



Unlocking employer insights: Using large language models to explore human-centric aspects in the context of industry 5.0

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ABSTRACT

This paper aims to enhance the understanding of Industry 5.0 by introducing an innovative AI-based methodology that proficiently maps employer expressions related to well-being using job postings. This process involves creating a comprehensive dictionary of well-being expressions, which is then compared with existing academic literature. This approach facilitates empirical well-being analysis from employers' perspectives. Bridging theoretical and practical realms, we offer valuable insights to academia and industry about well-being (human-centricity) interpretation by employers. The findings highlight UK employers' prioritisation of self-realisation and a positive work atmosphere to attract job seekers. Nonetheless, many vacancies do not explicitly emphasise well-being to attract potential workers.

1. Introduction

The arrival of Industry 5.0, frequently referred to as the fifth industrial revolution, has introduced a fresh wave of new ideas to the industrial landscape. This new industrial transformation has its roots in the evolution of Industry 4.0, which marked a significant leap in manufacturing and production practices (Ghobakhloo, 2020). Industry 4.0 emerged as a response to the growing interplay between technology and industry, driven by the digital revolution. It was a natural progression from the preceding industrial phases, integrating digital technologies into manufacturing processes and supply chains. The transition to Industry 4.0 was fuelled by the proliferation of digital innovations such as the Internet of Things (IoT), cloud computing, and advanced data analytics.

While Industry 4.0 revolutionised efficiency and productivity, it also raised questions about the role of humans in this new technological landscape. As industries became more automated and data-centric, concerns about job displacement and the loss of the human touch emerged. This critical reflection paved the way for the emergence of Industry 5.0, shifting the focus towards a more holistic approach. As highlighted by the European Commission (2023), three main pillars are supposed to be at the centre of Industry 5.0: human-centricity (placing human well-being, needs, and values at the centre of technological advancements and industrial processes), sustainability and

resilience (Ivanov, 2022). The paradigm recognises the significance of human involvement and aims to balance upcoming technologies and human-centric considerations. By prioritising human well-being and meaningful interactions, Industry 5.0 endeavours to create a harmonious coexistence between humans and machines, fostering a more sustainable and inclusive industrial landscape (Xu et al., 2021; Leng et al., 2022; Kolade and Owoseni, 2022).

However, as Industry 5.0 gains momentum, the challenge of analysing this phenomenon 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. Solely focusing on the concept of human-centricity begs the question of human-centricity according to whom? One perspective is academia, where researchers emphasise exploring various aspects of human-robot collaboration, human-cyber interaction, and well-being at the workplace (Leng et al., 2022; Shiroishi et al., 2018). Another one is that of employees, who place high importance on their personal time, relationships, and overall well-being beyond their jobs (Vyas, 2022; Gragnano et al., 2020; Tamunomiebi and Oyibo, 2020). They often seek workplaces that promote and support a healthy balance between their professional and personal lives. Lastly, there is the perspective of an employer who recognises the importance of having motivated and productive employees to foster growth and

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success for both the individuals and the company (Demir et al., 2019; Longo et al., 2020; Leon, 2023).

Among these diverse perspectives, well-being emerges as a common ground that unites all stakeholders. Academic authors have already highlighted that well-being is a crucial link in implementing human-centricity, a principle at the heart of Industry 5.0, where the well-being of the worker is prioritised (Ivanov, 2022; Alves et al., 2023). Moreover, European Commission (2023) emphasises that well-being is a key element of Industry 5.0, stating “(Industry 5.0) places the well-being of the worker at the centre of the production process and uses new technologies to provide prosperity beyond jobs and growth while respecting the production limits of the planet”.

Considerable efforts have already been delivered to conceptualise and showcase workplace well-being strategies from a theoretical standpoint (Ghobakhloo et al., 2023). For instance, one of the most prominent examples of this theoretical groundwork is Hettler’s model, a widely recognised and applied framework comprising six dimensions: physical, emotional, social, spiritual, intellectual, and occupational (Hettler, 1984; Oliver et al., 2018; Myers et al., 2013). However, limited attention has been given to studying the well-being aspect of human-centricity from the perspectives of employees and employers, mainly due to the dynamic nature of the phenomenon and the challenges associated with collecting and analysing up-to-date data (Lu et al., 2022; Waschull and Emmanouilidis, 2023; Mytna Kurekova et al., 2014). As a result, a research niche exists that can be further explored.

Acquiring and measuring data from multiple perspectives presents challenges. Traditionally, researchers have used quantitative and qualitative methods, like surveys and interviews, to map job characteristics and understand labour requirements. Text mining techniques have recently been explored to extract information from large datasets such as job postings and resumes (Adams-Prassl et al., 2020; Acemoglu et al., 2022; Napierala and Kvetan, 2023). However, text mining’s focus on extracting patterns from textual data may not accurately capture nuanced context and subtleties, leading to potential misinterpretations and irrelevant information (Pejic-Bach et al., 2020). These issues can significantly impact the pattern identification process and analysis outcomes (Vijayarani et al., 2015; Gaikwad et al., 2014).

Fortunately, the most recent Large Language Models (LLMs)¹ presented by OpenAI in 2022 and 2023 (Chatgpt 3.5 and GPT-4) have set a new milestone of what Artificial Intelligence algorithms can achieve. The sophisticated embedding mechanisms of transformers can capture the nuances of the text, reason accordingly, and infer when directed. Facebook Large Language Model Meta AI (LLaMa) weights have been open-sourced in 2023 for public use. As a result, an unlimited potential for new natural language processing techniques (NLPs) has been unlocked that can be applied to the labour market, such as well-being analysis.

In light of these advancements, this research addresses key challenges in understanding and applying the concept of well-being in the context of Industry 5.0. Specifically, we aim to answer the following research questions: How do employers envision well-being in job vacancies? (Q1); How could the latest Large Language Models be applied to enhance the analysis of well-being in unstructured data, such as job vacancies? (Q2); What overlaps or gaps exist between the academic perspective on human-centricity and the well-being expressed by employers in job postings? (Q3).

To tackle these questions, this research introduces a novel AI-based approach. The goal is to build an automatic pattern recognition system/algorithm that relates the well-being concept to employers’

¹ LLMs are advanced artificial intelligence systems designed to understand and generate human language. These models are built using vast datasets containing text from various sources. LLMs can perform tasks such as answering questions, summarising text, translating languages, and generating creative content (Meta AI, 2023).

expressions posted in job vacancies. In this process, a comprehensive dictionary of employer expressions is created. This unique approach enables an empirical analysis of the well-being aspect of human-centricity from the employer’s perspective. However, it may not fully capture the broader implications and complexities of well-being, as the data is solely derived from the employer’s standpoint. To identify potential gaps, a conceptual search on well-being in the academic Industry 5.0 literature is conducted. These findings are then compared with employers’ perspectives to highlight areas of overlap and identify discrepancies. Consequently, the research aims to bridge the gap between theoretical concepts and empirical evidence, offering valuable insights to both academia and industry regarding the interpretation of human-centricity from the perspective of employers. Lastly, the challenges associated with measuring and mapping the intricate terms related to employee well-being in the workplace using vacancy data are addressed.

Given the data-intensive nature of LLMs’ training requirements, the emphasis was placed on exploring the employer’s perspective, using the abundant data readily accessible through job search platforms. As a result, this paper uses over 1.8 million job posts collected from the UK. Fine-tuned LLM models have been deployed for the job posting text to capture a particular aspect of human-centricity. More specifically, while browsing job postings, certain employers have been identified as expressing a large variety of benefits for an employee’s well-being. These benefits include but are not limited to health benefits like mental health support, welfare, generous pension schemes, and autonomy. These perceived well-being benefits might contribute to a worker’s overall well-being and should be considered as an important aspect of the debate on achieving human-centricity within the workplace (Sirgy and Lee, 2018). After mining the benefit phraseology, data were further processed to conceptualise a detailed empirical image of perceived well-being from an employers’ perspective.

Thus, this research contribution is two-fold. First, a novel methodological approach for concept extraction applicable across various domains has been proposed. Secondly, a structured perspective on well-being is offered, focusing on employers’ and industry 5.0 academic literature viewpoint and their perceptions of employee well-being. The results support organisations, policymakers, and educational institutions in navigating the job requirements landscape of the fifth industrial revolution.

The paper proceeds with a background section (Section 2). The methodology employed to identify well-being patterns in job vacancies is outlined in Section 3. Section 4 showcases the mapping results, followed by a comprehensive discussion in Section 5. The final section concludes.

2. Background

2.1. Previous research on well-being

Academia has already started pursuing the well-being aspects of human-centricity. Authors strongly emphasise that future technologies should be implemented to maximise workers’ health, safety, satisfaction and performance at the workplace (Papetti et al., 2020; Alves et al., 2023). As discussed by Alves et al. (2023), strategies to create a human-centric workplace should involve motivating and rewarding work, as well as safe and inclusive environments, that put much emphasis on workers’ physical and mental health, dignity, autonomy, privacy and well-being (Xu et al., 2021; Orso et al., 2022). Other strategies to improve worker well-being were suggested through job rotation, diversity of work schedule times, considering the demands of getting the job done and ergonomic workplace exposure (Khamaisi et al., 2022). Thus, in the foreseeable future, the industry must shift from technological to socio-technological working environments where workers continue to acquire, upgrade and retain skills to better their career prospects while

keeping the work-life balance in check (Brauner and Ziefle, 2022; Alves et al., 2023).

Certainly, the academic perspective provides a solid foundation for the direction of human-centricity and well-being. However, it is equally important to consider viewpoints from employee and employer perspectives and how they understand the well-being at the workplace. Unfortunately, such viewpoints explicitly mentioning human-centricity are scarce, as most of the well-being literature comes from domains like psychology, human resources, health sciences and other related domains. Nonetheless, empirical research suggests that balance between work and non-work strongly impacts a person's motivation, productivity, happiness and fulfilment at the workplace (Sirgy and Lee, 2018). An interview with 61 IT professionals concluded that interpersonal relationships, fulfilling work, feeling safe and valued, and having colleague support are a big part of well-being (Zutavern and Seifried, 2021). Other studies have found a strong relationship between measures of job control and health (Spell and Arnold, 2007; Karasek, 1990). In a study of 8500 white-collar workers in Sweden who had undergone reorganisations, it was discovered that those who had more task control and influence over the process had lower levels of illness symptoms for 11 out of 12 health indicators, missed fewer days of work, and suffered from less depression (Karasek, 1990).

Moreover, an extensive review of 39 randomised controlled studies has outlined eight successful interventions that improve the workers' well-being (Sakuraya et al., 2022). For instance, environmental intervention has shown an improvement in evaluative worker well-being when communication, workflow and health services were improved. Likewise, physical intervention, where participating in yoga or other sports, has resulted in better worker mental health. Furthermore, a study involving focus groups on the employers' side found unanimous agreement among owners that occupational safety is paramount. Other important aspects were mental support, colleague support, and work-life-family balance (Pescud Melanie Teal et al., 2015).

Despite existing studies on well-being, there are still considerable drawbacks that must be accounted for. First, a considerable share of existing studies have limited sample sizes. Second, relatively few studies explore the perception of workers' well-being from an employer's eye. These constraints can be primarily due to the substantial costs associated with conducting surveys, as well as the potentially high expenses associated with acquiring relevant data. Moreover, the scarcity of publicly available data, especially concerning corporate practices, hinders the in-depth well-being analysis at the company level (Luhmann, 2017; Voukelatou et al., 2021). Fortunately, with the advent of digitisation, many employers communicate aspects of their organisational culture through social media channels and other publicly available online platforms. For instance, online job portals serve as a hub where employers post job listings that provide comprehensive details, including job titles, working conditions, salary information, required qualifications and experience to apply for a specific vacancy (Cárdenas Rubio, 2020; Cedefop, 2019; Barnes et al., 2021; Mytna Kurekova et al., 2014; Turrell et al., 2018, among others).

