 5.0 in available data sources, we developed a pioneering AI-based methodology to analyse Industry 5.0 concepts, which identifies potential companies' practices across different databases and countries. Our approach focuses on human-centricity, recognising the need for developing an Industry 5.0 dictionary that can pinpoint patterns closely associated with this concept. This approach enabled us to construct an Industry 5.0 dictionary that identifies companies more likely to align with Industry 5.0 practices.

Our analysis revealed several key findings. Firstly, it underscored the diverse array of Industry 5.0 companies' practices, which could be systematically mapped using AI-based methodologies and expert validation. This approach demonstrates the feasibility of establishing a standardised Industry 5.0 companies' practices dictionary. The analysis of job vacancies indicates a consistent focus on promoting supportive work environments and prioritising training and career development. On the other hand, the examination of company profiles reveals a prevalent emphasis on topics such as "Empowerment and sustainability," "Supportive and open work environment," "Training and career impact," and "Balanced living initiatives".

This report lays the groundwork for further research and policy development in the field of Industry 5.0. The innovative methodology and comprehensive Industry 5.0 dictionary developed here serve as valuable tools for future studies aiming to investigate deeper into the implications of Industry 5.0 on various aspects of the economy and society. The next project phase entails exploring the possibility of complementing the Industry 5.0 dictionary by adding 4.0 technologies. These phases also include finalising the collection/access and analysis of additional data sources, such as the OVATE dataset, stock exchange company data, and collective agreements. Upon the conclusion of this data collection phase, we will move forward with integrating these databases by establishing linkages between them. This integration will allow us to create a composite index that assesses the extent to which companies align with Industry 5.0 practices.

1 Introduction.

The European Commission conceptualises Industry 5.0 as an approach which "provides a vision of an industry that aims beyond efficiency and productivity as the sole goals, and reinforces the role and the contribution of industry to society" (European Commission, 2023). Within the landscape of digital transformation, Industry 5.0 aims to ensure that the industrial sector not only meets conventional objectives like job creation and enhanced productivity but also transforms into a resilient and sustainable contributor to ensure prosperity for EU citizens. At its core, it places the wellbeing of the worker at the centre of the production process" (European Commission, 2023). Research and innovation are also integral to the process and are needed to service the transition to a sustainable, human-centric and resilient European industry.

The present research project aims to contribute to a better understanding of Industry 5.0 and achieving its goals. To do so, the project comprises three work packages (WPs). WP1 provides a conceptual framework of Industry 5.0 to study workforce skills (Oeij et al., 2024). As highlighted in the main report produced under WP1, Industry 5.0 is recognised as an open and dynamic paradigm that demands input from various stakeholders, especially so because research on Industry 5.0 is still in its infancy (Akundi et al., 2022; Leng et al., 2022; Oeij P.R.A. et al., 2024; Xu et al., 2021). This makes our present research particularly pertinent as it can inform developments in the Industry 5.0 space.

WP2 provides a statistical perspective at both sectoral and regional levels, with a comprehensive analysis spanning the entire EU (Greenan et al., 2023). It also offers in-depth insights for five specific countries - the Netherlands, France, Lithuania, Norway and Italy – and within the manufacturing sector for the Netherlands, Norway or Sweden, Lithuania, Slovenia and Austria. This selection of countries allows the analysis of how the concept of human centricity manifests across different institutional contexts and economic and labour market structures. The analysis for WP2 relies on statistical information such as firm-level data (e.g., the European Manufacturing Survey-EMS or the Community survey on ICT usage and E-commerce) and individual-level data (e.g., the European Working Conditions Surveys-EWCS) as well as on administrative structural social and business data.

WP3 builds on the other WPs and empirically explores concepts and skills around Industry 5.0 using new and innovative data sources and techniques. While the traditional statistical sources used in an innovative way in WP2 provide valuable indicators about the labour force across Europe and ensure data representativeness, they exhibit limitations in terms of granularity and data periodicity (Cardenas-Rubio, 2020). Recognising Industry 5.0 as an emerging and evolving phenomenon, there is a compelling need to complement these traditional sources with non-traditional data streams to capture the dynamic and real-time aspects of Industry 5.0. Online information sources offer many benefits in this regard, although their representativeness is difficult to establish. They are more agile and up-to-date and provide a granular view of the labour market, allowing researchers and policymakers to continuously observe and thus respond swiftly to the rapidly evolving landscape. Integrating the two types of data is a further step towards making the most of them.

Against this background, the main purpose of WP3 is to add to the statistical assessment of the nature of job transformations in the context of the 5th Industrial

Revolution using non-traditional sources of information.[1] By incorporating unstructured data, we aim to enhance the depth and accuracy of our analysis to provide a more nuanced understanding of the transformative processes underway. For WP3, the main data sources include professional platforms, online job portals (for companies' profiles and job vacancy data), YouTube videos, academic journal articles (Scopus), company stock exchange data, collective agreements and contracts data. This approach ensures that our research remains at the forefront of Industry 5.0 developments, empowering stakeholders with timely and relevant insights for informed decision-making.

One of the main innovations of BRIDGES 5.0 is to use information on organisations to develop typologies that allow the identification of "Industry 5.0-type" policies. In our analysis, we will focus on understanding the impact of Industry 5.0 on the companies' practices (Industry 5.0 companies). The following research questions specific to WP3 will be addressed and presented in this report:

1. What are the requirements for Industry 5.0 at the organisational level (socio-centred) and individual level (human-centred)?
2. To what extent do companies already meet these requirements?
3. What gaps need to be filled for companies and their staff to meet the requirements for Industry 5.0?

A fourth research question under WP3 seeks to understand which Industry 5.0 related skills will become important in the future. This will be answered in the second report for WP3.

The answers to these research questions will lead to a Proof of Concept (PoC). This PoC will not comprise a full and representative study for the whole of Europe, but will be based on a selection of the highest quality data possible related to company and vacancy information from a selection of European countries – Austria, France, the Netherlands and the United Kingdom (UK).[2] This selection of data will be used to deepen understanding of the main research questions. The analysis below will primarily focus on the human-centricity dimension of Industry 5.0, as this is the dimension that sets Industry 5.0 apart from previous industrial ambitions.

How to read this research note.

This report marks the inception of Work Package 3 in the Bridges 5.0 project, setting the stage for an empirical examination of Industry 5.0 using unstructured data. Its primary objective is to establish a methodological framework that bridges the gap between theoretical concepts and practical applications in the analysis of Industry 5.0. To achieve this goal, the report is structured into the following chapters:

- Chapter 2 discusses into the challenges associated with measuring Industry 5.0 across various sources of information.

[1] "Non-traditional" sources of information refer to unconventional or alternative outlets for data that are outside the scope of traditional or established methods. These sources often encompass emerging technologies, digital platforms, or other online data streams that have gained significance in the contemporary information landscape. Non-traditional sources can include social media, online forums, websites, satellite imagery, and other unconventional data repositories.

[2] For this project, language is important as we analyse the content of job vacancies and other texts.

- Chapter 3 addresses the need of developing an Industry 5.0 dictionary that encompasses the diverse dimensions of this phenomenon.
- Chapter 4 focuses on the mapping, selection, and collection of data sources required for the development and testing of the Industry 5.0 dictionary. Additionally, this chapter implements the AI-based methodology to create the dictionary.
- Chapter 5 presents a preliminary analysis of the data collected using the Industry 5.0 dictionary.
- Chapters 6 and 7 outline the following steps to be undertaken in WP3 and offer a conclusive perspective on the preliminary findings.

2 Measuring Industry 5.0.

Industry 5.0 centres around the collaboration between machines, humans, societal values, tasks, and the convergence of knowledge and skills as the industrial process works to provide tailor-made products and services (Leng et al., 2022). The European Commission (2023) highlights three main pillars at the centre of Industry 5.0: human-centricity, sustainability and resilience (**Figure *1***). Human-centricity places human well-being, needs and values at the centre of technological advancements and industrial processes; sustainability ensures that industry respects planetary boundaries and resilience aims for robustness from disruptions in the industrial process.[3]

Figure 1: Core values of Industry 5.0

Source: European Commission (2023)

Academia and business leaders expect this paradigm to bring big changes in worker skills, qualifications, knowledge, expertise, as well as the work environment (Akundi et al., 2022; Long et al., 2020; Modgil et al., 2023; Nahavandi, 2019). Extensive academic research is underway as experts delve into the implications and applications of Industry 5.0, attempting to forecast changes and adequately prepare for the potential advantages and obstacles it may bring (Paschek et al., 2022). Likewise, business leaders have recognised the importance of aligning their strategies with the principles of Industry 5.0 in order to stay competitive in an evolving industrial landscape.

Despite the academic, policy and business relevance, the challenge of analysing Industry 5.0 lies in the absence of a clear understanding of what the major pillars of Industry 5.0 refer to and how to measure them empirically. The analysis from WP1 provides a conceptualisation of Industry 5.0, recognising its open and dynamic paradigm. However, the operationalisation of these concepts might be challenging. For example, what does human centricity really mean, and how does the meaning attached to this term vary depending on the stakeholders involved? There is a wide

[3] See WP1 for a more detailed discussion on these core values.

strand of literature from engineering sciences and ergonomics that tackle human centricity by exploring the various aspects of human-robot collaboration or human-cyber interaction taking into account the user perspective (Shiroishi et al., 2018). From the vision of Society 5.0 promoted by the Japanese authorities, Shiroishi et al. (2018) extend this approach to the macro-level by arguing that a super smart society providing safety, security and comfort to people could result from an extensive use of cyber-physical systems. Another strand of literature from social sciences argues that human centricity is achieved when technological choices are coordinated with forms of work organisation that promote the quality of jobs and the quality of working lives (Greenan et al., 2014; Guest et al., 2022; Berg et al., 2024).

From the employee perspective, the literature on job satisfaction also teaches us that workers value their personal lives, relationships and well-being outside of work, often seeking environments that support their ability to maintain this balance (Clark, 2015). Lastly, from the employer perspective, there is recognition of the importance of having motivated and productive employees in order to foster growth and success for both the individuals and the company (Kessler et al., 2020; Melián-González et al., 2015). Human-centricity would then be achieved when employer and employee objectives are aligned.

In this project, we assume that Industry 5.0 is an approach that results in different practices within companies; in its most comprehensive version, it is a mindset that comprehends a company at all levels. But, most likely, an Industry 5.0 approach at the company level cannot be classified in a binary way, but is a continuous variable, a degree of I5.0 maturity.

Importantly, companies with a high Industry 5.0 maturity level have practices different from companies with lower levels of Industry 5.0 (I5.0) maturity (Hein-Pensel et. al., 2023). Company practices as practice theory root in social practice theory (Warde, 2005; Schatzki, 2009; Shove et al., 2012). Practice theories emphasise stability and routines in collective ways of knowing and doing in everyday working life (Nicolini, 2013; Gherardi, 2012), and practices are socio-material, hence, integrate technology and company practices change when technology changes (Orlikowski, 2010).

Companies with high I5.0 maturity levels have different practices and, therefore, need different skill sets. Organisational practices in an I5.0 setting are most likely characterised by higher permeability between hierarchical levels, possibly flatter hierarchies and higher levels of participation of the entire workforce in decision-making (Oeij P.R.A. et al., 2024). Management practices are thus different from management practices in top-down firms where decisions are made in closed clubs of upper-level management. Human-centricity as a value and approach to digital transformation is most likely interpreted differently in a company with a high I5.0 maturity level compared to a company with a low level.

Hence, establishing and agreeing upon complex terms like 'human-centricity' can be challenging, as can measuring and identifying Industry 5.0-related concepts in available data sources. WP2 proposes a measurement framework and a data strategy that builds on the combination of complementary data sources from European official statistics (including surveys and administrative secondary data) collected at the company, household or worker level. WP2 describes the interplay between the social and organisational aspects within the realm of production and their consequences on human-centricity, resilience and sustainability. The focus is on the organisational practices likely to expand the stock of productive knowledge and foster innovation: the

learning capacity of the organisation, the environmental preservation capacity and investments in digital and green technologies adoption and use. In particular, the capability to learn, adapt, and orchestrate resources with proximity to human activities and the living world that enables them to take their needs into account is seen as a crucial aspect of orienting Industry 4.0 technologies towards Industry 5.0.

To avoid being restricted to data collected in the past, more recently, researchers have explored the use of text mining and big data techniques to extract information from large data sets such as job postings, resumes and online profiles to analyse jobs, tasks, and skills from the demand/employer side of the labour market. Such methods involve analysing data from job descriptions and often mapping this onto occupational/skills classifications to identify the labour requirements for specific roles. Despite the undeniable advantages of text mining in analysing large volumes of textual data, understanding the nuanced context and subtleties within the text can be challenging. Misrepresenting the intended meaning and extracting unrelated terms can considerably impact the analysis during the pattern identification stage in text mining (Gaikwad et al., 2014; Vijayarani et al., 2015). In the context of Industry 5.0, these issues are compounded by the fact that a taxonomy that indicates which job and company characteristics are associated with Industry 5.0 does not presently exist.

Our research attempts to address some of these challenges by presenting a novel AI-based approach applied to non-traditional sources of information to empirically analyse concepts related to Industry 5.0. In so doing, our research seeks to bridge the gap between theoretical concepts and practical applications focusing on companies and jobs. The analysis below will primarily focus on the human-centricity dimension. This dimension is both new and central to Industry 5.0 and distinguishes it from previous approaches. In practice, it can be observed with a focus on the company, where sustainability involves looking at the environment in which the company operates, and resilience requires analysis of value chains.

3 An Industry 5.0 dictionary.

3.1 The need for developing an Industry 5.0 dictionary.

Researchers and experts are particularly concerned about how Industry 5.0 will shape the nature of jobs, influence skills requirements, and change working environments and conditions (Battini et al., 2022; Saniuk et al., 2022). Understanding these implications is vital for effectively adapting the workforce to the evolving technological landscape, facilitating a smooth transition to Industry 5.0 and unlocking the full potential benefits for individuals and organisations.

Traditionally, researchers have been trying to monitor these changes by developing taxonomies and classifications. One example of these classifications is different versions of the International Standard Classification of Occupations (ISCO 1958, 1968, 1988 and 2008). This classification provides a systematic and hierarchical classification system that enables the grouping of occupations based on their similarities in tasks, skills, qualifications, and other job characteristics (International Labour Organization, 2023). Similarly, the O*NET (Occupational Information Network), a well-established skills classification, provides detailed information about various occupations and their corresponding skills, abilities, knowledge, tasks, work activities, and other job-related characteristics. Usually, these classifications are made through extensive consultation processes with experts, labour market stakeholders, and national statistical agencies.

These occupational classifications have been widely used worldwide in various fields to monitor changes in the labour market. However, they are not without limitations, particularly in capturing emerging trends and phenomena. Developing an occupational/skill taxonomy solely through traditional methods such as surveys and focus groups can be time-consuming and resource-intensive (Ikudo et al., 2019). The high costs associated with these methods make it challenging to constantly update these classifications in response to dynamic labour market changes. These limitations point to the ongoing challenges faced in effectively capturing and representing the diverse and evolving nature of work in occupational/skills classifications. Researchers and policymakers recognise the need for more agile and comprehensive frameworks that can better reflect the complexities of the modern labour market and provide a foundation for understanding emerging phenomena and their implications for workers and organisations (Zizic et al., 2022).

The importance of these classifications/taxonomies becomes even more noticeable when dealing with the analysis of non-traditional data sources. Non-traditional sources often present unstructured data. While analysing unstructured data can yield valuable insights (as discussed below), it is equally essential to standardise the data to ensure consistency and facilitate meaningful comparisons across different sources. The development and application of appropriate taxonomies in such cases play a crucial role in making sense of unstructured information, enhancing data reliability, and fostering a more comprehensive understanding of the subject matter.

Researchers have recently developed methodologies to measure and analyse contemporary labour market phenomena to address these challenges. One notable example is the work by Chiarello et al. (2018), Galati and Bigliardi (2019) and Pejic-

Bach et al. (2020), which focuses on developing an enriched dictionary of Industry 4.0 enabling technologies using non-traditional methodologies and sources of information, such as text mining, Wikipedia and scientific publications. The use of these sources offers several advantages, including their constant updates and widespread accessibility. Moreover, with the advent of innovative techniques such as machine learning and text mining, it has become feasible to process and organise the vast amount of information available online for statistical analysis (Cardenas Rubio, 2020). Furthermore, Chiarello et al. (2021) demonstrated that with scientific publications available online and text mining techniques, it is possible to increase the quality of existing skills frameworks.