Some concerns may arise because job advertisements can be seen as merely marketing or branding tools that do not necessarily reflect employers' ultimate intentions. However, authors such as Backhaus and Tikoo (2004) argue that employer branding reflects an organisation's human capital philosophy. Moreover, Edwards (2010), Breugh (2013) and Kowalski and Loretto (2017) found that organisations presenting an overly positive picture of their employment experience are likely to encourage unrealistic expectations in new employees, leading to high turnover intentions and low job satisfaction. Therefore, organisations have an incentive to provide accurate information about the benefits an employee would receive. Additionally, in countries such as the UK, the Consumer Protection from Unfair Trading Regulations 2008 prohibits unfair commercial practices, including misleading actions and omissions. If a job advertisement constitutes a misleading action by

providing false information or creating a false impression, it could be actionable (Legislation Consumer Protection, 2008).

Furthermore, job vacancies have become a widely used tool to understand labour market characteristics and changes. For instance, Acemoglu et al. (2022), Squicciarini and Nachtigall (2021), and Pouliakas (2021) use job vacancy data to study AI adoption and its implications in the US and European labour markets. This evidence suggests that, although this paper does not test whether job advertisements reflect an employer's ultimate intentions, these sources of information can, with proper statistical methods, reveal current employers' "ideology" regarding their employees' needs and the benefits extended to them.

2.2. Exploring solutions with online data and LLMs

Machine learning (ML), text mining techniques, and online sources of information have proven to be valuable tools for analysing and extracting information from text data, such as job vacancy postings. Regrettably, new text mining approaches for the well-being concepts using online data are still lacking. Research in other domains has proven to deliver useful results when incorporating web data. For instance, Pejic-Bach et al. (2020) used vacancy data and text mining techniques to develop a profile of Industry 4.0 job advertisements. Likewise, a paper by Chiarello et al. (2021) deployed text mining to classify Industry 4.0 and ESCO skills. Successful attempts have also been reported by Meganck et al. (2021), who analysed 1000 job positions to extract skills that concerned public relations advertisements. Thielen and Marsolek (2022) investigated 50 job postings for the librarian positions while Gardiner et al. (2017) analysed 2786 job advertisements that contained "big data" in the job title to capture the requirements.

Nonetheless, it is important to acknowledge the existing studies' limitations when identifying patterns in a text. One of the main challenges is the reliance on the quality and quantity of the training data used to train the 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). For instance, Pejic-Bach et al. (2020) used vacancy data and text mining techniques to develop a profile of Industry 4.0 job advertisements. Firstly, the relatively low number of job vacancies (1460 job advertisements) may not comprehensively represent all jobs and their associated characteristics. Secondly, the text-mining techniques employed in the study have the potential to introduce biases. Specifically, the chosen techniques may overlook important phrases or patterns of interest, as text mining focuses on specific patterns and variations in the wording used by employers or the inclusion of synonyms to describe job characteristics. Additionally, these techniques may struggle with understanding human language's context, subtleties, and nuances, making it challenging to capture complex patterns accurately (Qaiser and Ali, 2018; Vijayarani et al., 2016). The dynamic nature of language and the evolving use of slang, jargon, and cultural references pose difficulties for these techniques.

Despite severe challenges, the latest LLMs might be key to addressing the latter issues. Unlike previous NLP techniques, 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 (Wang and Cho, 2015; Zhao et al., 2023). Their ability to generate coherent and contextually appropriate responses allows for more accurate job characteristics identification. Thus, LLMs can extract more accurate semantic relationships for the well-being concept. However, since the revolution of LLMs only began in November 2022, the literature surrounding LLMs and their applicability to the labour market domain is relatively scarce. Consequently, within the realm of this paper, it is worthy of attempting to explore its potential.

2.3. Contrasting LLMs' potential contributions and academic well-being literature

As discussed, the use of LLMs in analysing data such as job vacancies appears promising for identifying semantic relationships related to the concept of well-being. However, their findings might not considerably advance the current understanding of well-being as established in the literature. Although LLMs benefit from extensive training on textual data, which enhances their ability to automate and refine text-mining processes, they may have limitations in identifying well-being patterns and dimensions that are thoroughly documented in existing research. Additionally, because LLMs are built on pre-existing academic content, they might not provide novel insights or push the boundaries of current understanding.

Therefore, it is essential to contrast these results with current academic literature to validate the findings and understand their potential contributions within the broader context of established research. Through this comparison, it is possible to construct a more comprehensive viewpoint that can help facilitate a dialogue about how the human-centred concept of well-being should be embodied. By integrating insights from LLMs with established academic findings, a more thorough understanding and application of well-being in various contexts can be achieved. The following section presents the data and methodology used to analyse employers' perspectives on well-being through LLMs and vacancy data, as well as the approach for comparing these findings with the academic literature.

3. Methodology

3.1. Data

To achieve a comprehensive understanding of the well-being aspect, substantial data is required. For this reason, a data pipeline has been established for data collection, as depicted in Fig. 1.

Data source. DC-301. A reliable data source is most important for successful data modelling results. As the saying goes, "garbage in, garbage out" will not be solved by machine learning methods; thus, trustworthy data is vital (Weyerer and Langer, 2019). As a result, it was decided to choose UK online job platforms. The UK has high internet penetration and adoption, making it a hub for online activities (ONS, 2020). Its extensive job portals provide broad coverage of the diverse job market within its economy. The job portals were selected based on the number of job advertisements, website quality (structure and the number of variables or granularity of information), and traffic ranking.² Moreover, the UK is a developed country that has been actively embracing the concept of Industry 4.0 (integration of advanced digital technologies, automation, data analytics, and the Internet of Things, etc.) (BEIS, 2019, 2020; ITA, 2022; Oztemel and Gursev, 2020). This positioning makes the UK an intriguing case study to explore the transition from Industry 4.0 to the complementary and human-centric Industry 5.0 (Xu et al., 2021).

Data collection. DC-302. Afterwards, an Ubuntu server was configured with a plethora of web-scraping scripts to collect data from various UK publicly available online job vacancy sources. The data was collected daily to weekly timetables (depending on the source) throughout the year 2022, from January to December.

Text Cleaning and Preprocessing DC-303. Raw text data obtained from web scraping underwent thorough cleaning, including removing HTML tags, special characters, and irrelevant content, to ensure accurate analysis. Data from different portals were integrated into a unified

² It is worth noting that this diversified selection of job portals was aimed at mitigating potential biases associated with focusing solely on a particular subset of occupations.

database structure. Columns and data types were aligned across different sources to ensure consistency in the database structure. Moreover, values representing the same information but formatted differently were standardised (e.g., "Full-Time" and "FT"). Given that, in principle, employers might post the same vacancy several times in the same or different job portals, duplicate vacancies are discarded. Duplicates are identified amongst vacancy announcements with the same job title, experience needs, educational requirements, localisation, wages, year, month, etc.

DC-304. After each collection and structuring, the data was stored in the SQL database within the server.

In the end, the final data set consisted of over 1.8 million observations. As discussed by different authors (Mytina Kurekova et al., 2014; Cárdenas Rubio, 2020; Napierala et al., 2022, among others), even though job portal information contains a considerable amount of data, this does not guarantee that this information is representative of the whole number of vacancies available in the economy. Given the nature of job portals, these sources might not sufficiently represent the agriculture sector or informal jobs. However, in the UK, the size of these sectors is relatively small (ONS, 2023). Thus, it is not expected that the inherent biases of job portals considerably affect this study's overall findings.

3.2. Employer modelling pipeline

Before proceeding to the machine learning phase, the collected data set was visually inspected (manually and randomly reading different job advertisements) to understand the contents and structure of the job postings. A pattern emerged through visual inspection of the vacancy database, as illustrated in Fig. 2. It became evident that certain employers only provided essential information about job requirements and necessary skills. However, another group of employers mentioned additional benefits that prospective candidates could expect. To name a few: "become a shareholder", "free sport facilities to use", "pension schemes", "autonomy", "support", "training", "safety at work", "free snacks", "mental therapist" and much more. Certainly not all, but out of many of the benefits mentioned, some could possibly be linked to the well-being aspect of a human-centric attitude towards an employee and the work environment. Afterwards, these aspects can be compared to the academic perspective (see Section 3.3 for methodology). As a result, it was decided to train a large language model to extract the well-being posting section keywords. The data modelling pipeline was constructed using five layers of data extraction and processing steps. For a visual representation, please refer to Fig. 3.

Text mining (TM) -401. Undoubtedly, the conventional NLP methods would face immense challenges in mining benefit data from job posting texts, primarily due to the intricate patterns and variations encountered in the text. For instance, role requesting "experience with CRM³ software" could be misconstrued by NLP if it interprets "CRM" as an unfamiliar acronym rather than customer relationship management.

The diversity of expressions used to convey benefits further exacerbates the difficulty, as there are countless ways in which benefits can be articulated. Thus, it was decided to work with the LLaMA LLMs and their derivatives. The LLaMA weights come in different sizes: 7B, 13B, 33B, and 65B parameters. In simple terms, the weights indicate how many configurable parameters were used in the training process of the models. The larger models exhibit higher accuracy but demand substantial computational power, which, unfortunately, comes at a significantly higher cost and is of limited use for consumer devices. Luckily, a recent paper by Dettmers et al. (2022) has developed a quantisation mechanism that allows LLMs to be loaded onto consumer Graphics Processing Units (GPUs) with little to no effect on the models'

³ CRM stands for Customer relationship management.

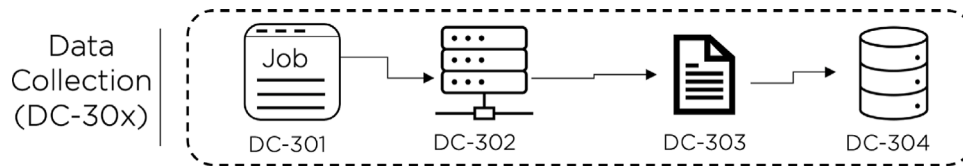


Fig. 1. Data collection pipeline.

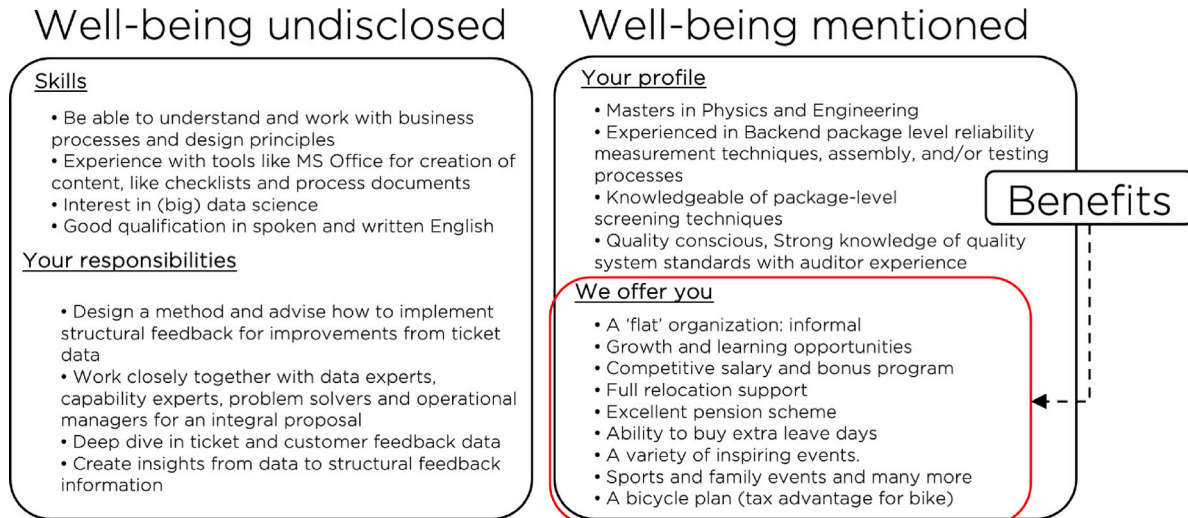


Fig. 2. A comparison of two job posting contents from two employers. Notes: On the left, an employer states the requirements and job responsibilities, while on the right, an employer not only states the required skill set but commits to providing additional benefits to promote the well-being of the employee.

ability to maintain accuracy. Nonetheless, through initial testing, it was quickly discovered that the original raw LLaMA weights of different sizes were inadequate to infer benefits. Regrettably, achieving fine-tuning of the network would have demanded substantial resources, including a minimum of six A100 GPUs for several months. Thus, a new route needed to be taken.

Instead, it was decided to tap into the LLaMA derivatives provided by other researchers who had access to significant computing power. Some trialled models are: Alpaca, Koala, Blaze, Palmyra, Camel, GPT4All. The difference between these models and the raw LLaMA weights is that they were fine-tuned with clusters of GPUs for instruction and inference. This allowed for inference operations to be understood by LLM more accurately. Although the models performed better in the benefits mining task than the raw weights, the fine-tuned derivatives were unstable in their search for human-centricity for a consistent mining operation.

TM-402. As mentioned before, fully fine-tuning the network of LLM is, in most cases, not viable using consumer devices. However, an ingenious solution was presented by Zhang et al. (2023), where Efficient Fine-tuning of Language Models with Zero-init Attention (LLaMA-Adapter) adds the learnable adaption prompts only to the topmost transformer layers. As a result, this reduces the number of trainable parameters and steers the model for better inference.

Consequently, a couple of thousand examples were randomly retrieved through visual inspection of random job postings. The latter examples comprised posting text and keyword examples that needed to be retrieved. This dataset was randomised and manually constructed. Subsequently, this dataset was used to fine-tune the Alpaca 13B model, which was trained over several epochs. It is important to understand that fine-tuning gives the LLM a framework to make a self-discovery of what empirical data might converge to after forming the boundaries of

the search space. It does not command exact word matching but rather a conceptual search.

TM-403-404. By using the fine-tuned model inference was made on all collected data. The final result of the BM-40x layer was a list of over 500k raw human-centric associated phrases and sentences.

Cluster. CL-501-504. The extracted phrases were further cleaned that resulted 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 either not very informative or were less meaningfully related to the well-being concept. Thus, it was decided to embed the 500k sentences using the "all-MiniLM-L6-v2" model to a 768-dimensional dense vector space, later reduce its dimensions and use a K-means for clustering.

The K-means clustering algorithm was chosen for its efficiency with large datasets, such as the 500k sentences in this study (Wu, 2012). It iteratively optimises clusters by minimising within-cluster variance, ensuring clear and distinct groupings. K-means is effective with uniformly scaled and structured data, which is advantageous given the similar length of sentences/keywords in the dataset. This property aligns well with K-means' requirement for balanced clusters, ensuring that each cluster represents a coherent group of sentences (Steinley, 2006). Additionally, K-means provides interpretable results through easily understood cluster centroids, which highlight common features or themes. Each sentence was assigned to a specific cluster number after the initial clustering.

CL-601-604. In the second layer of clustering, the idea was to create topics for each cluster. Thus, each sentence phrase in each cluster was vectorised using the Term Frequency - Inverse Document Frequency (Tf-Idf) method and clustered using the K-means. Furthermore, the K-means centroids were ordered, and the eight closest distance points

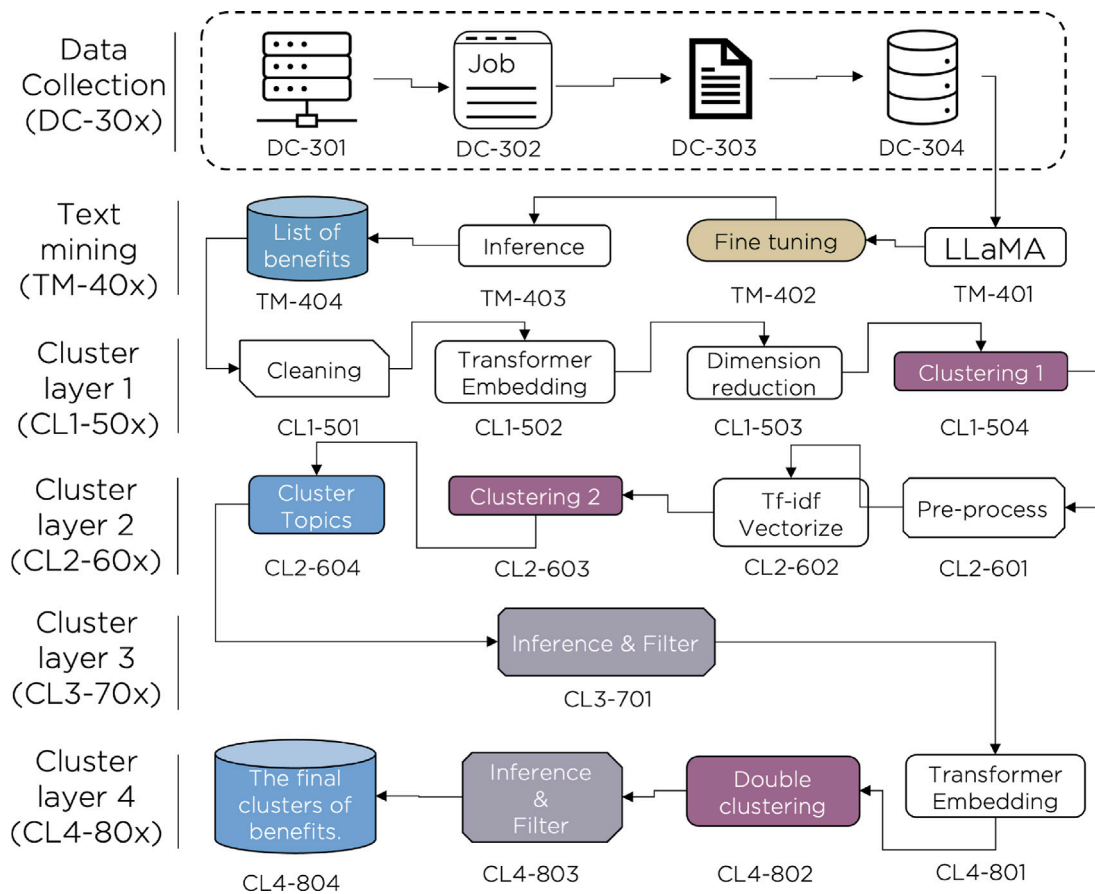


Fig. 3. Machine learning methodology for mining and conceptualising the empirical image of well-being dimension using the job-posting data.

were selected to represent the topic of that cluster. As a result, each cluster had a topic assigned to them with eight words.

CL-701. The received 3811 cluster topics from CL-60x helped understand each cluster content. However, many duplicates and less meaningful phrases to human-centric dimension existed that needed to be removed. Thus, a batch elimination was attempted by manually inspecting the topics that were not relevant, which resulted in 44k sentences. Afterwards, by sorting the received 44k topics, a clear pattern emerged that some keywords were solely health, finance or other topic-focused. For example, if a cluster consistently included keywords related to “equality for women” and “equal opportunity”, it was possible to identify and label this cluster as “equality”. Hence, it was decided to manually infer the over-arching dimensions that could group them from a macro level according to their meaning. Through careful manual examination, all the topics were effectively grouped in the following seven higher dimensions that fully embraced the intended meanings of the topics and did not overlap excessively: A - self-realisation, B - empowerment and corporate responsibility, C - infrastructure and safety, D - work-format, atmosphere, E - finance, F - health, nutrition, G - leisure, vacation. Further level details are outlined in the subsequent paragraphs.

CL-801-804. In the last part of clustering, all the previous cluster topics were deleted, and a double clustering was performed within those selected dimensions, e.g. clustering of sentences only within dimension A. By doing this, the algorithm had less noise to work with, and sub-dimensions can be further explored to micro-levels. The double clustering worked similarly to before. First, the sentence embeddings were performed when clustered using K-means, and afterwards, using Tf-Idf vectorisation, cluster topics were created using the top 8 terms.

While conducting the clustering, deciding how granular the dimensions must be was important. To generalise an employer’s well-being

perspective, three levels were established. First, the L1 level is the over-arching level that describes a group of phrases at the highest levels where each L1 dimension was referenced with capital letters, e.g. A - self-realisation, B - empowerment, etc. Second, the level L2, within each L1 dimension, attempts to group phrases into separate categories using respective capital letters and numbers, e.g. A1 - volunteer, A2 - family, B1, etc. Finally, level L3 had many topics within L2 levels and were named using capital letters and two numbers, e.g. A11. Differently, from the highest dimension topics that were manually inferred, the L3 dimension topics were auto-generated with keywords and were not edited. In the aftermath, each dimension had sentences with cluster numbers and cluster topics. Each cluster topic was assigned different levels of A, A1, and A11, and each level was given the appropriate topic name according to cluster topics.

3.3. Academia modelling pipeline and comparison with employers’ viewpoint

The collected phraseology in Section 3.2 offers valuable insights into the employer’s viewpoint, potentially shedding light on their priorities. Nevertheless, as mentioned in Section 2.3, it is vital to contrast how Industry 5.0 well-being concept realisation in academic literature differs from today’s employers’ viewpoint, emphasising the overlaps and gaps.

As such, it was decided to collect scientific papers mentioning Industry 5.0 and human-centricity keywords in the paper’s title, abstract or keyword section, as shown in Fig. 4. This process led us to find a total of 72 articles.⁴ Afterwards, all the textual information of the papers

⁴ The Scopus keyword search was conducted using the following patterns: title-abs-key(“Industry 5.0” AND (“human centricity” OR “human-centricity” OR “human-centric”).

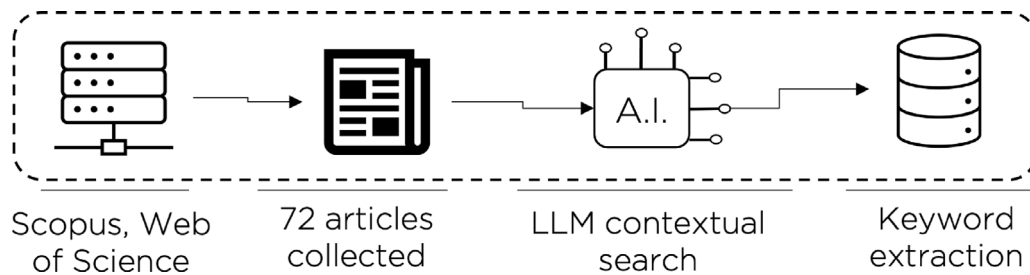


Fig. 4. Academic well-being keyword retrieval pipeline.

was retrieved and again used LLM contextual search abilities to detect well-being-related phraseology. The keyword extraction resulted in 271 keywords that were the epicentre of human-centricity discussion in the collected papers.⁵ After removing the duplicates, a total of 89 keywords remained.

Furthermore, in Section 3.2, the L1 dimensions were empirically generated solely for the employers' perspective, which might not encompass all the required dimensions for the academic part. To address this limitation, it was decided to adopt the Swarbrick and Yudof (2015) wellness model, which was built upon Hettler's wellness framework (Hettler, 1980, 1984) and has the following eight dimensions: emotional, physical, occupational, social, intellectual, environmental, financial spiritual. The decision to adopt the Swarbrick and Yudof (2015) model over other frameworks was based on its comprehensiveness and alignment with the academic context. The model builds upon Hettler's wellness framework, which has been widely recognised and utilised for its holistic approach to well-being. By incorporating eight dimensions, this model covers a broad spectrum of aspects contributing to an individual's overall well-being.