Given the relative infancy of the Industry 5.0 concept, there is no available dictionary or taxonomy specifically designed for studying this phenomenon at present. The absence of a dedicated dictionary or taxonomy for studying Industry 5.0 presents a significant challenge for researchers, analysts and policymakers. As a result, efforts to understand, monitor, and strategically respond to the Industry 5.0 transformation face additional complexities due to the unavailability of a defined set of terms and categories. Developing such a taxonomy could greatly enhance the accuracy and efficiency of research focused on Industry 5.0. For this reason, it is imperative to build such a dictionary/taxonomy.

3.2 Using LLMs to develop an Industry 5.0 dictionary.

Natural language processing (NLP) techniques and online sources of information have proven to be valuable tools in analysing and extracting information from text data. However, it is important to acknowledge their limitations when identifying patterns in a body of text. One of the main challenges is the reliance on the quality and quantity of data used to train machine learning models. Insufficient or biased training data can lead to inaccurate or incomplete pattern recognition (Chiarello et al., 2021; Pejic-Bach et al., 2020). Additionally, these techniques may struggle to understand the context, subtleties, and nuances in human language, making it challenging to capture complex patterns accurately (Qaiser and Ali, 2018; Vijayarani et al., 2016). Furthermore, the dynamic nature of language and the evolving use of slang, jargon, and cultural references pose additional difficulties for these techniques.

For instance, traditional NLP techniques would encounter significant difficulties in extracting valuable information from some online sources (such as job vacancy postings) due to the complex patterns and variations present in the text. For example, a requirement like “experience with CRM software” might pose challenges for NLP if it misinterprets “CRM” as an unfamiliar acronym rather than understanding it as customer relationship management (Cardenas-Rubio and Grybauskas, 2023). Consequently, careful consideration and validation are required when using machine learning and text-mining techniques to identify patterns in a text. Results need to be interpreted with caution and verified through human analysis. The diversity of expressions used to describe Industry 5.0 further exacerbates these challenges, as there are countless ways in which this phenomenon can be articulated in the different sources available.

Under this context, large language models (LLMs) are a promising technology that can help to overcome the challenges of identifying job characteristics related to Industry 5.0 in text data. LLMs work by being trained on vast amounts of text from diverse sources, such as books, articles, websites, and other textual data. This training allows LLMs to learn the statistical patterns and relationships between words and phrases (Zhao et al., 2023). LLMs, such as GPT-3, have demonstrated impressive capabilities in natural language processing and understanding context. They can analyse and generate human-like text, which makes them well-suited for extracting and comprehending complex information from diverse sources, including job postings, resumes, and other labour market data. Moreover, LLMs can capture the nuanced relationships between words and phrases, enabling them to recognise variations and synonyms (Wang and Cho, 2015). Their ability to generate coherent and contextually appropriate responses allows for more identification of accurate job characteristics.

LLMs can analyse vast amounts of text data, including job postings, industry reports, and professional profiles, to identify emerging job titles, responsibilities, and required skills associated with new phenomena such as Industry 5.0. Unlike traditional text mining algorithms, LLMs can capture nuanced meanings, identify context-specific phrases, and provide more accurate and meaningful insights. By understanding the context and patterns in the text, LLMs can recognise key terms and phrases related to advanced technologies which may be central to Industry 5.0 and potentially other phenomena in the labour market. Additionally, LLMs can provide insights into the interdisciplinary nature of Industry 5.0 companies and jobs, highlighting the need for a combination of technical, creative, and human-robot collaboration.

4 Methodology: Mapping Industry 5.0.

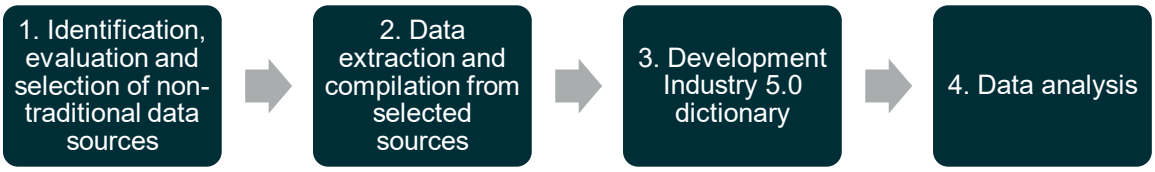
4.1 Four steps.

Our approach involved four steps (**Figure 2**). The first step involved identifying, evaluating and then selecting non-traditional data sources for the analysis. The focus was on non-traditional data sources related to jobs and companies, particularly those pertinent to the principles of Industry 5.0. For example, online job advertisements provide an indication of which positions prioritise well-being, as evidenced by features such as a friendly work environment and social support mentioned in the job description. Once potential sources are identified, a meticulous evaluation of these sources was conducted. This involved a mix of visual inspection and technical arrangements, such as the implementation of web scraping techniques and use of APIs to acquire the data. From this evaluation, we then prioritised sources which offered more detailed and relevant information (see Section 5.1).

Subsequently, having identified and selected primary sources, in the second step, we employed diverse methods such as web scraping and natural language processing to extract and compile the data.

The third step was data analysis related to pattern mapping, company categorisation and company practices identification, leading to the development of an Industry 5.0 dictionary. With the collected data from the selected databases, text mining techniques and an AI model were used to map patterns closely linked to the principles of Industry 5.0.[4] Thereafter, we pinpoint companies that align most closely with Industry 5.0—those, for instance, emphasising job quality or well-being in their job advertisements or company mission. Following this identification, we analyse the skills sought by these companies. The rest of this section explains in more detail each of the methodological steps conducted.

Figure 2: Methodological steps for mapping and analysing Industry 5.0



[4] An AI autoregressive causal language model based on transformers was employed to identify text patterns (companies' practices). This model functions by taking a sequence of words as input and iteratively predicting the subsequent word(s) in the sequence (see section 5.2).

4.2 Identifying and evaluating data sources.

Non-traditional data sources are useful for analysing rapid changes in the labour market. These sources include social media, online forums, websites, satellite imagery, and other unconventional data repositories. We focus our research on online websites and non-traditional data repositories (such as audiovisual sources and websites). Specifically, we identified and evaluated the following sources as they have been used in the literature to analyse companies and job profiles (Cárdenas-Rubio, 2020; Zide et al. 2014; Gionchetti, 2022; Jha and Verma, 2024).

- **Companies' websites**: A direct approach to obtaining data on companies' profiles and assessing their alignment with Industry 5.0 involves searching directly on each company's website to gather information such as mission and vision statements. However, this method can be resource-intensive. With thousands of companies in each of the selected countries, developing a web scraping algorithm for each website becomes necessary. These algorithms need to be versatile enough to comprehend the distinct structures of various websites and efficiently extract unstructured information. Additional considerations include customising the algorithm to handle diverse website structures, addressing dynamic content, and scalability planning (i.e., the ability to process large amounts of data). In light of the aforementioned challenges and the existence of more cost-effective alternatives for obtaining similar information (such as stock exchange companies, online recruitment websites, etc.), the direct collection of data from companies' websites was deemed impractical. One alternative approach to gather this data is by using platforms that aggregate and compile information on company profiles.
- **Professional platforms:** Professional platforms typically refer to online platforms or networks designed for individuals to connect, collaborate, and engage in a professional context. These platforms are used for various professional needs, ranging from job searching and networking to skill development and knowledge sharing. Some of the most well-known professional platforms include LinkedIn[5] and Glassdoor.[6] These platforms aggregate and consolidate comprehensive information about company profiles. Therefore, obtaining data from these platforms can be an efficient method for accessing insights into companies' adherence to Industry 5.0 principles.
- **Online job portals (for companies' profiles**): Job portals are online platforms that connect job seekers with employers. These websites serve as centralised hubs where companies post job vacancies, and individuals search and apply for

[5] A widely used professional networking platform, LinkedIn allows users to create and maintain professional profiles, connect with colleagues and peers, and explore job opportunities. It serves as a hub for professional networking, industry discussions, and knowledge sharing.

[6] Glassdoor serves as a comprehensive online platform, providing invaluable insights for job seekers and employees seeking information about potential employers. Users can anonymously review and rate companies, offering perspectives on crucial aspects such as work culture and management. The platform goes beyond employee reviews, aggregating salary data to furnish details on average salaries across various roles and industries. Additionally, Glassdoor provides information about companies' mission, vision, size, and CEO approval ratings, enhancing the depth of knowledge available to users exploring career opportunities.

relevant positions. Companies also provide a description of their business on these portals (e.g., mission, vision, size, etc.). As with professional platforms, collecting information from online job portals provides a valuable avenue for gaining insights into companies' adherence to Industry 5.0 principles. To implement this approach effectively, the development of algorithms capable of reading and extracting relevant information from these job portals becomes imperative (Cardenas-Rubio, 2020). Since the number of job portals is relatively manageable, and the potential to obtain information spans a broader spectrum of companies, this option stands out as a viable method for analysing Industry 5.0 characteristics.

- **Online job portals (vacancies):** As previously mentioned, online job portals serve as hubs where companies post job vacancies, and individuals search and apply for relevant positions. On these websites, employers provide detailed information about job characteristics and application requirements for specific positions. Therefore, by scrutinising the details of job vacancies, whether an employer emphasises Industry 5.0-related concepts to capture the attention of job seekers can be discerned. Such analysis can give an indication as to whether or not employers consider Industry 5.0 characteristics relevant to their vacancies.
- **Social media platforms:** Facebook and X stand out as possible sources of data to gain insights about Industry 5.0 characteristics given their large number of users (companies and people) and ability to capture what might be seen as “trending”. However, analysing Industry 5.0 characteristics using Facebook and X as primary sources presents several challenges and limitations. Facebook and X are primarily designed for personal/social interactions. Information shared on Facebook and X may not necessarily reflect the professional or business-related aspects inherent in Industry 5.0. Users on these platforms are more inclined to share personal experiences, opinions and lifestyle choices, rather than detailed professional insights. Industry 5.0 analysis requires substantial and detailed business-related information, hence Facebook and X may not be suitable for this type of extraction. Moreover, accessing data from Facebook and X typically involves costs related to data extraction tools, software, or services that facilitate the collection of data at scale. These costs can vary based on the complexity of the data extraction process and the volume of data needed. While both platforms provide application programming interfaces (APIs) for data access, there are limitations on the types and volume of data that can be retrieved. Certain data, especially user-specific information, may be subject to restrictions to protect user privacy. Finally, communication on Facebook and X tends to be informal and may lack the depth and technical precision required for a comprehensive analysis of Industry 5.0 characteristics. For these reasons Facebook and X platforms were not considered for analysis of Industry 5.0.
- **YouTube** also emerges as a valuable source for gaining insights into Industry 5.0, primarily due to its extensive collection of conference videos and presentations. This platform hosts content featuring industry experts, researchers, and practitioners who share their knowledge and perspectives on the evolving landscape of Industry 5.0. Analysing these videos not only provides access to diverse content, including keynote speeches and panel discussions, but also allows for real-time updates on the latest developments within this industrial

paradigm. The visual context offered by video content also enhances the understanding of complex concepts associated with Industry 5.0, and YouTube's global reach ensures access to worldwide content. While YouTube may not replace traditional scholarly sources, it serves as a dynamic and accessible complement, offering a unique perspective and facilitating a nuanced exploration of the transformative technologies and discussions associated with Industry 5.0. Moreover, these videos often introduce a distinct "vocabulary" or "terminology" that enhances the understanding of terms intricately linked to Industry 5.0. Given its easy access, YouTube conference videos are used to get insights about Industry 5.0.

- **Stock exchange companies' information:** Stock exchanges provide important financial sources to companies. To attract new investors and shareholders, companies need to provide clarity on how they perform. Stock-listed companies are obliged to provide timely information to their shareholders. The kind of information that these companies need to provide is highly regulated. Stock exchanges may require different information from their listed companies. The most basic information that companies provide is in their annual reports. In practice, companies follow a quarterly reporting scheme to their shareholders. The content of the annual reports will be highly comparable between the companies on a specific stock exchange, but companies may provide more information than is strictly necessary. Over time, public authorities have been keen to request more information from companies. A last information push is the request to provide information on sustainability, social and governance (ESG) efforts. The Corporate Sustainability Reporting Directive requires companies in the EU to comply with this non-financial reporting directive. About half of the companies listed in the EU need to comply to this CSRD. The amount of information available on companies is quite vast and this has led to the growth of specialised companies providing insight into the performance of companies. ESG information is provided by more than a dozen of companies, each with very different methods for assessing performance. The annual and other reports of these listed companies provide substantial (and high-quality) data on the performance of a lot of companies. However, the number of companies of stock-listed remains limited to several thousand in Europe. This remains a small selection of companies included in the other activities of this report.
- **Collective agreements:** Collective agreements are deals negotiated between employee representatives (trade union delegates, staff delegates) and employers. These discussions take place at different levels, such as establishment, company, group or sector. The main purpose of these negotiations is to set working conditions, working time regulations and pay levels. The agreement takes the form of a text with a series of clauses expressing the mutual consent of negotiations which is signed for a defined period. It is designed to build an alignment between the views of employers and that of employees. In this context, involving workers in discussions about the introduction and use of new technologies in the workplace ensures that these technologies are better adapted to their needs, and that job security and skills development are better planned. These discussions aim to establish a compromise on how new technologies are deployed in the workplace, which directly reflects a human-centred approach. Spotting company agreements

that mention Industry 4.0 technologies would enable us to identify companies that negotiate around the adoption and use of these technologies. Then, by carrying out textual analyses of these agreements, it becomes possible to deduce more precisely what they contain about the uses of new technologies and to observe in more detail which companies are moving closer to Industry 5.0 and in what way. Furthermore, when collective agreements are concluded at the company level, this non-traditional source of information can be combined with structured sources providing data on the specific characteristics of these companies.

- **Academic journal database (Scopus):** Academic journal databases are comprehensive repositories of scholarly articles and research papers from various disciplines. These databases provide a centralised and organised platform for researchers, students, and academics to access a vast array of peer-reviewed articles, book chapters, and conference proceedings. Academic journal databases typically include search functionalities and advanced filters to facilitate targeted searches based on keywords, authors, publication titles, and subject areas. These sources of information have been used to gain insight into Industry 4.0 (Kipper et al. 2020; Sikandar et al. 2021; Da Silva 2020). Consequently, they could also be used to get some insight into the Industry 5.0 from an academic perspective.

Following the evaluation exercise, seven types of sources were included in the analysis. These can be grouped into two categories: content created exclusively by the company (company-created content) and content created by or together with actors or stakeholders (non-company-created content).

Figure 3: Data sources for inclusion after identification and evaluation[7]

Company-created content	Non-company-created content
• Professional platforms • Online job portals (for companies' profiles) • Online job portals (vacancies)	• Company stock exchange data • Collective agreements • Academic journals database (Scopus) • YouTube videos

The analysis of this first group of sources (company-created content) can suffer from potential incompleteness and bias inherent in companies curating their online content to present a carefully crafted image (e.g., greenwashing[8]). This self-presentation may not faithfully reflect the comprehensive reality of their adherence to Industry 5.0 principles, introducing the risk of selective or biased information. Complementing the

[7] Company stock exchange data is 'market information'. However, the annual and quarterly reports are company created. ESG-information is company created, but selected by ESG-companies.

[8] This is less the case with stock information. While companies may portray themselves as more committed to the green transition than they actually are, this is less likely on stock exchanges where they can be severely punished for providing false information. Although companies may withhold some information, they still need to attract investors and often provide more information than their competitors.

analysis with the second group of sources (non-company created content) serves to incorporate company information that does not rely solely on self-representation, ensuring a more balanced and comprehensive understanding. This process will also show what works best for analysing Industry 5.0 companies' practices.

In sum, incorporating these diverse sources allows a comprehensive analysis of different perspectives of Industry 5.0, and allows the study to gain insights from various stakeholders including academics, employers, and jobseekers. This approach aims to strike a balance between self-reported and non-self-reported information, ensuring a well-rounded understanding of the phenomenon.

4.3 Data retrieval.

Different methods were applied to access to the information. Table 1 briefly describes the data sources used for this project.

Various methods were employed to gather information for this project, as outlined in Table 1. These methods included: 1). Web scraping: This is an automated process used to extract data from websites. It involves the use of software tools or scripts to access web pages, automatically parse their HTML or other markup languages, and extract specific information for further analysis or use; 2). Online search using website services: some websites provide search engines that facilitate the search and download of information. In such cases, web scraping techniques are unnecessary, as these websites already offer tools to download the requested information.