As a result, the clustered employers' L2 dimensions were manually aligned with the most relevant dimensions in the Swarbrick model, as was done for the academic phraseology. The alignment was done by carefully inspecting each dimension's description provided by Swarbrick and Yudof (2015). For instance, according to Swarbrick and Yudof (2015), and Swarbrick (2023), the financial dimension is described as satisfaction with current and future financial situations. Thus, salaries, remuneration plans, and welfare were added under this category.

It is worth mentioning that the proposed framework has certain limitations as the lines between categories can become blurry at times and may better fit one perspective than the other. They are also subject to interpreting what should be embodied by each category. Thus, if certain keywords had multiple meanings, they were distributed to more than one dimension. Nonetheless, the proposed framework provides structure and ensures a standardised evaluation, facilitating valuable insights into the potential overlaps and gaps between the academic and employers' viewpoints.

4. Results

4.1. Well-being dimensions identified through job postings analysis

The ML pipeline was deployed in May 2023, and it took around 24 days to mine the full list of benefits for the BM-40x part. The clustering part was finished within one week, and most of the time was spent cleaning and deciding the correct level names and their dependencies. Seven L1 dimensions were obtained, each having its own distinct characteristics and serving as placeholders for employers' expressed well-being benefits. The seven dimensions incorporate a plethora of diverse aspects of well-being, spanning from monetary and financial benefits to encompassing mind and body aspects like health,

meditation, yoga, and purpose. In terms of size, the A - Self-realisation was the most varied dimension, with 12,053 sentence phrases in total. Then followed E - Finance and D - Work-format, atmosphere dimensions with 6409 and 5758, respectively. The smallest one was B - empowerment and corporate responsibility. While the keyword size does not definitively confirm that self-realisation virtues were the most important dimension among those gathered, its frequent appearance in many job postings does indicate that employers highly value and prioritise this dimension. See Fig. 5 for a visual representation of each dimension.

The visualisation provided in Fig. 5 concisely depicts the well-being dimensions from a macro point of view. However, for deeper understanding, it was decided to make a hierarchical graph along with a meta-table for each dimension, e.g. the self-realisation dimension is represented by Table 1 and Fig. 5. The purpose of the hierarchical graph is to offer insight into the dimension content, while the table acts as a further descriptor of what is recorded within the dimension. The numbers near the branches of hierarchical graphs represent employers' total count of sentence phrases. Each branch ends with a topic cluster example for that level.

Meaningful work and self-realisation play a crucial role in promoting well-being in the workplace. As found by Glavinska et al. (2020), self-realisation is a significant factor in forming individual components of psychological well-being. It could also act as a buffer against stress and increase work engagement, commitment, and job satisfaction (Allan et al., 2011; Blake et al., 2018).

Unsurprisingly, this dimension was reflected in job postings, where employers increasingly emphasise the alignment of individual passions, personal growth, and meaningful contributions within their organisations, as shown in Fig. 6. On level A1, employers recognised the importance of volunteering work and fostered such behaviour by dedicating a certain amount of working hours to helping communities, the environment and others in need of support. Most importantly, the companies paid the volunteering work at working hour rates. Research suggests that volunteering work can positively contribute to job meaningfulness and that the pull of meaningful volunteer work was even stronger when employees had less meaning in their jobs (Rodell, 2018).

Employers acknowledged the significance of prioritising family commitments and that family is pivotal for many individuals. Hence, the A2 level was incorporated into job postings to accommodate these needs. In Fig. 6, two important branches have been established for the family (A2) level: support (A21) and atmosphere (A22). The prior was signalled through shared or paid maternity and parental leave opportunities. The leave benefits were also offered to be enhanced through increasing duration length and generous pay-outs in addition to the state compensations. Other ways of support offered were through on-site childcare, childcare on holidays, free childcare zones, parenting programmes, domestic support, assurance of childcare costs, and toddler groups. Employers also signalled the general atmosphere supporting the family (see Table 1). Assistance with childcare and family leave policies have shown lower levels of role conflict and engagement in work and non-work domains (Vaswani et al., 2001;

⁵ For full keywords please refer to Table 3.

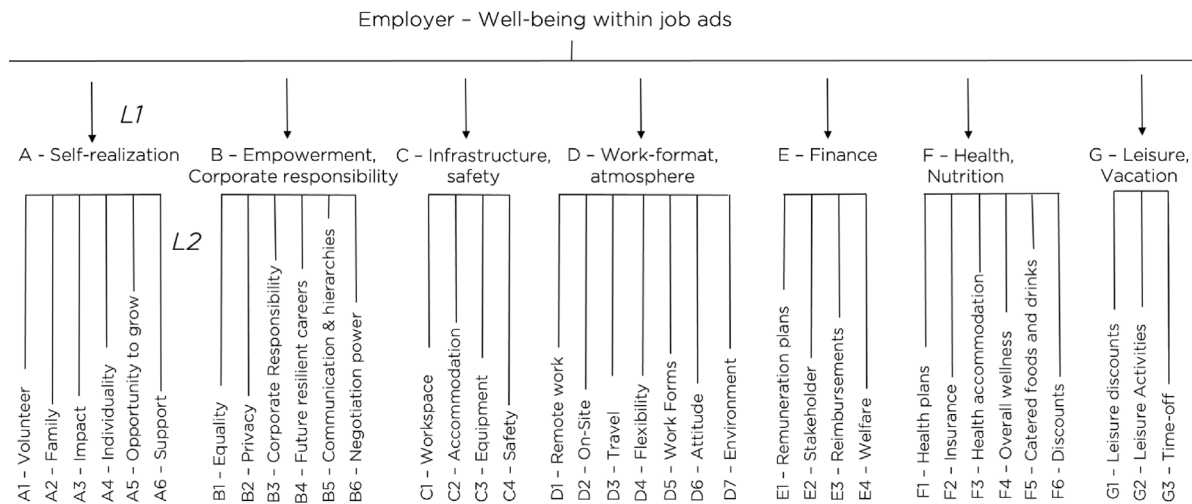


Fig. 5. Employer well-being dimension and its levels discovered using the job postings and machine learning pipeline. Notes: Each dimension incorporates phrases employers use to signal certain values, benefits or virtues. L1 level consists of 7 dimensions, and L2 consists of 35 dimensions.

Beauregard and Henry, 2009). There is also standing evidence of a spill-over effect from business to family and family to business (Glavinska et al., 2020). Dangerous loops can occur, where poor work-family balance induces conflicts in the family and conflicts in the family can further hurt work performance.

The subsequent branch levels, A3 and A4, further embody the self-realisation dimension through impact and individuality. Research by Hu and Hirsh (2017) shows that workers are more likely to take lower pay when engaged in meaningful work. This evidence demonstrates the significant impact of work with a purpose on employee satisfaction and motivation. This meaningfulness concept was signalled by employers through phrases like positive impact on society, making an impact at your city, or role with impact for the A3 level.

Furthermore, on the A4 level, Individuality was signalled with phrases like plenty of room for your own creativity and initiative, space to develop oneself further, room to make choices within your own work, freedom to initiate changes and suggest new approaches, space and freedom to innovate and construct new ideas, freedom to implement best ideas. As discovered in the literature section, having a higher level of control of one’s environment had a significantly better health outcome overall (Spell and Arnold, 2007; Karasek, 1990).

The A5 (opportunity to grow) and A6 (support) levels emphasise providing employees with opportunities for personal growth and showcasing how others can support their work. Personal growth has been linked to healthy workplace practices, better work satisfaction and less stress (Grawitch et al., 2006). Employers signalled their commitment to personal growth through offerings such as career and training opportunities, as well as providing free courses and seminars. In the career-focused A5 level, employers specifically highlight the existence of a career development path that can lead to advancement into more prominent positions within the company. Tangent to personal growth, level A6 offered other supporting mechanisms like the personal budget that can be individualised for training or mentorship programmes. As reported by Wen et al. (2017), mentorship has been associated with higher levels of life satisfaction through psychological safety, while personalised budgets can help employees have more control over their careers.

A subsequent important dimension is empowerment and corporate responsibility, as depicted in Fig. 7. Here lies an important principle of equality in terms of age, race, gender and other aspects (see B1 in Fig. 7). Employers expressed a deep commitment to eradicating discrimination in their hiring practices and are dedicated to fostering a work environment that values diversity and inclusivity, which has a strong impact on the overall well-being (Wilks and Neto, 2013).

Furthermore, the absence of privacy has been identified as contributing to increased stress, primarily due to environmental control mechanisms that can influence stress levels (Veitch, 2011). Employers signalled the care for privacy through confidentiality measures on level B2.

Employers have also tried to express whether they are aligned with corporate responsibility practices related to environmental conservation on level B3 by offering perks such as electric bike allowances, carpooling incentives, etc. This reflects a growing emphasis on environmental responsibility and eco-friendly practices within organisations.⁶ A study by Ahmad et al. (2023) found that corporate social responsibility is negatively linked to employee burnout, thereby enhancing overall well-being. Certain reports by WEF (2021) also raise attention that employees suffer from eco-anxiety (extreme worry about current and future harm to the environment caused by human activity and climate change) and view sustainable companies more favourably.

From an employers’ perspective, the future-resilience careers⁷ aspect at a workplace was understood as a means of ensuring job security and future-proof employment for an employee. Research indicates that job security positively affects the well-being of an employee (Abdelmotaleb and Saha, 2013; Green and Leeves, 2013). In addition, certain employers preferred flat hierarchical lines, open communication, and short decision lines to empower the worker and offered union support when negotiating salaries (see levels B5 and B6). The latter was signalled through phrases like “short communication lines with staff and managers”, “flat organisation structure”, “salary in accordance to collective agreement”. Evidence suggests that preventing staff from speaking their mind can stop companies from achieving their strategic goals and make them feel less valued, while weak salary negotiation positions can create negative well-being effects (Parke and Seo, 2001; Haddon, 2018; Bryson et al., 2013).

⁶ This dimension does not aim to measure the Industry 5.0 sustainability pillar. Instead, Industry 5.0 sustainability involves a comprehensive and systemic approach, using advanced technologies such as artificial intelligence and smart robotics. These innovations are designed to enhance operational efficiency, minimise waste, and optimise resource use in company processes (European Commission, 2023).

⁷ It is important to distinguish that future-resilient careers focus on future-proof employment and long-term job security, while resilience in Industry 5.0 refers to the robustness and adaptability of companies’ systems to withstand disruptions through advanced technology and sustainable practices (European Commission, 2023). Although these concepts may be related, they do not necessarily imply one another.