Professional platforms:

As mentioned earlier, the chosen professional platform for this project is Glassdoor. Web scraping techniques were employed to download the necessary information from this platform. While it would have been ideal to scrape data from all companies listed on the website, this proved impractical due to the large number of companies (over 170,000 in the UK alone) and the limitations of available resources.

To address these constraints, a decision was made to select a subset of companies for downloading randomly. The number of companies downloaded was determined based on the available time and the website's processing speed. Additionally, since each country analysed has its own Glassdoor platform, four separate algorithms were developed to download the corresponding information.

After the sample of information was downloaded, standard cleaning steps were implemented to organise the data. These standard cleaning procedures involve several steps to ensure the data is accurate and usable. Firstly, the data was checked for duplicates and inconsistencies. Next, data formatting issues, such as inconsistent date formats or variable types, were corrected to ensure uniformity. Overall, these cleaning procedures were essential for preparing the data for further analysis and ensuring its quality and reliability.

Online job portals:

The Austrian government makes available several lists[9] of online job portals and search engines. The lists are publicly available, and there are no restrictions on scraping and using their data. However, not all of them served as relevant sources for our objective. Therefore, to identify useful sources of company profiles and job vacancies, we assessed all sites given in the list of general job sites (*Allgemeine Jobbörsen und Jobsuchmaschinen*) in terms of the type of content they offer, the number of job listings, and the extent to which the page structure would facilitate scraping data from the sites.

Based on the assessment, we decided to scrape job-related and (where available) company-related data from *finden.at*[10], *Der Standard*[11] and *Stepstone*[12]. The chosen sites typically have the same page structure through the job and company pages, facilitating data extraction process by a scraper. For each site, a custom web scraper was implemented in Python[13]. Each scraper can navigate through the corresponding site, obtaining information on job listings and company details. The scrapers work by downloading the HTML page source using the Requests[14] or Selenium[15] packages, analysing it with the Beautiful Soup[16] package to extract structured data from the raw page source. Due to recurring difficulties with scraping Stepstone combined with needing more company data, we later added *karriere.at*[17] as an additional source of company profiles. The scraper for this site primarily concentrates on the company pages, following the same technical implementations as the other sites described above. Upon implementation, the crawlers were run daily to scrape all newly added data. Minor adaptations to the scrapers were needed depending on page reconstructions or changes in the sites. The obtained data were stored in SQLite[18].

The process of collecting vacancy databases for the UK, France, and Austria followed similar steps. In the UK, we scraped main job portals, including Reeds[19], Indeed[20] The

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9 https://www.oesterreich.gv.at/themen/arbeit_beruf_und_pension/jobsuche/jobboersen_und_stellenangebote.html

10 https://www.finden.at

11 https://jobs.derstandard.at

12 https://www.stepstone.at

13 https://www.python.org

14 https://requests.readthedocs.io

15 https://selenium-python.readthedocs.io

16 https://www.crummy.com/software/BeautifulSoup/

17 https://www.karriere.at/firmen

18 https://sqlite.org

19 https://www.reed.co.uk/

20 https://uk.indeed.com/

Guardian[21] and Monster[22], while for France, Emploi[23], we targeted Indeed[24] and Candidat[25]. These selections were based on the portals' widespread recognition within each country and their substantial volume of information, ensuring a comprehensive snapshot of employer requirements. Additionally, for the Netherlands, we acquired data from Jobdigger[26], a company that aggregates vacancy data from numerous job portals across the country. This approach enabled us to gather comprehensive and reliable data sets for analysis across multiple regions. However, it is important to acknowledge that while collecting these sources of information, the primary aim is to gain insights into employers' practices. As highlighted by Cárdenas-Rubio (2020), despite collecting data from various job portals, these sources have inherent limitations. For instance, occupations in agriculture might be underrepresented in online vacancy databases.

Stock exchange companies' information:

We limited our search to the AEX, the Dutch part of the Euronext, and to BCorp listed companies. For the AEX, we collected the last annual report and any report available on ESG-topics. The data has not yet been processed. BCorp-listed companies are a specific form of listing, in this sense that companies present themselves as more socially and environmentally sensitive than other listed companies. We are still at an experimental stage of the research how this kind of information may be helpful to our purposes.

Contract agreements:

We used the Légifrance French legal and regulatory text dissemination site (https://www.legifrance.gouv.fr/), which has been publishing all company agreements signed since September 2017. The site provides structured information, which we used to create an initial database. It provides the following coded information: the industry code, the company name and corresponding unique French identification number, the agreement title, the affiliation of the agreement signatories, the dates of signature and application, and the negotiation themes according to a classification determined by Légifrance.

In addition, every collective agreement is available in Word format. To download each Word document, we developed an algorithm capable of automatically retrieving and saving them. In total, 156,264 collective agreements spanning from 2017 to 2023 were downloaded. This figure corresponds to the total number of collective agreements available on the website service-public.fr at the time of data collection. With this

[21] https://jobs.theguardian.com/

[22] https://monster.co.uk/jobs/

[23] https://emploi.lefigaro.fr/

[24] https://fr.indeed.com/

[25] https://candidat.francetravail.fr/

[26] https://www.jobdigger.nl/

information we created a second database from the texts of company agreements signed between September 2017 and July 2023 mentioning Industry 4.0 technologies. To do this, we put together a dictionary of words relating to Industry 4.0 technologies. Then, we extracted the paragraphs of the agreements that mention these words, along with the text reference number and the establishment identification number that links to the first database. We can perform various statistical analyses based on texts and their metadata: thematic analysis, calculation of co-occurrences and cosine similarity, k-means, etc.

Academic journal database:

The academic journal database used for this project is Scopus. Scopus is a comprehensive abstract and citation database of peer-reviewed literature, including scientific journals, books, and conference proceedings. It covers a wide range of disciplines, including science, technology, medicine, social sciences, and arts and humanities. Scopus provides access to a vast collection of research literature and offers advanced search and analysis tools to help researchers discover relevant articles, track citations, and assess scholarly impact. It is widely used by researchers, academics, institutions, and organisations for literature review, citation analysis, etc.

The Scopus platform offers a comprehensive service allowing users to gather essential information from academic papers, including abstracts, keywords, paper titles, and more. To acquire pertinent data for our project, we employed the Scopus browser to conduct a targeted search for papers containing the keyword "Industry 5.0." While this approach may impose some limitations, it ensures that the sources obtained are directly relevant to the Industry 5.0 topic. Through this method, we collected a total of 142 (abstract) papers.

Audio-visual sources (YouTube):

We used the search feature on YouTube, entering the keyword "Industry 5.0" to identify conferences related to the topic. These conference videos were subsequently transcribed into text for analysis using text-mining techniques. In total, we analysed 26 conference videos, which collectively spanned over 1,100 minutes.

Table 1: Sources used

Source	Type	Method of collection	Key variables obtained	Period
Professional platforms				
Glassdoor	Website	Web scraping. Companies randomly selected	Companies' descriptions Companies' characteristics People's reviews of companies	Nov - Dec 2023
Online job portals (for companies' profiles):				

Source	Type	Method of collection	Key variables obtained	Period
ReedsUK	Website	Web scraping. All companies collected	Companies' descriptions	Nov - Dec 2023
Stepstone, karriere.at	Website	Web scraping.	Companies' descriptions	Nov - Dec 2023
Online job portals (vacancies):				
Reeds, NHS and the guardian (UK)	Website	Web scraping. Vacancies randomly selected	Job vacancy descriptions	2019-2023
Stepstone, Der Standard, finden.at	Website	Web scraping. Vacancies randomly selected (Der Standard) or all available vacancies (Stepstone, finden.at).	Job vacancy descriptions, employer names and locations	2023
Indeed (France)	Website	Web scraping. Vacancies randomly selected	Job vacancy descriptions	Nov - Dec 2023
Jobdigger (Netherlands)	Company data	Data was purchased from Jobdigger	Job vacancy descriptions	2022-2023
Stock exchange companies' information				
Companies with listing on Euronext	Websites	Downloading yearly reports	ESG policies	2020-2023
ESG-providers (MSCI, Sustainalytics; others)	Websites	Combination of company information and on websites	ESG ratings	2020-2023
Contract agreements				
Public service (Fance)	Website, word files	Web scraping. Most agreements collected	Detailed information about collective agreements	2018-2023
Academic journal database				
Scopus	Online database	Online search (use of website services)	Papers abstracts	2020-2023
Audio visual sources				
YouTube	Website	Online search (use of website services)	Conference scripts	2020-2023

Table 2 provides an overview of the data sources used and their respective purposes.

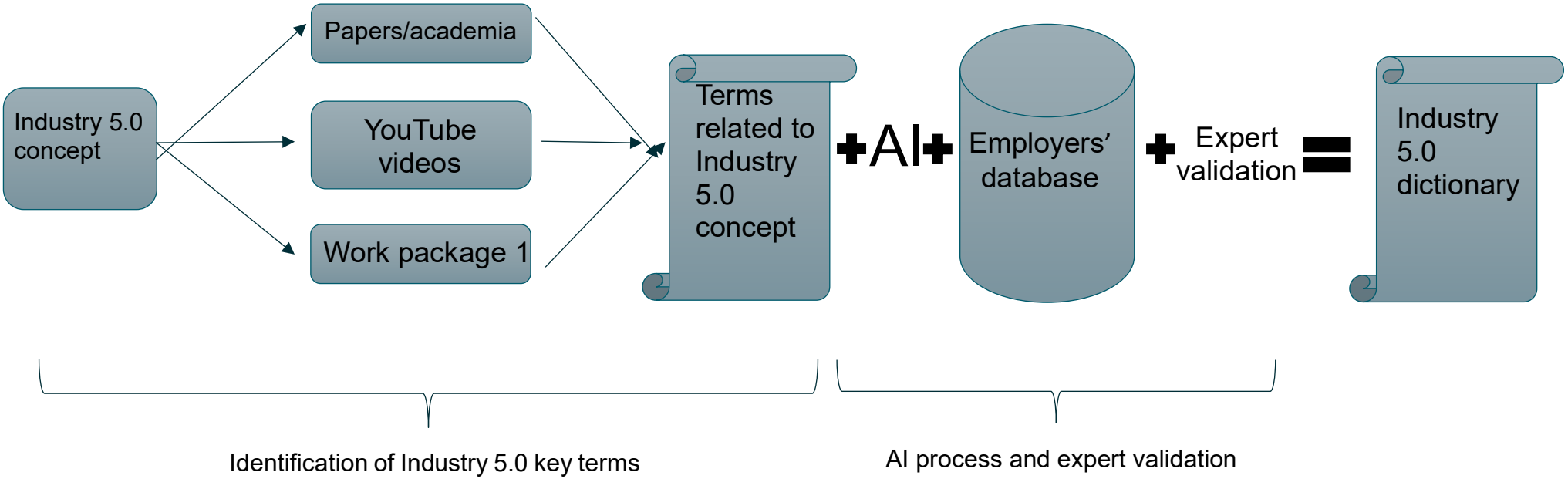
Table 2 Sources used and their respective purposes

Data involved	Development of Industry 5.0 dictionary	Analysis of companies' practices
Online job portals (for companies' profiles)	X	X
Online job portals (vacancies)	X	X
Stock exchange companies' information		X
Contract agreements	X	X
Academic journal database	X	
Audio-visual sources	X	

4.4 Creating an Industry 5.0 dictionary.

As noted above, there a is need for an Industry 5.0 dictionary to facilitate analyse of various research and policy analyses. **Figure *4*** depicts the methodological steps for developing an Industry 5.0 dictionary. The process begins by tapping into the collective knowledge of WP3 members regarding the Industry 5.0 concept. From there, the research team embarks on identifying key terms associated with Industry 5.0, using various sources such as Scopus, audiovisual materials, and more. Subsequently, an AI-driven approach is deployed, complemented by expert validation, to understand how employers express Industry 5.0-related concepts in sources like job vacancies. This methodological approach ensures the development of a comprehensive Industry 5.0 dictionary that accurately captures the intricacies of the subject matter. Further details of the steps conducted are elaborated in the following subsections.

Figure 4: Methodological steps for creating and Industry 5.0 dictionary



4.4.1 Identification of Industry 5.0 key terms.

Having retrieved the data, the first analytical step was to identify the key terms associated with Industry 5.0. WP1 usefully provides conceptual definitions of Industry 5.0but does not utilise empirical data to understand how different Industry 5.0 concepts manifest in different data sources. WP3 builds on WP1 in this regard.

Data from 26 YouTube videos of webinars and conferences from 2020 (spanning over 1,100 minutes) and 142 academic journals (via the Scopus database) were extracted and analysed in order to identify the key terms/patterns that are commonly associated with the Industry 5.0 concept. Specifically, text mining techniques were used to analyse these sources, whereby meaningful words were extracted and analysed. First, the text data were cleaned by removing unnecessary characters and symbols, as well as addressing any formatting issues. For the YouTube videos, an initial critical step involved transcribing the audio content into textual form. By transforming the audio data into a readable format, subsequent text mining and natural language processing techniques to extract meaningful insights from the spoken content were made easier. As with the other text sources, the transcribed text data from YouTube videos was also cleaned and prepared for analysis. Second, texts were “tokenised” into keywords. Tokenising the text into words involves breaking down given text into individual word units for further analysis. Third, ‘stop words’ were removed to facilitate the analysis. Stop words are common words that do not contribute much to the actual meaning of the text and are primarily used to perform lemmatisation (e.g. “a” “the”, “is”, “are”, etc.). And, finally, after formatting the data appropriately, an exploratory analysis was conducted to understand the distribution of words, common phrases, and key patterns in the text data. For the data from academic papers, the same process was applied to the text from the abstract and keywords of each article.

Analysing YouTube videos and academic sources offers insights into the perspectives of stakeholders of Industry 5.0. To complement this, the same text mining techniques were applied to output from WP1. In so doing, a comparison is made between the conceptualisation under this project and external empirical data sources. The results of this analysis are presented in section 5.1. This characterisation provides key terms associated with Industry 5.0 and helps to identify how employers might refer to Industry 5.0 characteristics in the different databases used.

4.4.2 AI process and expert validation

The second step was to implement AI that would learn to identify patterns related to Industry 5.0 from the data sources available (e.g. vacancy database) based on the key terms identified in the previous step. As previously discussed, LLM models such as Open AI and LLaMA (Large Language Model Meta AI) are useful in understanding the different ways in which employers might refer to a concept, in this case, Industry 5.0.

In order to do so, we require at least three elements: the list of concepts associated with Industry 5.0 (from the previous subsection), the database from which the LLM model will search for these patterns; and the LLM model to be used. The data used was web-scraped vacancy data of around 2.1 million observations from the four

countries analysed in this study.[27] The vacancy database served as a testing ground for the model due to its characteristic feature of containing extensive job descriptions. These descriptions potentially encompass a diverse range of terms and patterns associated with Industry 5.0.

In relation to the selection of the LLM model to be used, having considered accuracy, costs and practicalities of computational power, a decision was made to use LLaMA LLMs and their derivatives (Cardenas-Rubio and Grybauskas, 2023).[28] However, initial testing revealed that the original raw LLaMA weights in various sizes (i.e., the model without any calibration/tuning) and the patterns collected in the previous section were insufficient for deducing Industry 5.0 patterns from the vacancy database. This issue was attributed to the lack of fine-tuning for inference in the raw weights (calibration of the machine to specifically "understand" Industry 5.0 related concepts). In order to fine-tune the network of LLM, we followed Zhang et al. (2023) who implemented Efficient Fine-tuning of Language Models (tailoring pre-trained large language models to specific tasks) with Zero-init Attention (LlaMA-Adapter). This approach reduces the computational cost and memory requirements of the fine-tuning process and improves the results of the LLM.

To fine-tune the LLM, we used the patterns identified in the section 5.1 and manually classified around 2,000 examples extracted from the (scraped) vacancy databases for the four countries analysed. These patterns and examples were fed into and trained on the Alpaca 13B model for multiple epochs, leading to a more stable and refined model. It is important to note fine-tuning provides the LLM with a framework for self-discovery within the boundaries of the search space, allowing it to conceptualise and converge based on empirical data. This process does not involve precise word matching but rather a conceptual exploration. As a result, the fine-tuned model captures a broader spectrum of patterns compared to those included in the manually collected data.