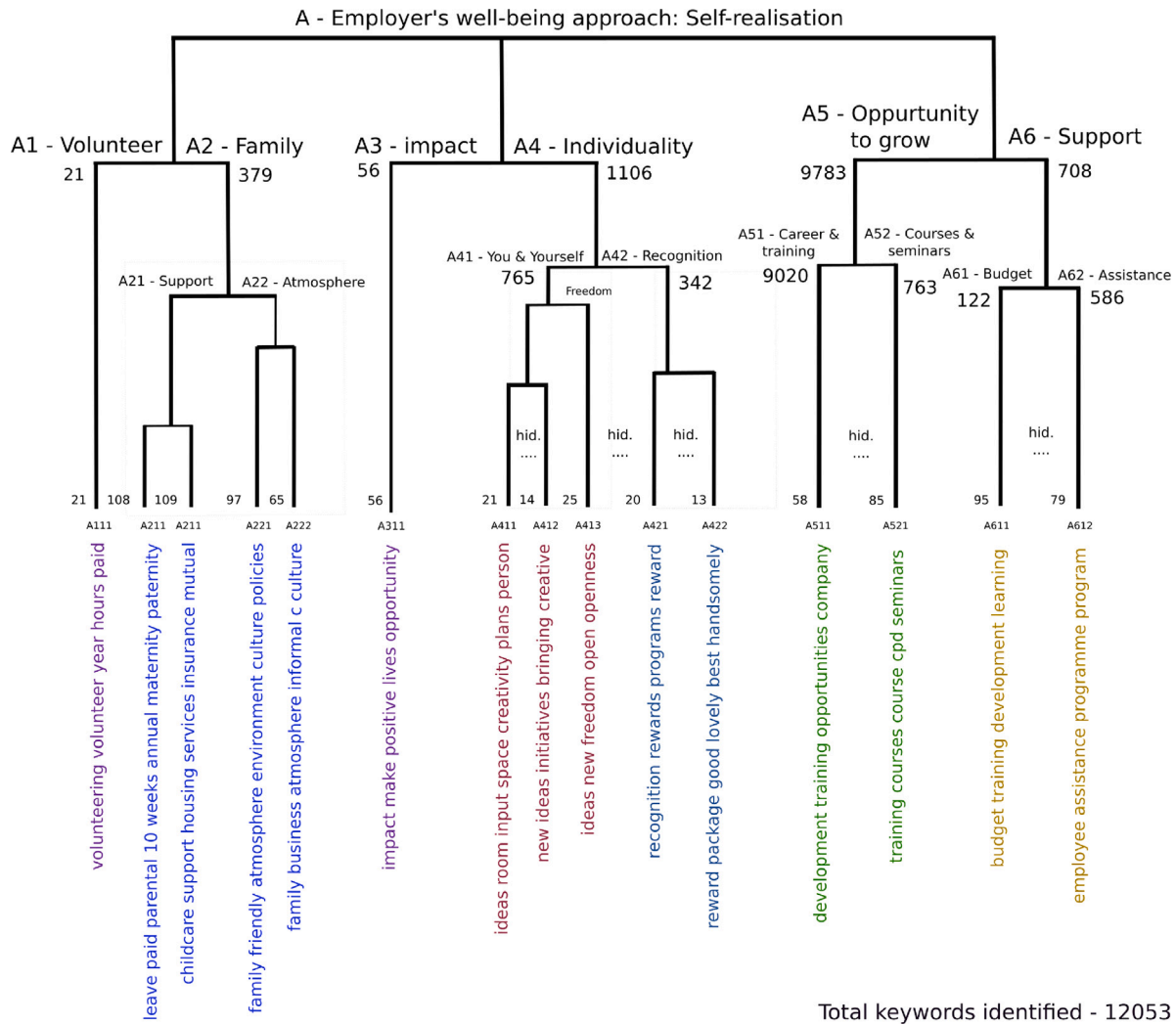


Fig. 6. A hierarchical map of self-realisation dimension. Notes: The branch output, e.g. A111, depicts cluster topic centroids. The abbreviation of hid. refers to many hidden topics that are not possible to depict due to its large size. The numbers near the levels represent the number of sentences or expressions recorded for that level.

The third discovered dimension was related to infrastructure and safety (see Fig. 11⁸). Sustaining physical damage due to equipment-related incidents has severe negative side effects on one's mental health. Thus, employers explicitly stated their commitment to compliance with safety regulations, affirming their dedication to following established safety protocols and regulations on level C4 (Grawitch et al., 2006). In addition, much attention was paid to workspace location and reachability. Evidence suggests that long commuting times and no parking might hinder certain aspects of well-being (Iftikhar, 2017). Employers also offered climate-friendly mobility with bikes and ticket schemes. Furthermore, a recent study has shown that rental and other housing costs can have an extreme financial burden on one's mental health (Shamsuddin and Campbell, 2022). Thus, accommodation benefits employers provide on level C2 can have a life-changing effect. Similarly, companies highlighted that they would provide necessary equipment for work, from phones and laptops to transportation.

⁸ To accommodate the extensive number of dimensions identified on the employer side, it was decided to put the hierarchical graphs in the Appendix and to omit the descriptive tables of each dimension. This does not imply that one dimension holds more value than others, but rather, it is a measure taken to prevent the paper from becoming excessively lengthy.

Employers were also considerate regarding work arrangement issues and atmosphere (see Fig. 12). Much attention was paid to remote work and on-site options. Evidence is complicated as to whether remote or in-office work is better for the well-being. Chevtavaeva et al. (2023) and Fan and Moen (2023). Likewise, the studies have mixed results regarding flexible work, scheduling, and finishing tasks according to one's timetables (Hartner-Tiefenthaler et al., 2023). Nonetheless, having options is preferable, and employers were willing to accommodate these needs on D1 to D5 levels.

The epitome of stress often concerns financial situations (Mensah et al., 2023; Baquero, 2023). As shown in Fig. 13, to soften the burden, employers signalled various schemes for how employees can benefit from their financial circumstances through remunerations, reimbursements, and bonuses. Certain companies were eager to share profits and provided financial guidance to assist with money management, savings, and utilising tax benefits. Employers were also eager to think long-term and provided pension schemes and payment frequency options for struggling individuals.

A considerable amount of attention in the job postings was also paid to the health amenities and nutrition (see Fig. 14). Affordable healthcare can contribute to subjective well-being. Thus, employers were eager to suggest health plans and insurance schemes (Kim, 2021). Furthermore, the importance of disability accommodation was prominently emphasised, as shown in Fig. 14, level F31. Moreover, evidence

Table 1

A – Self-realisation.

L1	L2	L3	L3 description	In sentence examples
A – Self realisation	A1 – Volunteer	A11 - Volunteer	Some employers had designated programmes for volunteering work to help employees do valuable community work. Such activities are great for self-exploration and personal happiness. Most importantly, the volunteer work will be paid for by the company. Different volunteering schemes and programmes exist.	<ul style="list-style-type: none"> - 24 h per year that can be used for voluntary projects. - Paid volunteer work. - Three dedicated volunteer days. - Corporate volunteering hours. - Paid volunteering time (up to 16 h per year).
		A21 – Support	Employers expressed support for job candidates with families. The support came in generous parental leaves, parental policies, child-care protection, subsidies for children, and childcare zones.	<ul style="list-style-type: none"> - Generous annual leave entitlement. - Childcare services for children aged 15 months to 6 years with ALPLA Kids. - Free childcare zone. - Annual leave of 4%.
	A2 – Family	A22 – Atmosphere	Another way family endorsement was signalled was through phrases promoting a family-friendly environment, culture, values, atmosphere, or even domestic support. Several companies went further and obtained certification as family-friendly organisations.	<ul style="list-style-type: none"> - Good family atmosphere. - Family-like atmosphere and culture. - Domestic support. - Certified as a family-friendly company. - We swear by our family working atmosphere.
		A3 – Impact	A31 - Impact	Certain employers emphasised that work done within the company will not be mundane but will have a real impact that an employee could be proud of. In turn, this can contribute to self-realisation and a deep sense of fulfilment at the workplace.
	A4 – Individuality	A41 – You and Yourself	Job postings prioritise creativity, freedom, and innovative thinking. Opportunities to implement innovative ideas, and even encourages questioning and improving existing practices.	<ul style="list-style-type: none"> - Space for creativity and open to further developments. - Creative and challenge the status quo by bringing new ideas. - Open to hearing and implementing new ideas.
		A42 – Recognition	Employers proposed various initiatives such as award ceremonies, schemes, and programmes to ensure employees feel valued and appreciated for sharing their ideas.	<ul style="list-style-type: none"> - Handsomely rewarded. - Recognition awards. - Recognition of efforts and contribution. - Global awards and nominations. - Peer recognition and rewards programmes.
	A5 – Opportunity to grow	A51 – Career and training	Job postings emphasised career progression and training opportunities. Employers highlighted the existence of career advancement paths, allowing employees to grow and avoid being stagnant in one position. They highlighted the importance of training activities supported by personal budgets or organised by the company, encouraging applicants to pursue further training.	<ul style="list-style-type: none"> - Continuous development opportunities and a personal training budget. - Training is fully funded as part of the work-study programme. - Professional training and education. - Diverse training and development opportunities within the company. - Opportunity for career advancement advice and guidance. - Career development and progression opportunities.
		A52 – Courses and seminars	To achieve personal growth, seminars and courses will be provided that are paid for by the companies.	<ul style="list-style-type: none"> - Sponsored online courses. - Training courses offered by the company. - The possibility of following courses and training.
	A6 - Support	A61 - Budget	The growth support was also provided in the form of a budget from the employers that allow employees to choose their own path of development rather than taking firms organised courses.	<ul style="list-style-type: none"> - Personal learning budget (2000 Eur/year). - Visa sponsorship. - Budget for professional development. - Budget for the employee's education.
		A62 - Assistance	Employers mentioned mentorship, guidance, resource groups, and networking to support employees. They emphasise leveraging top performers' expertise and experience to benefit newcomers joining the company.	<ul style="list-style-type: none"> - Access to an employee assistance programme. - Employee resource groups for networking and support. - Opportunity to network with like-minded individuals. - Coaching from experienced developers, where necessary. - Mentoring assistance from a senior member of staff.

suggests employers can meaningfully contribute to work-life benefits through their policies, fitness facilities and programmes, and wellness programmes (Beauregard and Henry, 2009; Sirgy and Lee, 2018; Sakuraya et al., 2022). In response, employers were willing to adopt proactive measures by hiring company doctors and providing accessible mental health support services.

On the F6 level, employers offered various meal discounts by giving restaurant vouchers or tickets. Employees can access a broader range of choices through meal subsidies. It incentivises employees to take regular breaks from work, fostering opportunities for socialising and team building. In addition, when all employees can afford various foods, it promotes a sense of equality within the workplace. Furthermore, although subsidising certain aspects of foods and activities is beneficial,

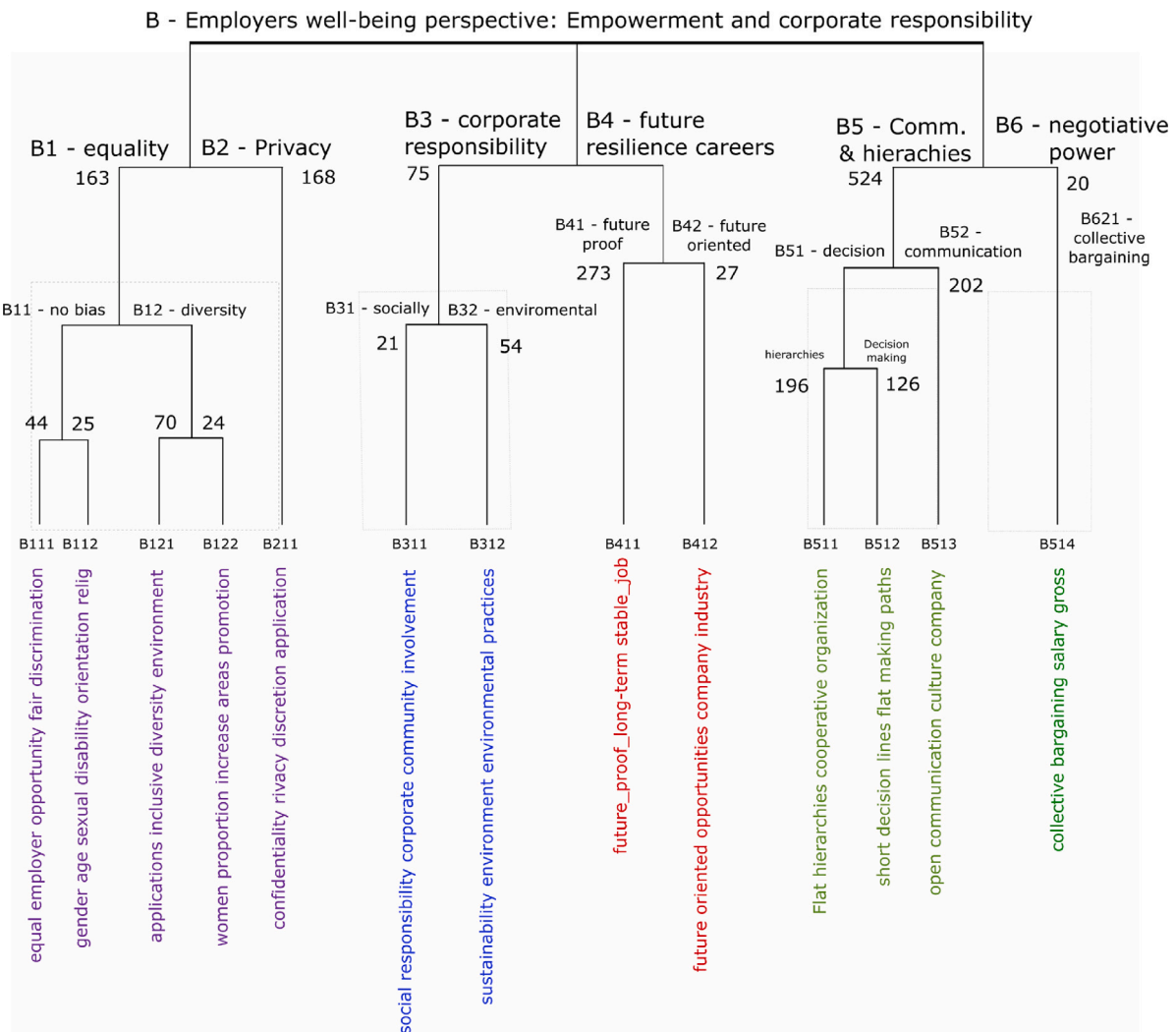


Fig. 7. A hierarchical map of empowerment and corporate responsibility dimension. Notes: The numbers near the levels represent the number of sentences or expressions recorded for that level. The branch output, e.g. B111, depicts cluster topic centroids. The abbreviation of hid. It refers to many hidden topics that are impossible to depict due to its large size.

some employers were eager to provide free meal and drink experiences (see level F5).

Last but not least is the leisure and holiday/vacation dimension (15). Balancing work, having time off, and relaxing with co-workers or friends helps prevent burnout and reduces stress and exhaustion. Employees can prioritise self-care through exercise, nutrition and sufficient rest (Sirgy and Lee, 2018) when given personal time. The latter also compensates unsatisfactory activities within work with satisfactory activities outside, thus keeping a healthy mind balanced (Sirgy, 2002). Most importantly, there is a limit to a person’s satisfaction from one domain. Thus, being involved in other life activities is useful for an employee to stay focused, positive and productive (Sirgy and Lee, 2018; Diener et al., 2008).

The employers signalled such relaxation and leisure activities in the job postings depicted in Fig. 15. On the G1 level, employers aimed to provide discounts on sports and other fitness activities. The latter can help deal with stress and reduce the chances of over-burning (Sakuraya et al., 2022). As depicted in level G2, employers in the job postings descriptions promised team events, adventures, BBQ parties, hiking, sports games like darts, soccer, karting, cultural outings, employee parties and other recreational activities. Likewise, the purpose of level G23 is to provide infrastructure for such activities.

Concerning the G3 level, two types of time-offs were detected. First, conventional holidays/vacations are legally binding to state law, but their conditions vary as employers can address the bare minimum requirements or be more generous. This category includes flexible vacation schedules, school closing days, replacement opportunities, attractive holidays in the company’s resorts and other holiday entitlements. In addition, certain employers have implemented unlimited holiday schemes, wherein employees who efficiently complete their required tasks are granted the flexibility to take additional vacations. This benefit may not be viable for many professions, but this could be an invaluable proposition for certain specialists who can automate workflows. On the other hand, differently from conventional vacations, some firms provided additional rest days, see level G32, in various forms: free day from work on birthdays, the possibility to have a four-week day, extra days off, Monday rest day, ability to buy extra holidays, purchase extra leave and much more. These small conveniences amplify personal autonomy, enhancing subjective well-being (Wheatley, 2017).

To sum up, the development of the ML pipeline based on LLM marked a significant step forward in uncovering the dimensions of employers’ expressed well-being benefits, which would otherwise be too complex to detect and analyse via other means. These findings provide a comprehensive picture of the dimensions that shape employers’

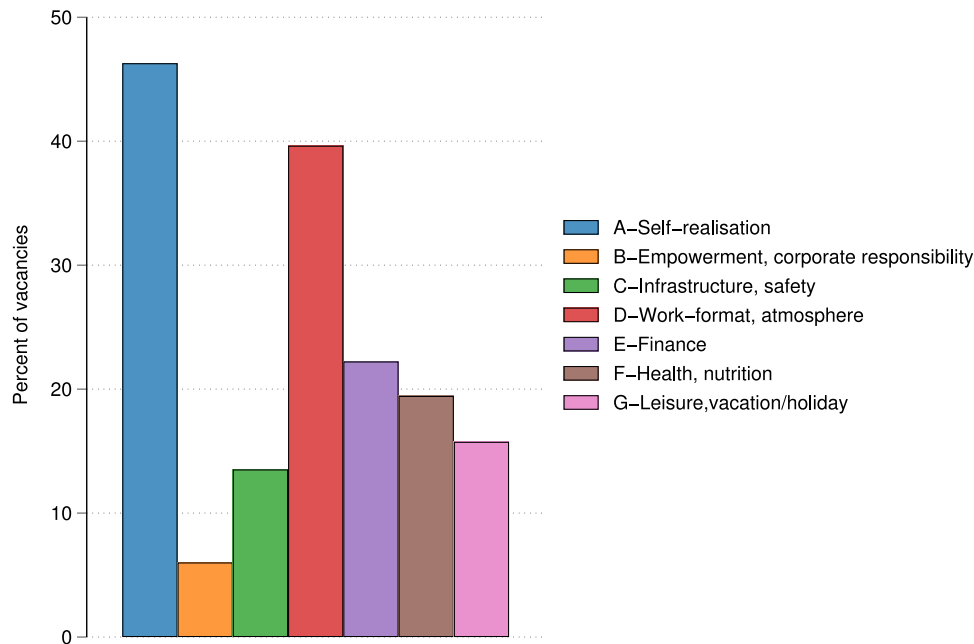


Fig. 8. Share of vacancies by dimensions - L1.
Source: Vacancy data. Own calculations.

perspectives on well-being, laying the foundation for a more holistic understanding of Industry 5.0 workplaces.

4.2. Distribution of well-being patterns in the UK vacancies by dimensions

After identifying potential well-being patterns and forming clusters, the percentage of UK vacancies that explicitly referenced these patterns was estimated. Fig. 8 depicts the distribution of vacancies mentioning pattern-related across the seven macro dimensions highlighted in Section 4.1. Among these dimensions, A-self-realisation stands out as the most commonly mentioned (46% of vacancies mentioned patterns/sentences related to this dimension), followed by D-Work-format, atmosphere (39%), and E-Finance dimension (23%). In contrast, the least frequently mentioned dimensions are B-Empowerment, corporate responsibility, and C-Infrastructure, safety accounting for only 6% and 13% of the total vacancies, respectively.

Fig. 9 illustrates the prevalence of sub-dimensions at the L2 level mentioned in the UK job vacancies. Approximately 36% of the vacancies refer to patterns related to the A51-career training sub-dimension. This particular sub-dimension stands out as the most frequent one because job vacancies in the UK commonly mention some training opportunities will be provided at the beginning of the job. The D42-caring sub-dimension is also frequently mentioned in job vacancies. Employers frequently mention phrases such as “supportive team”, “friendly team”, “team lead”, and “teamwork”, among others. Thus, this evidence confirms that self-realisation (via offering training opportunities) and work format (via offering a friendly/team environment) are prioritised by employers to attract job seekers.

Importantly, the data reveals that around 27% of job vacancies in the UK did not explicitly mention any terms or patterns associated with well-being from the dictionary. This finding highlights that for a substantial portion of employers, the human-centric aspect of well-being may not be a prominent consideration when posting job advertisements. This insight offers valuable implications for understanding the priorities and perspectives of employers regarding employee well-being in the job market.

While Industry 5.0 is often associated with manufacturing, its principles and benefits are not limited to this area alone (Skobelev and Borovik, 2017). Industry 5.0 emphasises human-centric approaches, collaboration between humans and machines, and sustainability, which have broad applications across various economic activities. For example, in healthcare, Industry 5.0 fosters the integration of AI and human expertise to enhance patient care and address ethical considerations (Gomathi et al., 2023). In the retail sector, it enables personalised shopping experiences through advanced AI and human creativity (Lyu et al., 2024). Therefore, Industry 5.0's focus on enhancing human-machine collaboration and sustainability is relevant and transformative across multiple economic areas.

To provide a comprehensive picture of how elements of Industry 5.0, such as well-being, are considered in different economic activities, Table 2 presents the distribution of UK job vacancies across various occupations according to the SOC2020 classification (Standard Occupational Classification) at one-digit level,⁹ detailing the percentage of vacancies that mention different well-being dimensions (A: Self-realisation - G: Leisure, vacation/holiday). Each occupation category includes the total count of vacancies, along with the percentage breakdown for each well-being dimension.

“Professionals” and “Associate professionals” categories have the highest total number of vacancies, with 604,751 and 310,493 vacancies respectively. Vacancies for “Associate professionals” show a strong emphasis on A-Self-realisation, 56.5% of vacancies mentioning this dimension, which suggests that roles within these occupations heavily focus on personal development and fulfilment. Similarly, the “Sales and customer service” category, although having fewer total vacancies (68,193), also places a high emphasis on self-realisation, with 58.7% of vacancies mentioning this dimension. On the other hand, the “Administrative and secretarial” and “Professional” categories show a lower emphasis on self-realisation.

⁹ Classification methods, such as machine learning algorithms, developed in Cárdenas Rubio (2020) were implemented to classify job titles into occupations.