The LLM found over 500k raw phrases and words that could be associated with Industry 5.0 from the 2.1 million job vacancies obtained via web scraping. The extracted patterns were further cleaned, resulting in short sentences of employers' benefits, like the following: "Catered lunch every day and regular drinks", "Company culture focused on the well-being and work-life balance'', "Inclusive culture with progressive well-being support", "Fair employment practices" and so forth. However, by visually inspecting many phrases, many sentences were duplicated, not very informative or were less meaningfully related to the Industry 5.0 concept (e.g., "Regular travel activities and customer contacts", "compact team", "Long-term job" etc.). Thus, it was decided to first eliminate those duplicated patterns. Second, we use a bottom-up approach to group the patterns according to their meaning into two-level dimensions (major groups and minor subgroups). This process enables us to identify,

[27] This data was collected in an initial stage of the project and serve as input to identify Industry 5.0 patterns. The vacancy analysis presented in section 5.4 encompasses a larger number of job vacancies, as the data collection for vacancies continued beyond the initial stage.

[28] The LLaMA weights are available in various sizes, including 7B, 13B, 33B, and 65B parameters. These weights represent the number of adjustable parameters used during model training. While larger models offer increased accuracy, they require extensive computational power, making them costly and less practical for consumer devices.

analyse, and eliminate pattern groups that are not relevant to the concept of Industry 5.0. Initially, the first layer of grouping utilised the all-MiniLM-L6-v2 model with cosine similarity for clustering, resulting in 3811 clusters.[29] In the second layer of clustering (major groups), the idea was to create topics for each cluster. Thus, each sentence phrase was vectorised using the Term Frequency – Inverse Document Frequency (Tf-Idf) method and clustered using k-means. This process resulted in the assignment of a topic to each cluster, ultimately leading to the creation of seven major groups.

The resulting 3811 cluster topics helped us to understand each cluster's content. Many duplicates and less meaningful phrases to human-centric dimension existed that needed to be removed. Thus, we attempted batch elimination by manually inspecting the topics that were not relevant, which resulted in 24k sentences. Afterwards, by sorting the received 24k topics, a clear pattern emerged that some keywords were solely health, finance or other topic-focused.

Lastly, the data-driven results underwent validation and refinement by experts from WP1. This validation process entailed manually reviewing the 24k patterns and their corresponding clusters identified by the LLM. The experts identified additional patterns for removal and suggested adjustments to the grouping structure. The final result of this process is an Industry 5.0 dictionary composed of 12,257 patterns with 31 clusters (minor groups).

[29] The MiniLM-L6-v2 model generates document embeddings (numerical representations of texts), computes cosine similarity scores between pairs of documents, and then it is used clustering algorithms to group similar documents together based on these scores.

5 Analysis.

5.1 Characterising Industry 5.0 key terms.

WP1 offers a conceptual discussion of Industry 5.0, provides a plausible understanding of its pillars and their interrelationships, and usefully establishes a multidimensional framework that facilitates the examination of workforce skills (Oeij et al., 2024). It also highlights that Industry 5.0 is a complex multi-dimensional concept. What WP1 has so far been silent on in its conceptualisation is sufficient details on how different dimensions of Industry 5.0 are operationalised in the data. For example, while WP1 emphasises human-centricity as a pillar of Industry 5.0, the challenge lies in defining how we determine whether a company, occupation, etc., is well aligned with Industry 5.0 in this dimension. The text mining analysis from WP3 deepens our understanding in this regard.

As discussed in the methodology section (section 4.3), text mining techniques were applied to data extracted from YouTube videos (webinars and conferences) and academic journals (via the Scopus database), and then compared with the text presented in output from WP1. **Figure *5*** displays three word clouds, each highlighting the most frequently occurring words in different data sources, and compares this to the conceptualisation of Industry 5.0 from WP1.

Figure 5: Word clouds illustrating common words associated with Industry 5.0 by data source, with WP1 as a comparison

Source: Author illustrations.

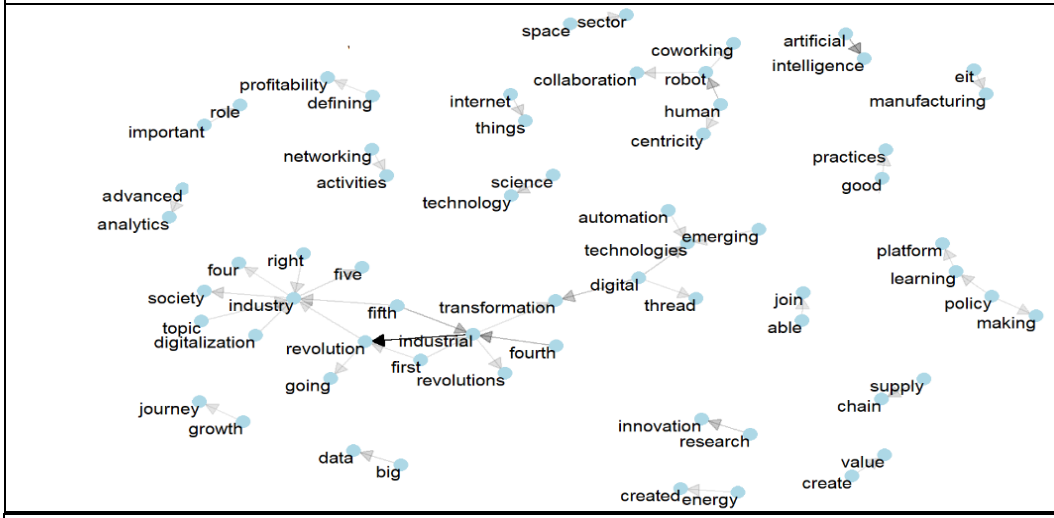
As expected, the most dominant word in all three figures is “Industry”. Words such as “human”, “people”, “digital”, “technology”, “manufacturing”, “industrial” and “work” appear in both the data from the YouTube webinars and the academic articles retrieved from Scopus. From this, we can infer that the sample of industry experts, researchers, and practitioners included in these sources perceive people, work, technology and industrial sectors like manufacturing to be integral to Industry 5.0. What is also noteworthy is that the other two core principles of Industry 5.0

(sustainability and resilience) are not mentioned with as much frequency as words like “human” and “people”, reinforcing our proposition that the human-centricity component of Industry 5.0 is indeed one of the key things that make the approach stand out. The text from WP1 also highlights similar words to the data from YouTube videos and Scopus, but also brings to the fore the term “skills” and thus the need for skills to be part of conversations around Industry 5.0 – especially given the focus on people.

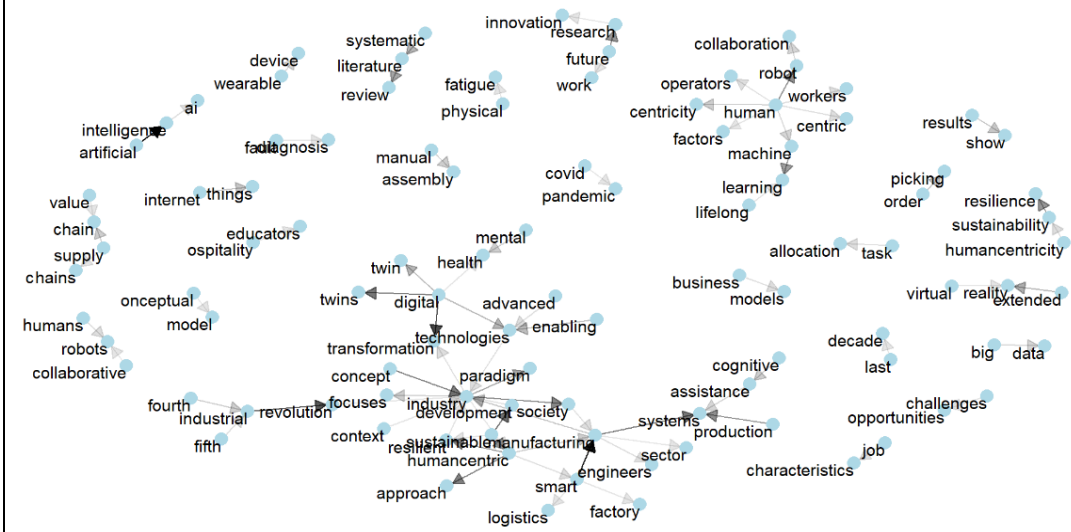
Figure *6* shows the correlation between words mentioned in the texts and highlights the emergence of different patterns. From the YouTube data, the term “human” is commonly used with words like “collaboration”, “coworking”, and “robot”. Similar words are associated with “human” from the Scopus data, in addition to terms like “operators”, “workers” and “machine learning”. Together, we can see the human-centricity aspect of Industry 5.0 being associated with both humans and automation (robots and machine learning), while recognising important concepts like collaboration and coworking. In both the Scopus data and the WP1 output, we also see the linking of the three Industry 5.0 concepts (human-centricity, sustainability and resilience), though there is less of an observed linkage between these three terms in their usage in webinars and conferences on YouTube. These key concepts and linkages are shown in **Figure *6*** will be used in the section 5.2 to build an Industry 5.0 dictionary that allows identifying which companies/jobs are more aligned to the Industry 5.0 paradigm. Patterns such as human-centricity, sustainability, technological advancements, smart manufacturing, collaborative robotics (cobots), augmented reality (AR), human-machine collaboration, diversity, equity, inclusion, work-life balance, etc. were identified through this analysis.

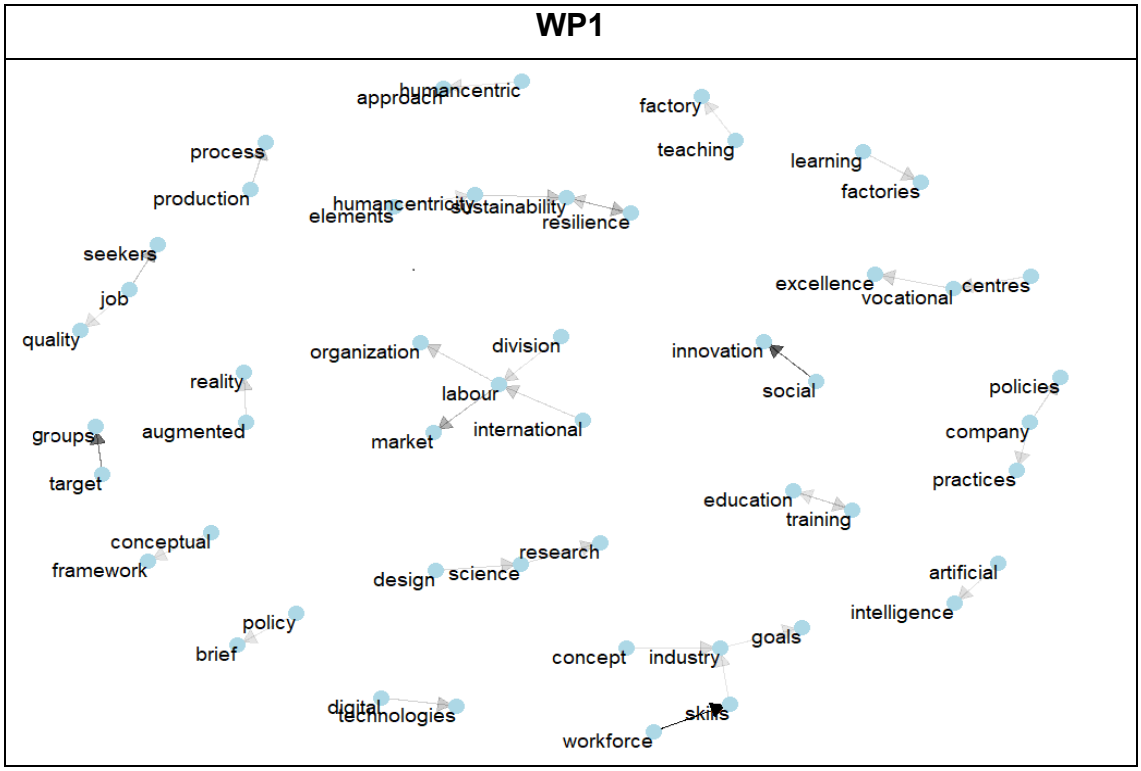
Figure 6: Pattern mapping of correlation between words mentioned in the texts

Webinars/conferences



Scopus




WP1
humancentric
approach
factory
process
teaching
learning
production
factories
humancentricity
sustainability
elements
resilience
seekers
excellence
centres
vocational
job
quality
organization
division
innovation
reality
labour
social
policies
groups
augmented
international
market
company
target
practices
education
training
conceptual
framework
research
design
science
artificial
intelligence
policy
brief
goals
concept
industry
digital
technologies
skills
workforce

5.2 An AI approach to the Industry 5.0 dictionary.

Having applied the AI-driven methodology displayed in Table 3, we obtained 24,000 patterns/phrases from the 2.1 million job vacancies analysed, which the AI-process suggested as Industry 5.0 patterns. These patterns were grouped using a two-level bottom-up approach. The initial layer of clusters (minor groups) comprises 36 groups that categorise the 24,000 patterns based on their semantic meaning. For example, the A1_atmosphere minor group includes patterns such as "Family-friendly conditions," "Family-friendly environment," "Family-like atmosphere," and so forth. Moreover, for a more aggregate analysis, the minor groups were grouped into seven major groups based on their semantic meaning. These groups were categorised as follows: A – self realisation, B – Empowerment, sustainability, C–Infrastructure, safety, D – Work-format, atmosphere, E – Finance, F Health, Nutrition and G – Leisure, vacation (see Table 3).[30] Each of these major groups is composed of minor clusters. For instance, A – self-realisation is composed of second-level categories including A1 – atmosphere, A2 – impact, A3 – yourself, etc.

This initial output offers insight into the frequency of Industry 5.0 phrases or patterns found within a database, such as the vacancy data. However, to obtain the final Industry 5.0 dictionary, further examination and refinement were necessary. This process involved scrutinising and validating the identified phrases/patterns to ensure accuracy and completeness.

Table 3: AI mapping of Industry 5.0 patterns within job ads

Level1 (major group)	Level2 (minor group)
self-realisation	A1_atmosphere
self-realisation	A2_impact
self-realisation	A3_yourself
self-realisation	A4_recognition
self-realisation	A5_courses_seminars
self-realisation	A5_career_training
self-realisation	A6_budget
self-realisation	A7_assistance
Empowerment, sustainability	B1_social
Empowerment, sustainability	B2_enviroment
Empowerment, sustainability	B3_future_proof
Empowerment, sustainability	B4_future_oriented
Empowerment, sustainability	B5_decision
Empowerment, sustainability	B6_comminication
Empowerment, sustainability	B7_collective
Empowerment, sustainability	B8_nobias
Empowerment, sustainability	B9_diverse
Infrastructure, safety	C1_state
Infrastructure, safety	C13_amenities

[30] Note that the authors manually assigned these labels based on the meaning of the minor clusters within each major group.

Level1 (major group)	Level2 (minor group)
Work_format	D1_remote_degree
Work_format	D2_onsite
Work_format	D3_expected
Work_format	D4_scheduling
Work_format	D5_flextime
Work_format	D6_style
Work_format	D7_motivated
Work_format	D8_caring
Work_format	D9_informal
Finance	E1_transport
Finance	E2_allowance
Finance	E3_bonuses
Finance	E4_pension_scheme
Finance	E5_pension_contribution
Finance	E6_social_benefits
Finance	E7_equity
Finance	E8_profit_sharing
Finance	E9_savings
Health, Nutrition	F1_health_plans
Health, Nutrition	F2_elderly_disabled
Health, Nutrition	F3_programs
Health, Nutrition	F4_proactive_measures
Health, Nutrition	F5_drinks
Health, Nutrition	F6_meals_discounts
Leisure, vacation	G1_sports_fitness_discounts
Leisure, vacation	G2_outings
Leisure, vacation	G3_events_work_life_balance
Leisure, vacation	G4_facilities_sports
Leisure, vacation	G5_vacation

5.3Expert validation.

Importantly, as the final step, experts from WP1 manually reviewed and validated the outcomes from the data-driven process presented in Table 4. This validation occurred in two phases: initially, a comprehensive check was conducted to understand the content of the lines, involving recoding or disaggregating the groups. A total of 10,176 (42%) of the original codes underwent recoding. Notably, 56% of these recodes (5,730) were assigned new codes during the second recoding phase. These changes were necessary as some categories were overly general and required more specificity. For instance, the code “A22_atmosphere” was a major code, which we further divided into four distinct categories: a family atmosphere, a growing company, a human-centric culture, and a professional category. The first column of Table 4 shows the clustered result after the expert manual inspection.

In the second stage, we conducted an evaluation to ascertain the alignment of the identified clusters with organisational practices. The assessment results are presented

in Table 4 below. The assessment indicates that not all categories identified by the LLM model have to do with organisational practices (second column of Table 4). Some of the patterns identified are related to the characteristics of the job vacancy (e.g., contract type, amenities offered, allowances, etc.); tasks (e.g., partnering with stakeholders, arranging courses/training for employees); requirements (e.g., basic IT skills, possibility for beginners, strong knowledge in specific areas, etc.). Moreover, we found that some organisational practices are not strongly related to Industry 5.0 (e.g., opportunity to join a growing company, bonuses depending on company and team results). Importantly, we also found organisational practices that are negatively related to human-centricity or are "Non-Industry 5.0" (busy schedule, holding weekend sessions, repetitive activities) (See fourth column of Table 4). As seen in the table, the code with the most frequent results is "B31_career" that is offered. Within organisation practices, "B33_training" is the largest code.

Table 4: WP1 Expert assessment of category

Cluster classification	Number of phrases	Type of pattern	Category	Degree of relation
A11_atmosphere_family	128	Organisation practice	Industry 5.0	Some
A12_atmosphere_grow	133	Organisation practice		No relation
A13_atmosphere_human	169	Organisation practice	Industry 5.0	Strong
A14_atmosphere_professional	133	Organisation practice		No relation
A21_impact	82	Organisation practice	Industry 5.0	Strong
A31_yourself	1879	Requirements		No relation
A32_recognition	294	Vacancy characteristic		No relation
A41_courses_seminars	775	Organisation practice	Industry 5.0	Medium
A51_budget	168	Organisation practice	Industry 5.0	Medium
A52_assistance	401	Task		No relation
B11_social	40	Organisation practice	Industry 5.0	Strong
B12_enviroment	59	Organisation practice	Industry 5.0	Strong
B21_future_proof	213	Organisation practice	Industry 5.0	Some
B22_future_oriented	29	Requirements		No relation
B31_career	3820	Vacancy characteristic		No relation
B32_decision	359	Organisation practice	Industry 5.0	No relation

Cluster classification	Number of phrases	Type of pattern	Category	Degree of relation
B33_training	3113	Organisation practice	Industry 5.0	Medium
B34_comminication	107	Organisation practice	Industry 5.0	No relation
B41_collective	135	Vacancy characteristic		No relation
C11_nobias	120	Organisation practice	Industry 5.0	Strong
C12_diverse	78	Organisation practice	Industry 5.0	Strong
C13_state	321	Vacancy characteristic		No relation
C14_amenities	59	Vacancy characteristic		No relation
D11_remote_degree	732	Organisation practice	Industry 5.0	Some
D21_onsite	19	Vacancy characteristic		No relation
D31_expected	185	Task		No relation
D41_scheduling	177	Vacancy characteristic		No relation
D42_flextime	49	Vacancy characteristic		No relation
D51_style	326	Organisation practice	Industry 5.0	Some
D61_motivated	828	Organisation practice	Industry 5.0	Some
D62_caring	1944	Organisation practice	Industry 5.0	Some
D71_informal	77	Organisation practice	Industry 5.0	Some
E11_allowance	585	Vacancy characteristic		No relation
E12_pension_scheme	181	Organisation/Vacancy characteristic	Industry 5.0	Some
E13_bonuses	1042	Vacancy characteristic	Non-Industry 5.0	Negative
E14_pension_contribution	77	Organisation/Vacancy characteristic	Industry 5.0	Some
E16_social_benefits	70	Vacancy characteristic		No relation
E21_equity	160	Organisation practice	Industry 5.0	Some

Cluster classification	Number of phrases	Type of pattern	Category	Degree of relation
E22_profit_sharing	236	Organisation practice	Non-Industry 5.0	Negative
E31_sustainable transport	161	Organisation practice	Industry 5.0	Medium
E32_transport	518	Vacancy characteristic		No relation
E33_phone	20	Vacancy characteristic		No relation
E41_savings	66	Vacancy characteristic		No relation
F11_health_plans	93	Organisation/Vacancy characteristic	Industry 5.0	Some
F21_elderly_disabled	87	Organisation practice	Industry 5.0	Strong
F21_proactive_measures	100	Organisation/Vacancy characteristic	Industry 5.0	Some
F31_drinks	525	Vacancy characteristic		No relation
F41_meals_discounts	1	Vacancy characteristic		No relation
G11_sports_fitness_discounts	636	Vacancy characteristic		No relation
G21_outings	440	Vacancy characteristic		No relation
G22_events_work_life_balance	534	Organisation practice	Industry 5.0	Some
G23_facilities_sports	24	Vacancy characteristic		No relation
G31_vacation	256	Vacancy characteristic		No relation
O11_Gifts	52	Vacancy characteristic		No relation
O21_Health_insurance	82	Organisation/Vacancy characteristic	Industry 5.0	Some
O31_Hierarchy	11	Organisation practice	Non-Industry 5.0	Negative
O41_Job demands	45	Organisation practice		No relation
O51_Perks	190	Vacancy characteristic		No relation
O61_Personal characteristics	104	Requirements		No relation

Cluster classification	Number of phrases	Type of pattern	Category	Degree of relation
O71_Productivity bonus	175	Organisation practice	Non-Industry 5.0	Negative
O81_Recruitment	33	Requirements		No relation
O91_Sector	58	Organisation practice		No relation
O101_Task	403	Task		No relation
O111_Contract	56	Vacancy characteristic		No relation
O121_Educational level	52	Requirements		No relation
O131_Experience – expertise	58	Requirements		No relation

Table 5 provides an overview of the consolidated Industry 5.0 dictionary. It presents the finalised clusters, both major and minor groups, after expert validation. Additionally, the table includes the count of phrases/patterns within each group and provides concise descriptions along with examples.

Table 5: Consolidated dictionary

Major group	Minor group	Number of phrases	Category	Brief description/examples
A-Family-Driven engagement	A11_atmosphere_family	128	Industry 5.0	This group comprises organisations characterised by a strong emphasis on familial bonds, mutual respect, and a welcoming, nurturing atmosphere. They prioritise fostering relationships akin to those found in a family setting, promoting camaraderie, mutual support, and a positive work environment. These organisations often exhibit traits such as friendliness, informality, and a sense of belonging, with an emphasis on personal connections, professional growth, and a shared commitment to success.
A-Family-Driven engagement	A12_atmosphere_human	169	Industry 5.0	This group characterises organisations that foster a positive and empowering workplace culture, where employees are encouraged to grow and thrive. With a focus on teamwork and creativity, employees are encouraged to explore new ideas and approaches to problem-solving.
A-Family-Driven engagement	A13_informal	77	Industry 5.0	This group of patterns describes a work environment characterised by a relaxed atmosphere and informal culture. Teams are described as informal, and motivated, contributing to a positive and informal working atmosphere.
B-Empowerment and sustainability	B11_enviroment	59	Industry 5.0	This group focuses on identifying companies that prioritise sustainability and seek to make a positive environmental impact. They are dedicated to supporting eco-profit companies that contribute to society and the environment.

Major group	Minor group	Number of phrases	Category	Brief description/examples
B-Empowerment and sustainability	B12_future_proof	213	Industry 5.0	This group identifies companies that offer job security in stable environments, ensuring employees feel secure in their positions. It encompasses various aspects, including the assurance of long-term employment, stability within innovative companies, and career advancement opportunities. These organisations are known for their reliability, providing a safe and secure working environment with a focus on social responsibility.
B-Empowerment and sustainability	B13_decision	359	Industry 5.0	This group represents organisations with cooperative teams characterised by flat structures and open communication. They foster a work environment where hierarchies are minimal.
B-Empowerment and sustainability	B14_open_comminication	107	Industry 5.0	This group is defined by its open cultures of discussion and constructive communication, where individuals are encouraged to express their views openly. Employees are valued for their ability to engage positively with others, promoting effective communication and a sense of community within the organisation. The company emphasises authenticity and simplicity in its communication practices, fostering an open and inclusive culture.
B-Empowerment and sustainability	B15_social	40	Industry 5.0	This group highlights the array of social benefits and incentives offered by the company to its employees. These benefits include a personal annual vitality budget, which employees can use for various wellness-related expenses. The company offers attractive benefits and social perks. Employees also benefit from the support of

Major group	Minor group	Number of phrases	Category	Brief description/examples
				a collegial environment and various dedicated aid and services, such as mutual insurance, accommodation assistance, childcare support, travel benefits, and access to works council resources.
C-Equality	C11_no_bias	120	Industry 5.0	This group represents companies committed to fostering inclusivity and diversity in the workplace. They explicitly prioritise equal opportunities for all individuals, regardless of background or ability. Through their anti-discriminatory employment policies, they ensure fair treatment and opportunities for advancement for every employee.
C-Equality	C12_diverse	78	Industry 5.0	This group comprises companies that embrace diversity and in their composition. With a multicultural workforce, they prioritise creating an inclusive environment where individuals from various backgrounds feel valued and respected. They offer equal opportunities for all employees, irrespective of specific characteristics, and celebrate the differences among team members.
C-Equality	C13_elderly_disabled	87	Industry 5.0	This group focuses on providing support and accommodations for employees with disabilities. Companies identify themselves as disability confident employers, welcoming applications from people with disabilities and ensuring equal opportunities in recruitment processes. These initiatives may involve guaranteed interviews for disabled applicants meeting essential requirements, providing disability inclusivity, and offering reasonable adjustments or accommodations during the recruitment process.

Major group	Minor group	Number of phrases	Category	Brief description/examples
D-Work-format	D11_remote_degree	732	Industry 5.0	This group of patterns encompasses the concept of remote work, indicating that working from a location outside the traditional office setting is feasible. They endorse the idea of autonomy and remote work, allow individuals to decide where they work. Some key features include being a remote-first company, offering telecommuting options, and providing benefits like online remote nurse jobs. They may offer modern office spaces in specific locations alongside remote work opportunities. Additionally, they might provide allowances for remote work, cater to fully remote positions, or offer hybrid arrangements combining remote and in-office work.
D-Work-format	D12_style	326	Industry 5.0	This group of patterns highlights the importance of both teamwork and independence in the workplace. These patterns emphasize the opportunity to contribute to a team dynamic while also having the freedom to work independently. Candidates may be part of self-directed teams or contribute independently within a global team setting, showcasing their ability to balance teamwork with individual initiative.
E-Benefits and financial wellness	E11_equity	160	Industry 5.0	This group refers to schemes within companies that enable employees to purchase company shares, often at discounted rates or as part of their compensation package. It includes initiatives like employee stock purchase plans, share save schemes, and company share option plans, which offer opportunities for employees to invest in their organisation's future by

Major group	Minor group	Number of phrases	Category	Brief description/examples
				acquiring company shares. These programs may also include performance bonuses or stock options, providing additional incentives for employees to participate and aligning their interests with the company's success.
E-Benefits and financial wellness	E12_pension_contribution	77	Industry 5.0	This group underscores the various pension schemes and contributions offered by the company to support employee financial security and retirement planning. The company provides a generous pension plan with employer contributions.
E-Benefits and financial wellness	E13_pension_scheme	181	Industry 5.0	This group highlights the comprehensive pension and insurance benefits provided by the company to ensure employees' financial security and well-being. It includes accident insurance coverage available round the clock, coupled with company contributions aimed at enhancing pension accumulation.
F-Health Support	F11_proactive_measures	100	Industry 5.0	This group emphasises the importance of emotional and mental well-being support provided by the company. It includes access to various programs aimed at promoting mental health, such as mental health first aiders and counselling helplines.
F-Health Support	F12_health_plans	93	Industry 5.0	This group highlights initiatives focused on promoting health and well-being within the company. It encompasses various health promotion programs, including private healthcare schemes and initiatives aimed at improving employee well-being. These may involve access to occupational health services, workplace health promotion measures, and employee assistance programs. Additionally, the group may

Major group	Minor group	Number of phrases	Category	Brief description/examples
				include benefits such as complementary healthcare plans and collective health and welfare contracts, reflecting the company's commitment to supporting the health of its employees.
F-Health Support	F13_Health_insurance	82	Industry 5.0	This group encompasses the company's private health insurance package and related insurance benefits, demonstrating its commitment to employee well-being and security. It includes comprehensive coverage such as long-term disability cover, group life assurance, and critical illness insurance. Additionally, the company may offer benefits like mutual insurance commitments and facilitation of company fitness and group health insurance schemes.
G-Balanced living initiatives	G11_sustainable transport	161	Industry 5.0	This group pertains to initiatives and benefits offered by companies to encourage cycling and support a healthy lifestyle among employees. It includes schemes such as cycling plans, lease bike opportunities, and bike leasing programs, which allow employees to lease bicycles for commuting or personal use.
G-Balanced living initiatives	G12_events_work_life_balance	534	Industry 5.0	This group emphasises the importance of achieving a healthy balance between work and personal life commitments. It encompasses initiatives aimed at promoting employee wellness, both physically and mentally, and fostering a supportive environment for maintaining a harmonious professional and personal life balance. These initiatives may include wellness programs, family-friendly policies, access to health services, and resources to support mental health.

Major group	Minor group	Number of phrases	Category	Brief description/examples
H-Training and Career Impact	H11_impact	82	Industry 5.0	These positions offer the chance for personal impact and growth, contributing to a better future for employees. With a focus on social goals and community impact, working in these jobs allows individuals to play a role in creating positive change on both a local and international scale.
H-Training and Career Impact	H12_courses_seminars	775	Industry 5.0	This group encompasses various training pathways and opportunities for professional development within the company. Employees have access to training provided directly by the company, which includes attending conferences, workshops, and technical courses.
H-Training and Career Impact	H13_budget	168	Industry 5.0	This group offers employees individual development budgets to support their professional growth and personal advancement. This includes personal competence development, training courses, books, and other expenses.
H-Training and Career Impact	H13_training	3113	Industry 5.0	This group prioritises ongoing learning and development. It offers diverse career paths that include training and educational avenues to facilitate professional growth. Through structured training initiatives, employees can enhance their skills and expertise, empowering them to excel in their roles. The company provides comprehensive training resources and support, ensuring employees have access to high-quality learning opportunities.

Major group	Minor group	Number of phrases	Category	Brief description/examples
I-Supportive and open work environment	I11_motivated	828	Industry 5.0	This group of patterns emphasises the dynamic and collaborative nature of the team environment. Candidates can expect to engage in challenging work alongside ambitious and active team members. They will have the opportunity to lead and contribute as integral parts of the team, surrounded by enthusiastic and hardworking colleagues.
I-Supportive and open work environment	I12_caring	1944	Industry 5.0	This set of patterns describes a workplace culture that prioritises dynamism and teamwork. Employees can anticipate collaborating within a positive atmosphere alongside a vibrant and energetic team. With a strong focus on employees support and mutual respect among team members, these companies foster environments where employees can excel.
O-Opposite concepts[31]	O11_bonuses	1042	Non-Industry 5.0	Activity bonuses encompass additional compensation or rewards provided to employees based on their performance, achievements, or specific outcomes.
O-Opposite concepts	O12_profit_sharing	236	Non-Industry 5.0	This group refers to the inclusion of performance bonuses or profit-sharing schemes within the company's benefits package. Employees may receive additional compensation based on the company's profitability or individual performance.
O-Opposite concepts	O13_Hierarchy	11	Non-Industry 5.0	Hierarchical structures within the organisation. The emphasis on following predetermined schedules,

[31] Organisational practices that are negatively related to human-centricity or are "Non-Industry 5.0".

Major group	Minor group	Number of phrases	Category	Brief description/examples
				participating in management control activities, and holding regular meetings with colleagues suggests a hierarchical framework where roles and responsibilities.
O-Opposite concepts	O14_Productivity bonus	175	Non-Industry 5.0	This group denotes the bonus structure within the company, primarily based on individual and company performance. Employees may receive personal performance bonuses, company performance-based bonuses, or a combination of both.