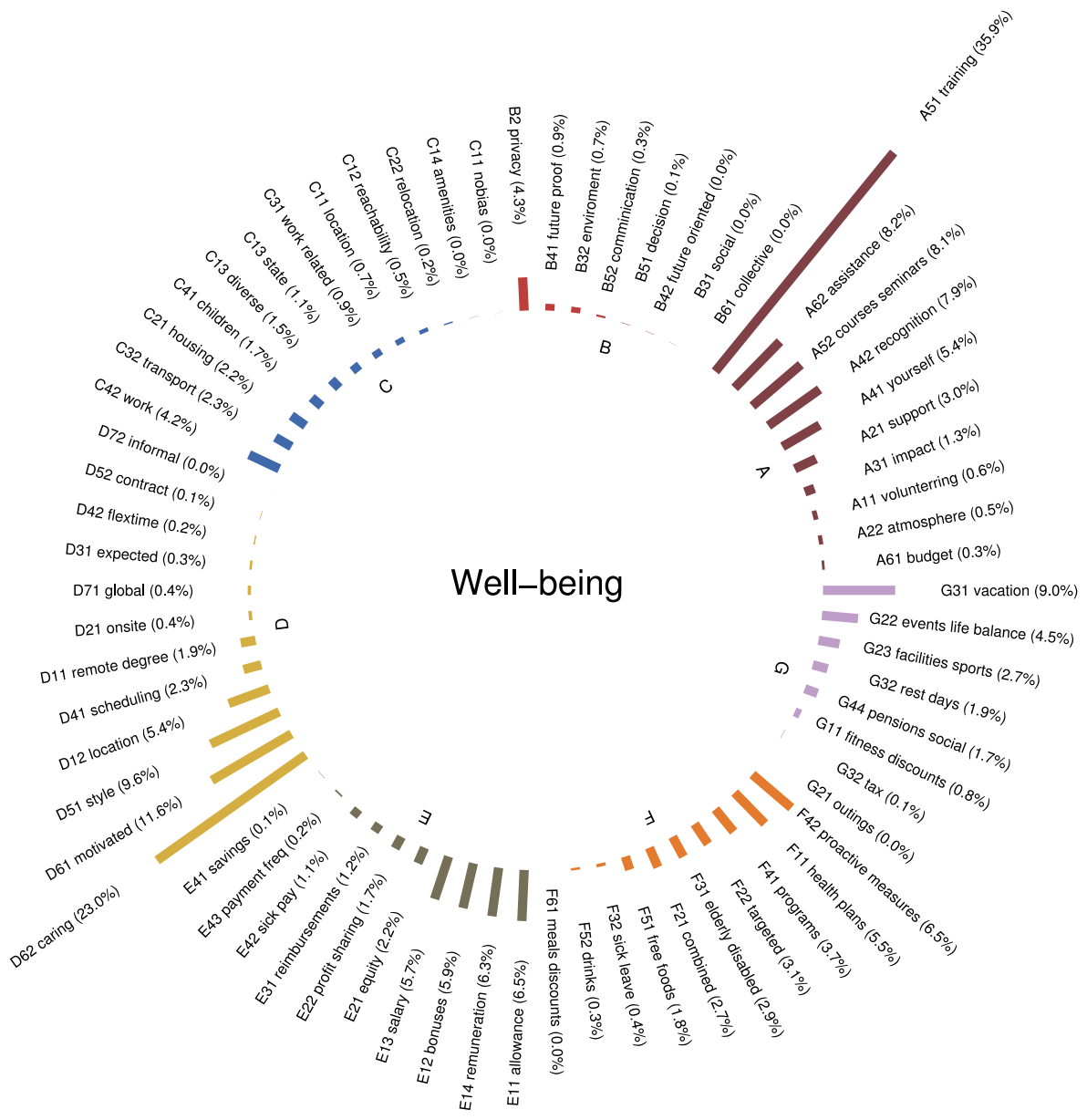


Fig. 9. Share of vacancies by sub-dimensions-L2. Source: Vacancy data. Own calculations.

In contrast, the dimension related to C-Infrastructure, safety is notably emphasised in the “Process, plant and machine operatives” (21.0%) and “Elementary” (21.1%) occupations. This reflects the importance of Infrastructure and safety conditions in these roles. Overall, the table shows a diverse distribution of well-being dimensions across different occupations, indicating that the focus on well-being aspects varies considerably depending on the nature of the job. This underscores the evolving priorities in the job market, where different roles emphasise distinct elements of employee well-being.

Fig. 10 shows the monthly percentage of vacancies referencing well-being patterns across the seven macro dimensions outlined in Section 4.1 from January to December 2022. The category of A-self-realisation consistently leads, beginning at around 40% and peaking at approximately 61% by August 2022. This upward trend suggests a strong and increasing emphasis on jobs that offer personal fulfilment and growth. The category of D-Work-format and atmosphere also shows

a notable rise, starting at about 31% and stabilising around 55% by the end of the year. This suggests that employers are placing greater importance on flexible work arrangements and positive workplace environments.

In addition to these trends, the E-Finance category exhibits significant growth, starting from 15% and reaching around 31% by the end of 2022. Other categories, such as C-infrastructure and safety, B-Empowerment and corporate responsibility, and F-health and nutrition, also show upward trends, although they represent a smaller percentage of the vacancies. Overall, this indicates that job vacancies are increasingly incorporating elements of well-being, reflecting the evolving expectations and priorities in the job market. These findings align with the observations of Kowalski and Loretto (2017), Fleming (2024) and CIPD (2022), who indicate that fostering employee well-being is gaining importance for numerous employers in the UK, both within and beyond the workplace.

Table 2
Share of vacancies by occupations and (L1) dimensions.
Source: Vacancy data. Own calculations.

Occupations (SOC2020)	Total	Classification (in %)						
		A	B	C	D	E	F	G
Managers, directors and senior officials	106,456	54.6	7.7	13.5	39.3	27.0	17.1	16.6
Professional	604,751	39.9	5.3	9.0	37.2	17.4	20.2	11.7
Associate professional	310,493	56.5	7.0	12.9	44.5	27.8	18.3	18.4
Administrative and secretarial	186,441	39.0	6.7	11.1	40.2	16.7	14.1	14.8
Skilled trades	107,729	51.3	7.4	19.6	31.9	28.8	21.1	19.3
Caring, leisure and other service	157,518	49.8	5.2	13.8	41.8	23.1	31.0	15.3
Sales and customer service	68,193	58.7	6.3	10.8	48.9	36.0	17.1	30.6
Process, plant and machine operatives	70,616	48.7	5.5	21.0	39.0	19.2	11.4	15.6
Elementary	85,236	49.8	4.2	21.1	38.3	23.1	17.5	20.1
Non-classified	103,709	49.1	6.0	14.0	41.8	20.7	17.6	14.3
Total	1,801,142							

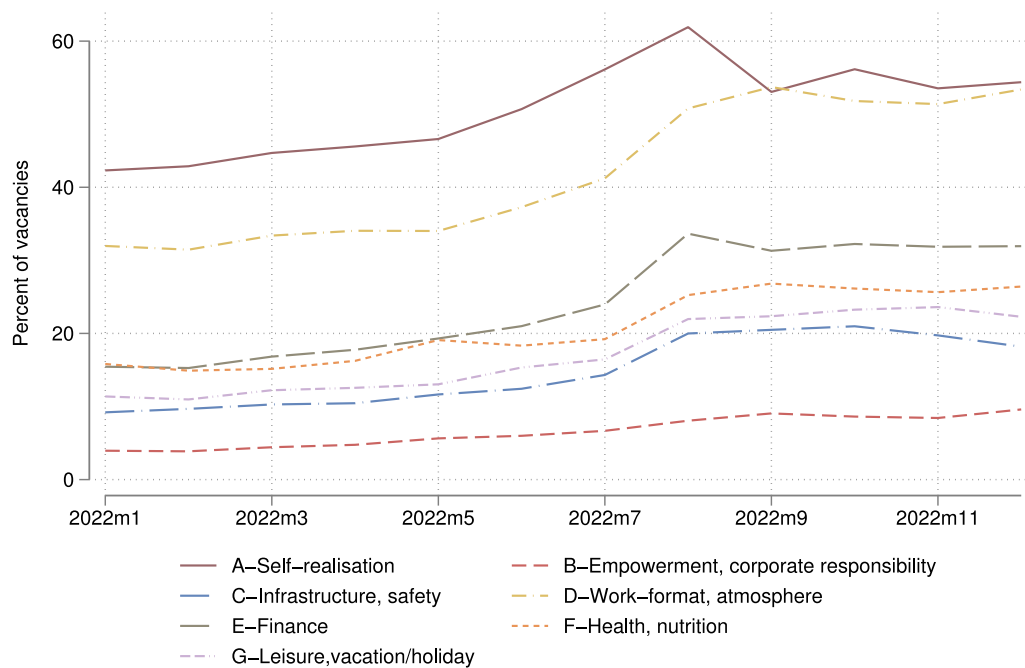


Fig. 10. Monthly percentage of job vacancies mentioning well-being dimensions (L1) (January 2022–December 2022).
Source: Vacancy data. Own calculations.

4.3. Comparing employers dictionary with the academic syllabus

The collected clusters of keywords in Section 4.1 are an important part of understanding the employers’ well-being perspective. However, it is crucial to compare the L2 dimensions with the academic literature to determine whether all L2 clusters can genuinely be regarded as integral components of Industry 5.0 well-being. Table 3 depicts the academic and employers’ phraseology according to the Swarbrick and Yudof (2015) eight-dimensional well-being model (See Section 3.3 for details on the search strategies used in the literature review for the academic comparison).

The comparison table corroborates that the dimensions identified in Section 4.1 are aligned with the evidence provided by the literature. However, it also sheds light on a crucial aspect of well-being that academia might have overlooked. For instance, academics have emphasised that, on the emotional level, a worker in Industry 5.0 should be associated with feelings of health and safety. Considerable emphasis was placed on mental health, recognising that working with machines can sometimes lead to feelings of loneliness. Burnout and other psychological disorders were also mentioned as many technologies anchor Industry 5.0 workers to be connected to technology 24/7.

Most importantly, a generally positive attitude and personal happiness should be at the core (Rožanec et al., 2022; Kaasinen et al., 2022; Cillo et al., 2022).

In parallel, from an employers’ perspective, the mental health issues were addressed through mental aid resources, counselling and other support measures (see F4). A positive working environment and attitudes were encouraged on the D6 level. Differently from academia, employers recognise the need for family emotional support on level A2, which considerably influences the overall mental well-being of the worker. However, academia recognised the danger of unethical use of wearable devices that might cause emotional stress of being constantly monitored, which was lacking on the employers’ side.

On the physical level, the health of an operator was mentioned in different journals, suggesting following occupational safety guidelines and taking precautionary measures for burnouts (Tran et al., 2022; Cillo et al., 2022; Orso et al., 2022). On the other hand, many employers have also communicated strong values of promoting and sustaining workers’ health through healthcare plans, insurance schemes, and health promotion. They also emphasised nutrition, one of the most important elements of sustaining people’s health. The latter part was lacking in the academic literature. Employers also addressed physical burnout by offering adequate rest days and vacation schemes.

Table 3
Comparing human-centric well-being findings in academic literature with employers' perspectives.

Dimension	Academia	Employer
Emotional	Satisfaction; Feeling safe; Feeling healthy; Feeling well-surrounded; Resilience; Positive attitude; Psychological effects; Personal preferences; Psychological disorder; Respect; Happiness; Mental well-being; Burnout; Data security; Ethical considerations of wearable self-tracking devices.	F4 – Overall wellness, D6 – attitude, A2 – family, B2 – privacy.
Physical	Safety; Ergonomics; Bad postures; Musculoskeletal disorders; Health; Healthy operator 4.0; Ergonomic risks; Physical health; Hygiene; Safety measures; Perceived stress level; Posture; Physical fatigue; Health-related quality of life; Occupational safety and health; Burnout; Work-life conflict; Job autonomy; Privacy.	C13 – State, F1 – health plans, F2 – health insurance, F3 – health accommodation, F4 – Overall wellness, F5 – catered foods and drinks, F6 – discounts (meals), G3 – time off.
Occupational	Collaboration; Flexibility; Continuous learning; Lifelong learning; Empowerment; Workplace learning; Fulfilling and rewarding jobs; Workforce flexibility; Work-life balance; Transformational leadership; Employee retention; Respect; Valued; Resilience; Organisational climate; Employee voice; Non-discrimination and fairness; Proactive human-robot collaboration for well-being; Autonomy; Privacy.	A3 – impact, A4 – individuality, B2 – privacy, B4 – personal resilience, B5 – communication & hierarchies, B6 – negotiation power, C1 – workspace, C3 – equipment, C4 – safety, D1 – remote work, D2 – on-site work, D3 – travel, D4 – flexibility, D5 – work-forms, D6 – attitude, D7 – environment, G3 – time off.
Social	Social cohesion; Social exclusion; Social responsibility; Social determinants of health; Community well-being; Social care issues; Inclusion; Relationship; Diversity; Communication; Participation; Work-life balance; Social/emotional context.	A1 – volunteer, A6 – support, B1 – equality, G1 – leisure discounts, G2 – leisure activities, A2 – family, A3 – impact.
Intellectual	Lifelong learning; Immersive learning; Self-actualisation; Proactive human-robot collaboration for well-being; Workplace learning; Continuous innovation; Motivation; Autonomy.	A3 – impact, A4 – individuality, A5 – opportunity to grow, A6 – support, D6 – attitude.
Environmental	Environmental responsibility; Sustainability; Environmental sustainability; Smart, sustainable, and inclusive solutions; Eco-friendly behaviours; Sustainable supply chains; Sustainable societies; Sustainable digital transition; Eco-innovation.	B3 – Corporate responsibility.
Financial	Financial performance; Prosperity; Profitability; Economic challenges; Financial well-being; Economic well-being; Social welfare.	E1 – remuneration plans, E2 – stakeholder, E3 – reimbursements, E4 – welfare.
Spiritual		

Notes: The eight wellness dimensions are architected by [Swarbrick and Yudof \(2015\)](#).