5.4 Companies' practices: Vacancies.

After arriving at a consolidated Industry 5.0 dictionary based on AI-methods and expert validation (Table 5), the patterns and terms identified in the dictionary were then used to analyse job vacancy data for Austria, France, the Netherlands and the UK. Data for Austria, France, and the Netherlands were analysed for 2023 only, while the analysis for the UK and Netherlands covered the period 2022-2023 (**Table *6***). This was due to the availability of previously collected data for those countries. Given the vast number of vacancies in the UK (over four million), we begin most of the analyses with the UK and subsequently analyse the other countries. It is important to note that the figures from the different countries are not directly comparable due to representativeness issuesand differences in the samples and sources, among others. The objective here is to assess the feasibility of employing the same methodology across all four countries. Further analysis of the datasets from the four countries would be necessary to compare the results accurately. Furthermore, the results presented in this section are preliminary, as they are based on initial data analysis. Additional validation and refinement of the findings are required to draw more definitive conclusions.

Table 6 : Percentage of vacancies that mention at least one Industry 5.0 pattern

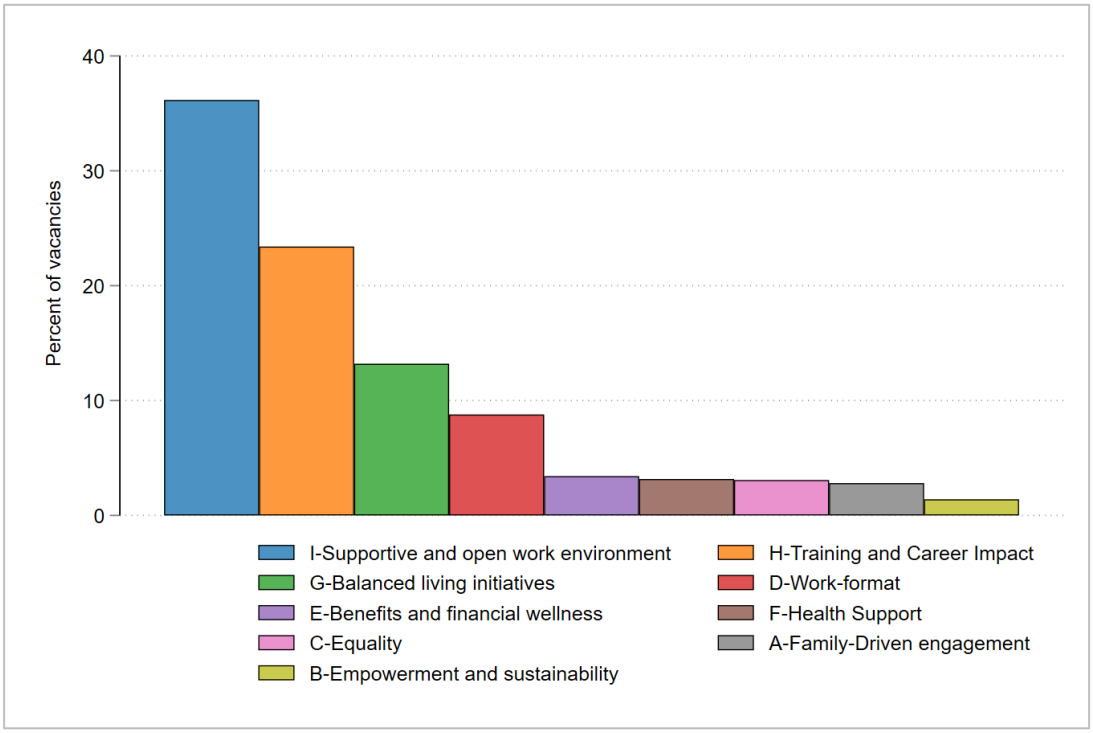
	Period of analysis	Total vacancies analysed	Percentage of vacancies mentioning at least on Industry 5.0 pattern
Austria	2023	245,784	33.8
France	2023	237,427	50.4
The Netherlands	2022-2023	475,814	60.2
UK	2022-2023	4,441,374	57.1

Of the vacancies that mentioned at least one Industry 5.0 pattern, these were analysed to determine which of the major groups from Table 5 was most likely to be mentioned. For the UK, this was the group "supportive and open work environment", with over 35% referring to this grouping. Second to this was "training and career impact", followed by "balanced living initiatives" (Figure 7). All other groups were mentioned in less than 10% of vacancies.

Similar to the UK, the modal group for France is also "supportive and open work environment", with over 30% of vacancies mentioning patterns related to this group. Second to this "work format" (20%), followed by "training and career impact" (slightly over 10%). A "supportive and open work environment" is also prominent in the Austrian data, but unlike the UK and France, it is the second most frequent grouping (slightly over 20%). Most commonly mentioned in the Austrian vacancy data is "training and career impact" (close to 25%). Third is "family-driven engagement" (about 8%). For the Netherlands, the most common pattern mentioned is "training and career impact" and "supportive and open work environment". From the cross-country comparison, an emerging pattern is the prominence (from the employer perspective) of having a "supportive and open work environment" and "training and career impact" as these two groupings appear in the top three in the UK, France, Austria and Netherlands. The

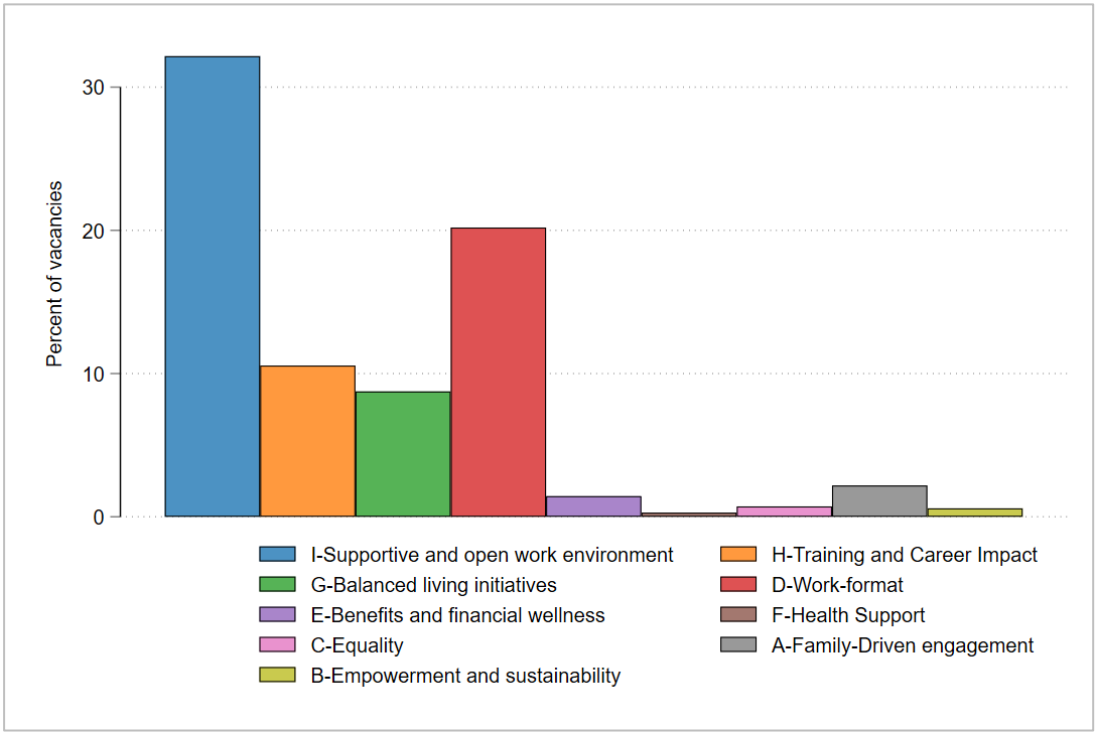
third frequent grouping varies across country, but this is expected given different economic systems, cultures and preferences.

Figure 7: Percentage of vacancies mentioning Industry 5.0 patterns by major groups, UK (2022-2023)



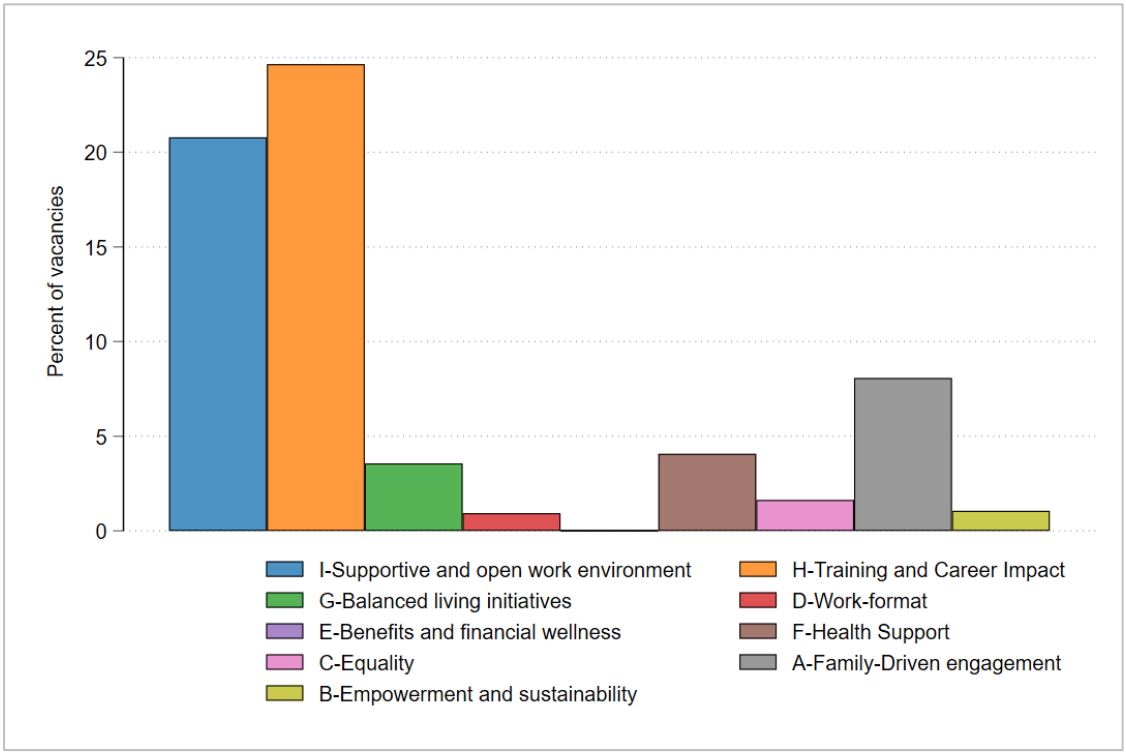
Source: Author illustrations.
Note: Percentages can sum more that 100%. A job vacancy can mention more than one major group.

Figure 8: Percentage of vacancies that mentioning Industry 5.0 patterns by major groups, France, 2023



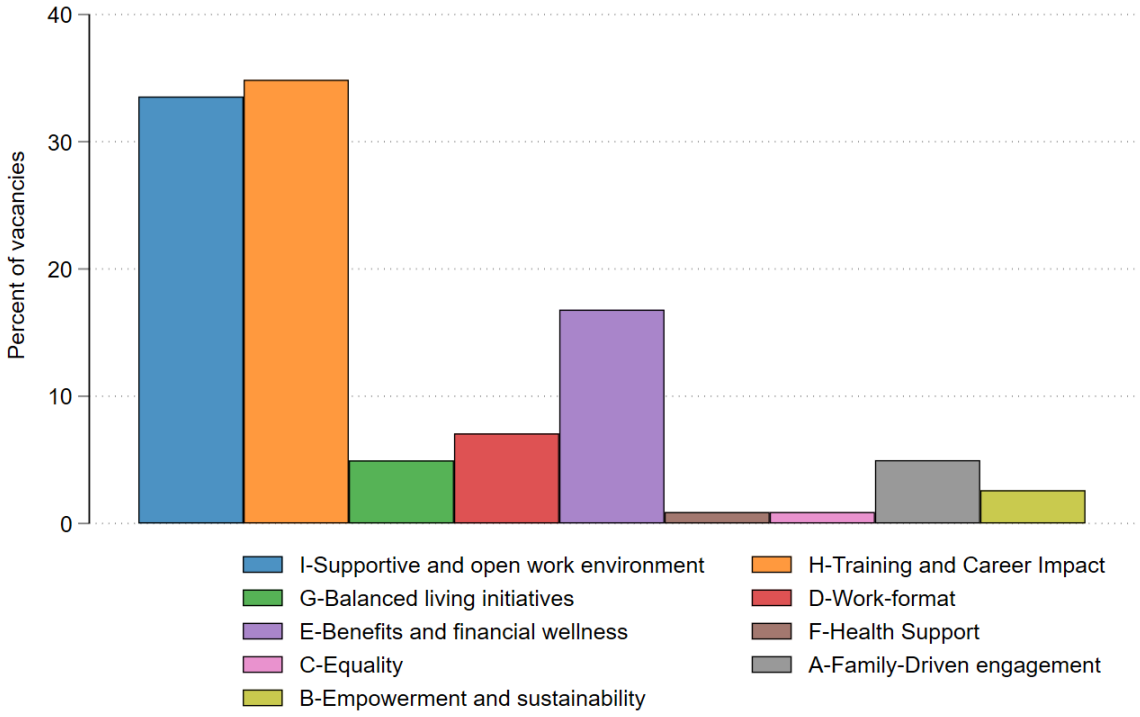
Source: Author illustrations.
Note: Percentages can sum more that 100%. A job vacancy can mention more than one major group.

Figure 9: Percentage of vacancies mentioning Industry 5.0 patterns by major groups, Austria (2023)



Source: Author illustrations.
Note: Percentages can sum more that 100%. A job vacancy can mention more than one major group.

Figure 10: Percentage of vacancies mentioning Industry 5.0 patterns by major groups, The Netherlands (2022-2023)



Source: Author illustrations.
Note: Percentages can sum more that 100%. A job vacancy can mention more than one minor group.

As shown in Table 5, within each major grouping, there are several minor groups. Analysing the vacancy data by minor groups allows us to see the distribution of patterns within each major group. For example, the major grouping “supportive and open work environment” was most frequent in the UK and French data, and second most frequent in the Austrian data. Within this major grouping the minor group “caring” was most mentioned to indicate a supportive environment. “Training” and “courses/seminars” (under the major group “training and career impact” were frequently mentioned in the UK and Austrian data, but less so in the French data. Figure 11 – Figure 14 show the breakdown by minor groups for each country.

Figure 11: Percentage of vacancies mentioning Industry 5.0 patterns by minor groups, UK (2022-2023)

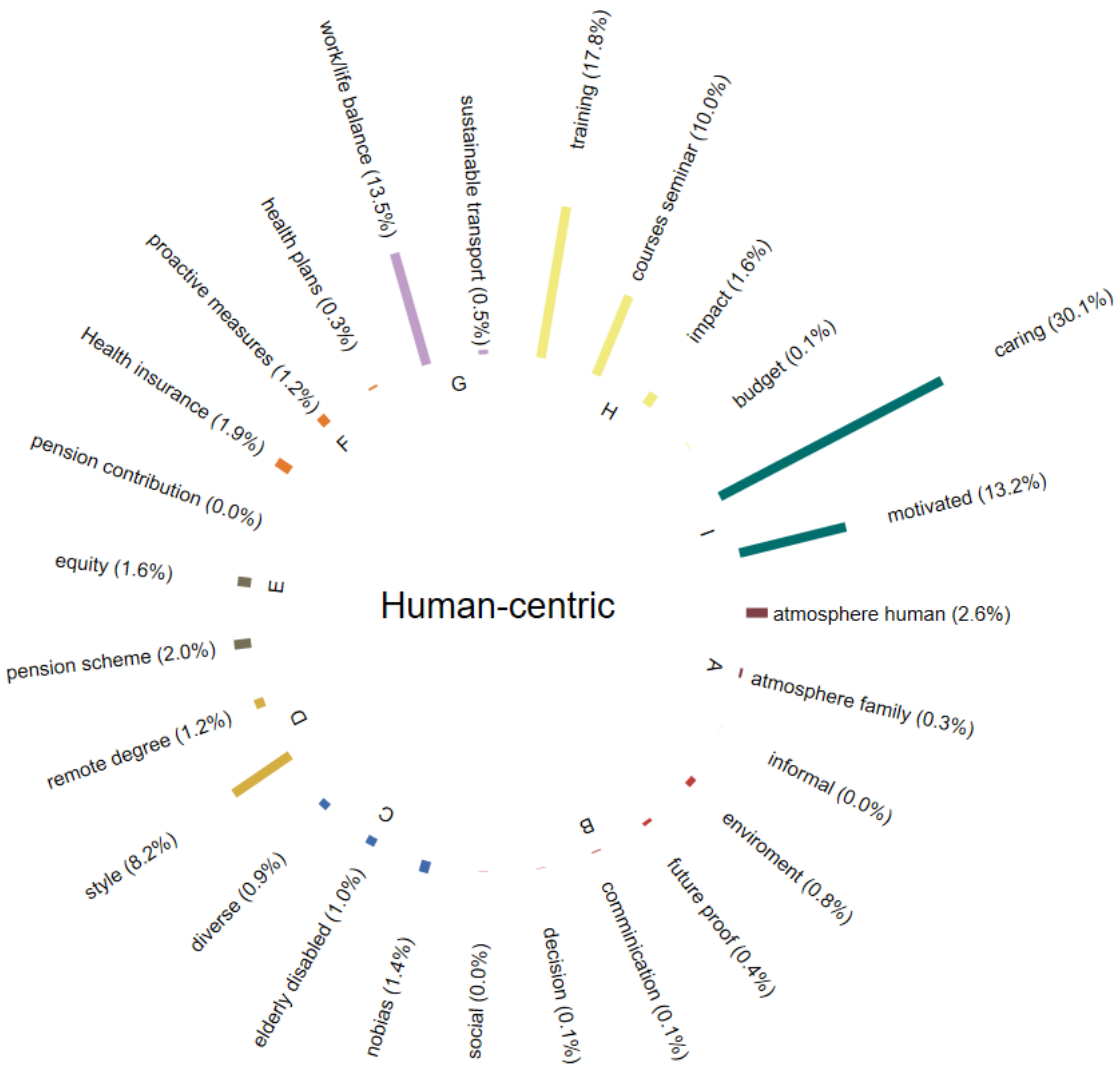


Figure 12 Percentage of vacancies mentioning Industry 5.0 patterns by minor groups, France (2023)

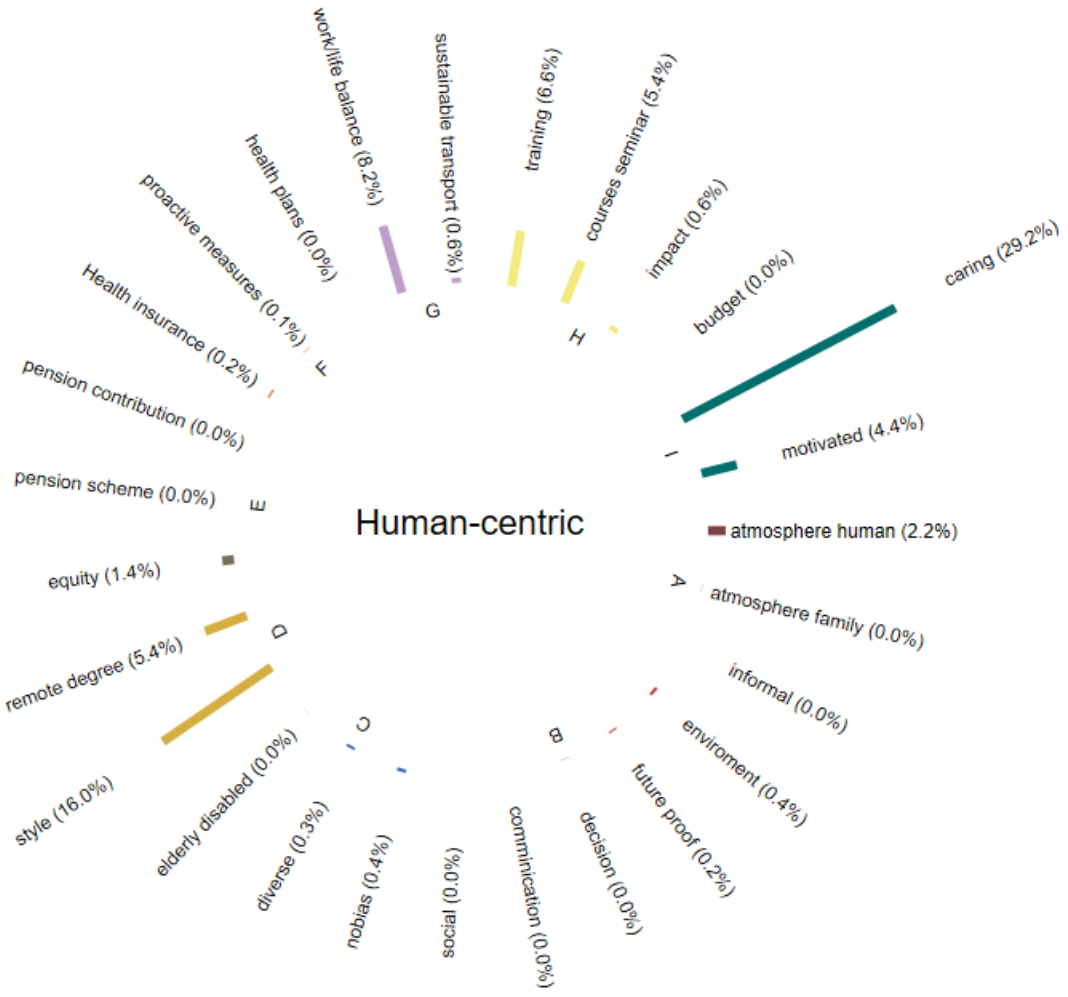


Figure 13: Percentage of vacancies mentioning Industry 5.0 patterns by major groups, Austria (2023)

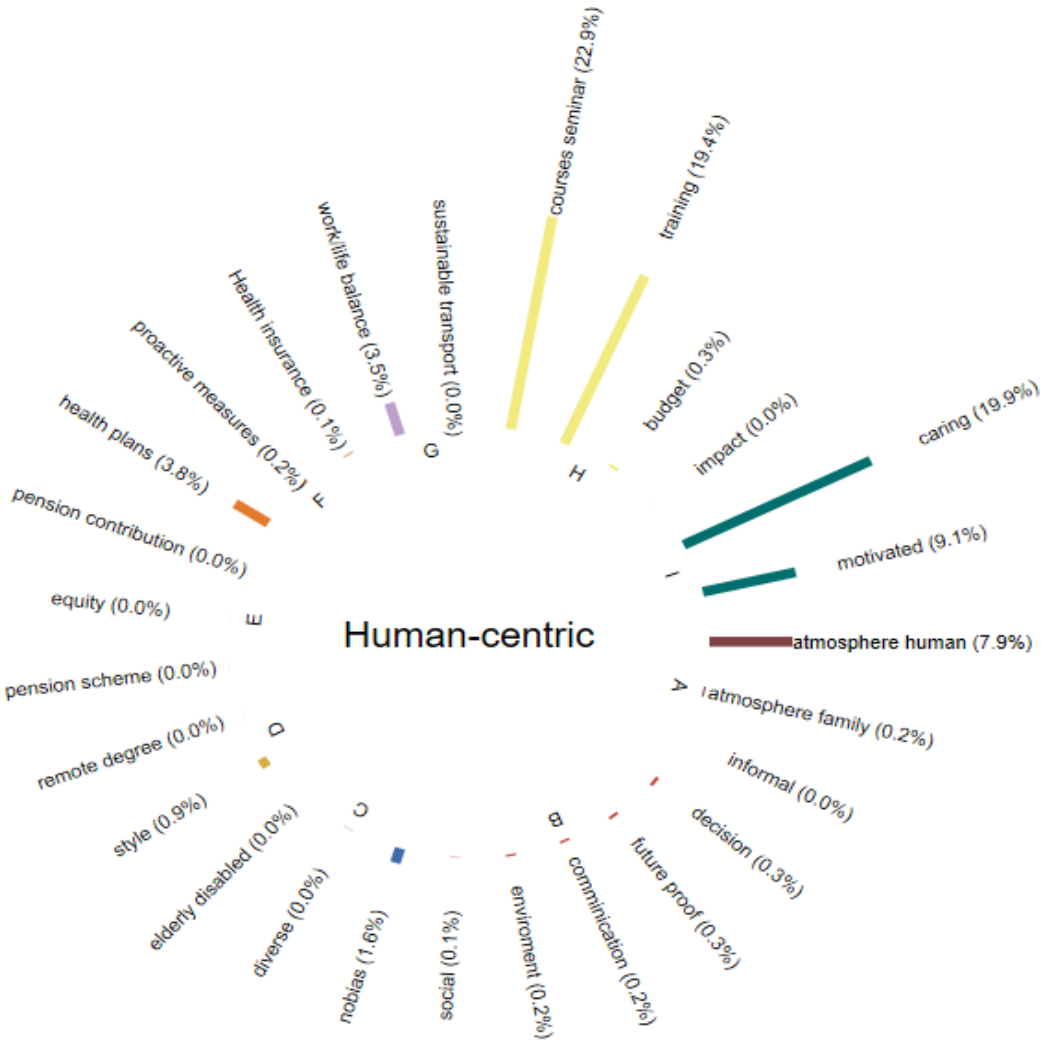


Figure 14: Percentage of vacancies mentioning Industry 5.0 patterns by major groups, The Netherlands (2022-2023)

Source: Author illustrations.
Note: Percentages can sum more that 100%. A job vacancy can mention more than one minor group.

5.5 Companies' profiles (*Can we identify companies aligned with Industry 5.0?*) (Social media, linked data, etc.).

Having developed an Industry 5.0 dictionary, one of its uses would be to identify companies that align with Industry 5.0. To test this, we utilise data from Glassdoor. Glassdoor gives companies a space to project themselves to jobseekers (including the company's mission and vision and general description of the company): employees can leave reviews and ratings of companies, and jobseekers can search for jobs and access company ratings, which can be used to inform application decisions.[32]

Table 7 - Table 9 present descriptives of a randomly selected sample of UK companies from Glassdoor as illustrative example of variables available in this source of information. The majority of firms (over 85%) have over 1000 workers, with over 40% employing more than 10,000 workers (Table 7). Revenue data was not provided for the largest share of companies (26%) (Table 8). Only 0.24% of companies had revenue less than $1 million. The distribution of companies across industries is relatively balanced, with slightly greater representation from companies in industries related to Enterprise Software & Network Solutions and Information Technology Support Services (Table 9). This information helps characterising the companies listed in Glassdoor.

Table 7: Firm size (by employees) of companies analysed, UK

Employees	Number of companies	%
1 to 50	12	0.73
51 to 200	26	1.59
201 to 500	51	3.12
501 to 1000	94	5.75
1001 to 5000	505	30.87
5001 to 10000	244	14.91
10000+	688	42.05
Unknown	16	0.98

Table 8: Revenue profile of companies analysed, UK

Revenue	Number of companies	%
Less than $1 million	4	0.24
$1 to $5 million	17	1.04
$5 to $25 million	23	1.41
$25 to $50 million	63	3.85

[32] See About Us | Glassdoor

$100 to $500 million	231	14.12
$500 million to $1 billion	145	8.86
$1 to $5 billion	311	19.01
$5 to $10 billion	103	6.3
$10+ billion	312	19.07
Unknown / Non-Applicable	427	26.1

Table 9: Industry breakdown of companies analysed, UK

Industry	Number of companies	%
Enterprise Software & Network Solutions	88	5.38
Information Technology Support Services	82	5.02
Business Consulting	71	4.34
Clothing & Shoe Stores	67	4.10
HR Consulting	64	3.91
Investment & Asset Management	56	3.43
Colleges & Universities	51	3.12
Internet & Web Services	51	3.12
Banking & Lending	49	3.00
Energy & Utilities	47	2.87
Advertising & Public Relations	46	2.81
Biotech & Pharmaceuticals	44	2.69
Restaurants & Cafes	44	2.69
Computer Hardware Development	43	2.63
Healthcare Services & Hospitals	40	2.45
Consumer Product Manufacturing	34	2.08
Insurance Carriers	33	2.02
National Services & Agencies	28	1.71
Welfare & Social Services	26	1.59
Software Development	25	1.53

As previously highlighted, Glassdoor offers a platform for companies to share their mission and vision statements, providing job seekers with insights into their organisational practices. Although these statements may not encompass every aspect of company operations, they offer valuable indicators of key practices and their alignment with the principles of Industry 5.0. Consequently, we used the Industry 5.0 dictionary developed in the previous section in the companies' descriptions. Consequently, we used the Industry 5.0 dictionary developed earlier to analyse the companies' descriptions. Table 10 presents the total number of company descriptions collected from each country, along with the percentage mentioning at least one Industry 5.0 pattern, and the corresponding collection period. 39.1% of companies in Austria referenced at least one Industry 5.0 pattern, followed by the UK (33.8%), Netherlands (17.2%), and France (14.3%).

Table 10: Percentage of companies' descriptions that mentioning at least one Industry 5.0 pattern

	Period of analysis	Total companies' descriptions analysed	Percentage of companies' descriptions mentioning at least on Industry 5.0 pattern
Austria	Dec-2023	413	39.1
France	Dec-2023	2,154	14.3
The Netherlands	Dec-2023	1,099	17.2
UK	Dec-2023	1,636	33.8

Next, we conducted an analysis to ascertain the major groups from Table 5 that were most commonly mentioned. Across all analysed countries, a distinct pattern emerged: companies frequently emphasised "Empowerment and sustainability" in their descriptions, followed by "Supportive and open work environment," "Training and career impact," and "Balanced living initiatives." (Figure 15 -

Figure ***18***). While assessing the extent of greenwashing is challenging, the emerging trends suggest a rising inclination among companies to portray themselves as environmentally friendly.

Figure 15: Percentage of vacancies mentioning Industry 5.0 patterns by major groups, The UK (December 2023)

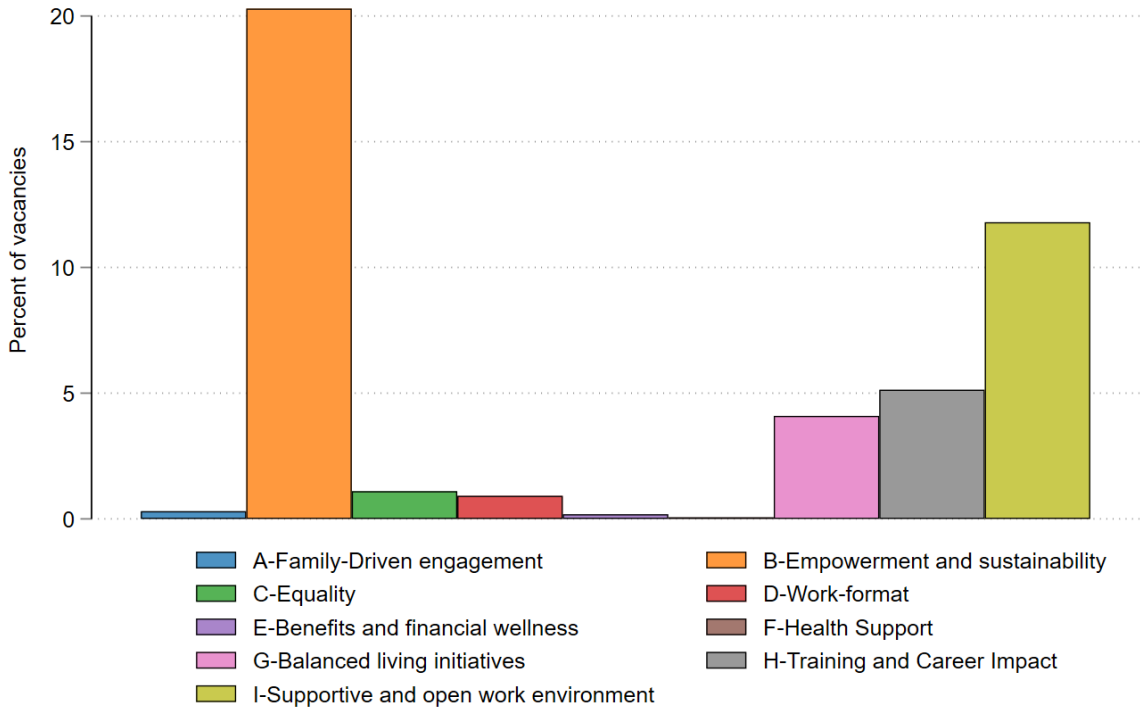


Figure 16: Percentage of vacancies mentioning Industry 5.0 patterns by major groups, France (December 2023)

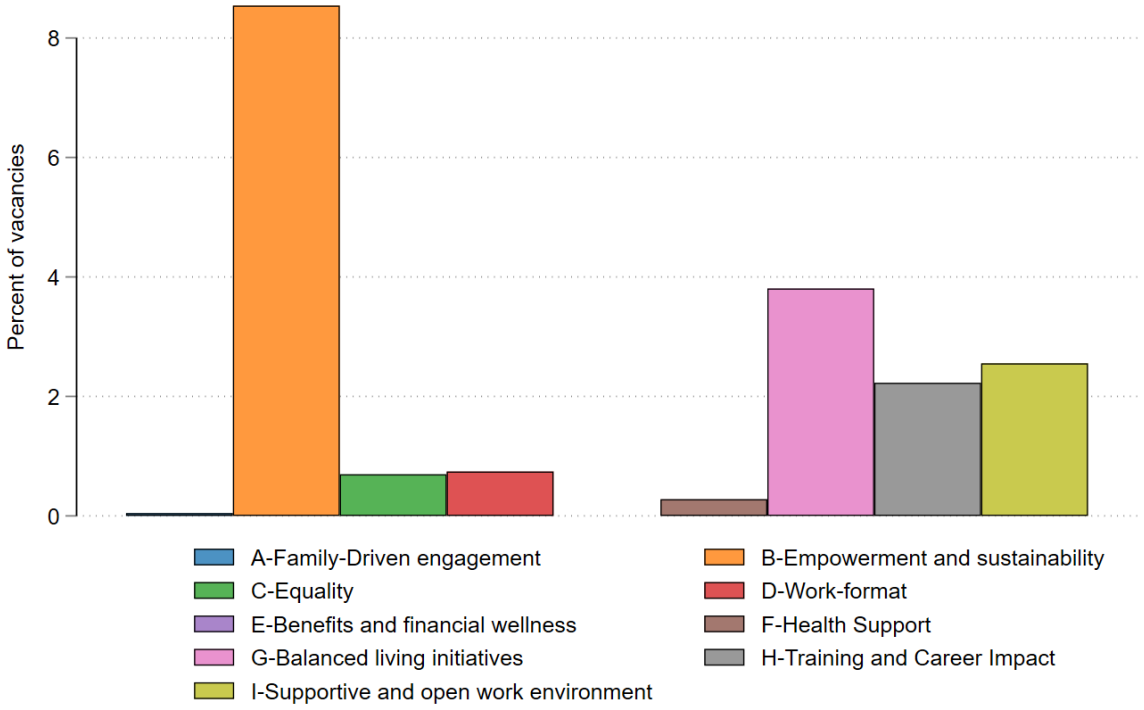


Figure 17: Percentage of vacancies mentioning Industry 5.0 patterns by major groups, Austria (December 2023)

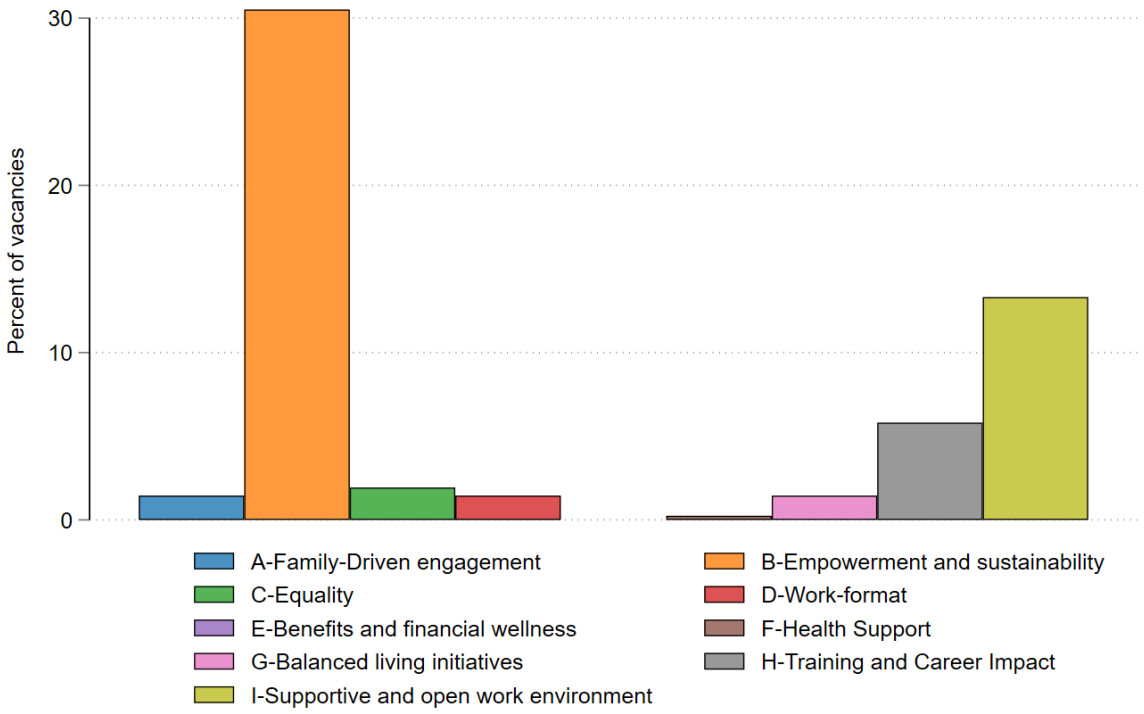
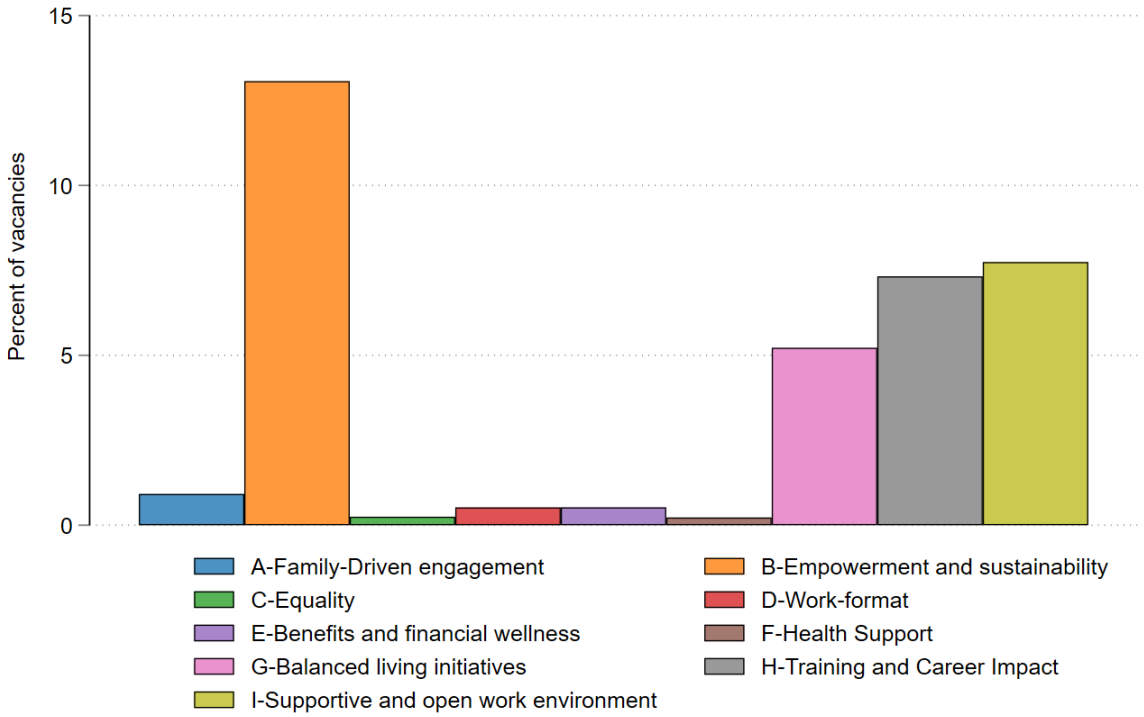


Figure 18: Percentage of vacancies mentioning Industry 5.0 patterns by major groups, The Netherlands (December 2023)



Source: Author illustrations.
Note: Percentages can sum more that 100%. A company description can mention more than one major group.

5.6 Job seekers' evidence: People's review on companies (Glassdoor).

As noted above, employees can review companies and rate their experience at said company. Glassdoor determines company ratings based on recent feedback from employees. Using a proprietary rating algorithm, Glassdoor places importance on the timeliness of reviews. Typically, the more recent a review, the greater its impact on the overall rating displayed on Glassdoor. This methodology aims to provide job seekers and employers with the most up-to-date insights into the employee experience within any given company. Ratings/scores (out of five) can be given for "Culture & Values", "Diversity & Inclusion", "Work/Life Balance", "Senior Management", "Compensation and Benefits", and "Career Opportunities".[33] Although Glassdoor does not formally define these dimensions, they are considered as key workplace factors. Interestingly,

[33] Where 0.00 - 1.50 Employees are "Very Dissatisfied", 1.51 - 2.50 Employees are "Dissatisfied", 2.51 - 3.50 Employees say it's "OK", 3.51 - 4.00 Employees are "Satisfied", 4.01 - 5.00 Employees are "Very Satisfied"

Glassdoor's categorisation aligns with the dimensions identified in the Industry 5.0 framework discussed earlier.[34]

For example, the "Culture & Values" category corresponds to aspects of "A-Family-Driven engagement" in the Industry 5.0 dictionary. Similarly, "Diversity & Inclusion" aligns with "C-Equality", "Work/Life Balance" with "G-Balanced living initiatives", "Compensation and Benefits" with "E-Benefits and financial wellness", and "Career Opportunities" with "H-Training and Career Impact".

However, the category of "Senior Management", which encompasses reviews about leadership effectiveness, communication, and decision-making within the company, may not have a direct association with the Industry 5.0 framework and could encompass elements unrelated to Industry 5.0. Despite this, most of Glassdoor's dimensions are directly linked to the Industry 5.0 concept, providing valuable insights into various aspects of workplaces.

Table 11 shows the average scores by countries. As shown, the average score is broadly similar across the four case study countries.

Table *12* shows the distribution of companies across countries based on sample size. Again, using the UK as an example, Table 13 provides UK analysis by each dimension. The "Senior Management" dimension received the lowest average score (3.32), while "Diversity and Inclusion" received the highest average score (3.86) across all companies in the sample.

Table 11: Overall scores based on reviews by country

Country	Mean	SD	Min	Max	N
UK	3.685670	0.457652	1.1	5	9,763
Austria	3.760244	0.830038	1	5	5,823
France	3.715596	0.455086	1.3	5	9,900
Netherlands	3.758254	0.484284	1	5	9,438

[34] For more details: https://help.glassdoor.com/s/article/Ratings-on-Glassdoor?language=en_US#:~:text=5%2DPoint%20Scale%3A&text=1.51%20%2D%202.50%20Employees%20are%20%22Dissatisfied,5.00%20Employees%20are%20%22Very%20Satisfied%22

Table 12: Descriptives of companies analysed across countries

	UK		Austria		France		Netherlands	
Employees	Number of companies	%	Number of companies	%	Number of companies	%	Number of companies	%
1001 to 5000	2,807	28.75	706	12.09	2,545	25.69	2,213	23.43
10000+	2,001	20.49	901	15.43	2,232	22.53	1,759	18.62
501 to 1000	1,191	12.2	425	7.28	1,007	10.17	1,021	10.81
201 to 500	1,168	11.96	593	10.16	989	9.98	1,042	11.03
5001 to 10000	948	9.71	341	5.84	1,055	10.65	802	8.49
51 to 200	919	9.41	673	11.53	1,012	10.22	1,217	12.88
1 to 50	391	4	1,106	18.94	500	5.05	706	7.47
Unknown	340	3.48	1,094	18.74	566	5.71	686	7.26

Table 13: Scores by dimension based on reviews, UK

UK (N=1,636 companies)	Mean	SD	Min	Max
Culture and Values	3.75	0.45	2	4.9
Diversity and Inclusion	3.86	0.35	2.3	4.8
Work/life balance	3.70	0.45	1.4	4.9
Senior Management	3.32	0.43	1.4	4.9
Career Opportunities	3.47	0.42	1.7	4.8
Compensation and Benefits	3.76	0.47	1.5	4.8
Overall score	3.72	0.39	1.9	4.9

Source: Author illustrations.

6 Next steps.

The subsequent phases of this project entail exploring the possibility of complementing the Industry 5.0 dictionary by adding 4.0 technologies. These phases also include finalising the collection/access and analysis of additional data sources, such as the OVATE dataset, stock exchange company data, and collective agreements. Once this data collection phase concludes, we will proceed to integrate these databases by linking them together using the companies' names as the primary connecting variable. This integration process will enable us to combine insights from different sources to construct a composite index that informs us about the degree to which companies are aligned with Industry 5.0 practices. The corresponding methodological details will also be provided in the next stage of the project.

7 Conclusions.

This report builds on the previous Bridges 5.0 WPs by empirically exploring Industry 5.0 concepts and companies' practices using innovative data sources and techniques. We discussed the challenges associated with measuring Industry 5.0 in available data sources and recognised the need to develop an Industry 5.0 dictionary. To overcome these challenges, we proposed a pioneering AI-based methodology to analyse Industry 5.0 concepts using non-traditional data sources. By focusing on human-centricity, we aim to provide insights into how companies and jobs are adapting to the evolving economic context, ultimately bridging the gap between theoretical concepts and practical applications.

By collecting and analysing diverse data sources, including professional platforms, online job portals (for company profiles and job postings), YouTube videos, academic journal articles (Scopus), and others, we have constructed an Industry 5.0 dictionary. This dictionary enables us to pinpoint patterns that are closely associated with the Industry 5.0 concept. As a result, we can identify companies that are more likely to align with Industry 5.0 practices. For instance, we identified how companies mention Industry 5.0 practices in the job vacancies. In the UK, the most frequently mentioned group among job vacancies was 'supportive and open work environment'. Followed by 'training and career impact', and 'balanced living initiatives'. Similarly, in France, the predominant group was also a 'supportive and open work environment'. Following this, 'work format' was the second most common grouping, followed by 'training and career impact'. In Austria, while a 'supportive and open work environment' is significant, it ranks second, with 'training and career impact' being the most frequently mentioned pattern. Additionally, 'family-driven engagement' emerges as a notable pattern. For the Netherlands, 'training and career impact' and 'supportive and open work environment' stand out as the most common patterns. This cross-country comparison reveals a consistent emphasis on fostering a supportive work environment and prioritising training and career development, underscoring employer perspectives across varied economic systems and cultures.

From the companies' profiles analysis is evident an emphasis on "Empowerment and sustainability," "Supportive and open work environment," "Training and career impact," and "Balanced living initiatives" across all analysed countries underscore a prevailing trend among companies. This pattern suggests a growing inclination among

businesses to prioritise aspects related to sustainability, employee well-being, and professional development. While the assessment of greenwashing remains complex, the recurring themes in company descriptions indicate a heightened awareness and desire to present themselves as environmentally conscious entities. Furthermore, based on the sample of companies analysed across various countries, it was observed that, on average, employees rated their satisfaction levels as "OK" (with scores averaging around 3.9 on the Glassdoor scale).

This report lays the groundwork for further research and policy development in the field of Industry 5.0. The innovative methodology and comprehensive Industry 5.0 dictionary developed here serve as valuable tools for future studies aiming to investigate deeper into the implications of Industry 5.0 on various aspects of the economy and society. Furthermore, the insights gained from this analysis can inform policymakers and industry stakeholders about emerging trends, facilitating informed decision-making and strategic planning. In the next project phase, we will gather and analyse (if possible) additional data sources, including the OVATE dataset, stock exchange company data, and collective agreements. After completing this data collection phase, we will integrate these databases by linking them using the companies' names as the primary connecting variable. This integration will allow us to create a composite index that assesses the extent to which companies align with Industry 5.0 practices.

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BRIDGES 5.0 PROJECT IDENTITY

Project name	BRIDGES 5.0 **B**ridging **R**isks to an **I**nclusive **D**igital and **G**reen future by **E**nhancing workforce **S**kills for industry 5.0
Coordinator	**Prof. Dr Steven Dhondt (scientific coordinator).Nederlandse Organisatie Voor Toegepast Natuurwetenschappelijk Onderzoek (TNO), (Netherlands)**
Consortium	Katholieke Universiteit Leuven
	Austrian Institute of Technology
	Panepistimio Patron (Patras University)
	Conservatoire National des Arts et Métiers, Centre d'Études de l'Emploi et du Travail-Lirsa
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