The occupational dimension was the most widely covered category by academics and employers. Researchers acknowledged that Industry 5.0 workplace should promote continuous learning, have flexible work, good work-life balance, respect, reward, and empower its employees as well as work itself needs to be fulfilling and meaningful ([Tran et al., 2022](#); [Leng et al., 2022](#)). Most of the latter aspects have been addressed by employers in their own way, but another important consideration for a human-centric workplace is that workspace and equipment should be easily accessible and designed to inspire productivity and motivation. However, one missing component on the employers' side was the proactive human-robot collaboration that can contribute to the worker's well-being.

On the social level, academia highlighted the importance of community well-being, social relationships, issues and responsibility ([Gomathi et al., 2023](#); [Carayannis et al., 2023](#)). Hence, the volunteering work offered by employers and strong work environment support from colleagues with off-work team activities can create a better social foundation for a worker to thrive in Industry 5.0. Both parties admit that social life outside work should be another vital component in the social category and put forward the importance of diversity and equality in the workplace and outside.

From an academic standpoint, the significance of lifelong learning, personal growth, and intellectual development cannot be overstated in achieving a human-centric workforce in the intellectual category ([Leng et al., 2022](#); [Tóth et al., 2023](#)). Here again, the pro-active collaboration with robots can help humans accelerate their journey to personal development, which was missing on the employers' side ([Leng et al., 2022](#)).

The sustainability aspect was covered by both parties in terms of producing sustainable products that are important for a healthy environment ecosystem to thrive. On the financial side, academics emphasised the ongoing social issues concerning the economic challenges and social welfare ([Saniuk et al., 2022](#)). In contrast, employers have suggested many savings, pension, and financial reimbursement schemes. Most importantly, a common theme for Industry 5.0 was

moving from shareholder to stakeholder. Hence, the share options employers provide could help employees be more invested in the company. Lastly, spiritual well-being has not been explored by either group.

5. Discussion

The discourse unfolding around human-centricity in Industry 5.0 is highly complex and nuanced. For one, it seems that the interpretation of human-centricity has many perspectives yet to be settled in a clear consensus. There has been a strong technological push where humans are envisioned to collaborate closely with robots. However, it is also important not to lose track of the problems in Industry 4.0, which should be continuously addressed in Industry 5.0. Industry 4.0 has raised many concerns about an employee's well-being, income and social inequalities that have begun to occur due to robotisation and automation in factory settings ([Frey and Osborne, 2017](#); [Lee and Lim, 2021](#)). As of now, it is unclear whether the human-robot collaboration will exacerbate the ongoing issues further or will truly help workers to be more satisfied with their lives and prospects. Thus, understanding how well-being is envisioned in the evolving labour market is essential.

This paper addresses three key questions to advance understanding in this field. First, it provides a comprehensive and up-to-date analysis of how employers describe well-being when posting a job vacancy (Q1). Second, it presents an innovative methodology that extends beyond basic text-matching algorithms to enable more sophisticated semantic searches (Q2). Third, it offers a thorough analysis of human-centricity, with a particular focus on the well-being dimension from both employer and academic perspectives (Q3), thus contributing to the evolving narrative of Industry 5.0 and addressing the social concerns overlooked in Industry 4.0.

5.1. Implications

The proposed methodology circumvents the existing limitations of conventional NLP techniques in mining complex element targets from

unstructured text (Q2). By using modern machine learning techniques, particularly LLMs and their derivatives like the fine-tuned LLaMA-Adapter, a more nuanced and context-aware extraction of different kinds of concepts from large-scale job posting data is possible.

Furthermore, the methodology extends LLMs with pre-existing machine learning techniques which open new realms for contextual understanding by employing a multi-layered clustering approach. By embedding and clustering extracted phrases, and then further refining these clusters through topic modelling and manual inference, the method allows for the emergence of meaningful dimensions and sub-dimensions. This, in turn, can help build frameworks and develop a better understanding of current processes within societies, in this case employer's well-being vision. This hierarchical categorisation (L1, L2, L3) provides a rich, contextual framework for understanding how employers describe and communicate employee well-being, offering valuable insights into the real-world manifestation of human-centric practices in the job market.

The methodology also took the route of open-sourced software. Meaning that all frameworks and models are publicly available and can be used by any entity. This further empowers researchers with new tools to explore that were not possible to acquire before.

In this paper analysis, both academic literature and gathered data from various employers were explored, aiming to shed light on ongoing social topics. More precisely, the current state of employers' perspectives on employee well-being is reviewed (Q1), along with an exploration of how well-being has emerged in academic discussions within the context of human-centricity (Q3). Results indicate that the focus on workers' well-being is considerably overlooked in the job vacancies; instead, it appears to be a byproduct of other organisational priorities. For instance, the L2 mapping procedure highlights that the training dimension has been the top priority for employers. This evidence aligns with the trends observed in Industry 4.0, where there is a strong emphasis on enhancing workers' productivity and placing significant demands on them for continuous, non-stop learning.

On the positive side, the training opportunities can make an employee more resilient and aid in their personal development. However, even in such cases, the training L2 dimension has only been detected in less than 47% of job postings, whilst other dimensions, except work format, barely crossed or were under 20% threshold. Even more worrying is the fact that around 27% of the job ads did not mention any of the 44k thousand keywords related to an employee's well-being. It is unclear if such companies had no intentions to support an employee's well-being or did not explicitly mention those intentions.

On the academic front, the well-being discussion has only been touched on the surface, as most Industry 5.0 papers exploring the human-centricity concept focused on how robotics will be integrated with humans in the loop. Hence, ergonomics of postural risk and general safety have been raised. While there are some references to well-being as a general concept, a comprehensive and nuanced exploration of how the well-being approach should differ in Industry 5.0 to prevent the exacerbation of social issues witnessed in Industry 4.0 remains largely unexplored. Many keywords discovered were loosely placed within the text without further analysis.

In light of these findings, it is advisable to sharpen the discussion of well-being within Industry 5.0 by not only including the human-robot collaboration aspect but the well-being of the employee as well, transitioning from solely productivity benefits for factories to a balanced work-life philosophy. This approach envisions a workforce where employees are not only merged with cyber and artificial intelligence technologies but are also personally satisfied, healthy, and engaged in meaningful workplace work.

Different actors can meaningfully contribute to the worker's well-being with different means: employers can implement a wide range of policies, some of which have been gathered and depicted here in L1 and L2 levels in Fig. 5. Academics should further draw attention to the fact that human-robot collaboration not only can increase productivity

but there are at least eight other well-being dimensions where artificial intelligence and robotics can contribute to increasing workers' life satisfaction. Lastly, there should be a strong representation of an employee's side of how they envision the future of the workplace.

Thus, promoting the transition from Industry 4.0 to 5.0 requires a paradigm shift in how employers perceive and prioritise their workforce's well-being. Policymakers play a crucial role in driving this change by fostering awareness and understanding among employers about the importance of valuing workers' wellness in the context of Industry 5.0.

Policymakers can launch awareness campaigns and initiatives to highlight the benefits of a well-being-centric work environment. These efforts should emphasise the positive impact of employee well-being on productivity, creativity, and overall organisational performance. By showcasing success stories and best practices of companies that have integrated well-being into their core values, policymakers can inspire and encourage other employers to follow suit. Moreover, this information can guide the design of targeted support and incentives for training and development programmes. Investing in these initiatives could help create a work environment that not only enhances the skills and capabilities of the workforce but also prioritises employee well-being and job satisfaction.

Consequently, vacancy data is not only a resource for discerning skill demands but also a valuable tool for examining and enhancing well-being aspects. These findings underscore the importance of adopting a data-driven approach to decision-making for policymakers. Understanding how well-being is represented in job advertisements could enable tailored interventions that address specific gaps and challenges in promoting a healthier and more human-centric work environment.

Collaboration with academic institutions is crucial to further explore the link between well-being and human-centricity in the context of Industry 5.0. Engaging with researchers and experts could allow policymakers to develop evidence-based policies that effectively address the well-being needs of the workforce. This partnership can lead to innovative and comprehensive approaches to promoting employees' well-being and fostering a thriving workforce in the era of Industry 5.0.

Additionally, LLM-based methodologies open up the opportunity to explore more aspects of job vacancies and their relations with other variables. Future research can focus on identifying the specific types of jobs (occupations/sectors) that are more likely to offer human-centric benefits to potential employees. Exploring sector-specific occupational patterns will be a forthcoming stage of this research. This deeper analysis will provide valuable insights into the industries and roles that prioritise employee well-being and can contribute to shaping a more human-centric workplace culture.

5.2. Limitations

This research is not exempt from limitations. While vacancy data has proven to be a valuable and well-established source of information for understanding employers' perspectives on well-being, it represents only one of various critical viewpoints. Therefore, exploring additional sources is crucial for analysing the broader complexities of well-being. Contract agreements, for instance, could offer valuable insights into the intricacies of implementing Industry 5.0 practices within organisations. Analysing these agreements could provide a deeper understanding of how different firms are embracing human-centricity and making Industry 5.0 a reality. Moreover, many other aspects warrant exploration. One such area of investigation could focus on understanding how productivity gains can be achieved by automating specific tasks while simultaneously enhancing and retraining the remaining human workforce.

Despite having collected over 1.8 million job vacancies and most academic papers on human-centricity, some research limitations persist. The second limitation is related to the content of the job advertisements. Not all employers fully disclose well-being benefits on job

platforms. Moreover, creating attractive and professional job ads is a skill of its own. Thus, lacking the necessary knowledge and talent may influence the job description content. The latter limitation also can lead to the discussion of whether the declared intentions are true or are just a marketing scheme, similar to the concept of “greenwashing”.

The third limitation relates to the geographical and temporal scope of the data. This research focused solely on job vacancy data from the UK, which may introduce a country-specific bias. Additionally, analysing data over a longer period would provide more comprehensive insights. As of now, there is an indication that a shift in employers’ perspectives has occurred, but whether this change will be sustained or is merely a temporary fluctuation remains unanswered.

Finally, academic circles have just started to accelerate Industry 5.0 research. It is still early to judge the academic point of view and whether social issues will be fully addressed in the future. Moreover, the LLM modelling style is still a new method that needs to be improved on its own. The conceptual search is intriguing but can also contain errors whether used for the vacancy or academic modelling. The same issue applies to clustering algorithms, which may not capture meaning adequately and group things incorrectly. Nonetheless, it was demonstrated that without the need for a dictionary, it is possible to build a well-being taxonomy on its own.

6. Conclusion

This research aims to advance the understanding of Industry 5.0 by introducing an innovative AI-based approach. The creation of comprehensive pattern identification and clustering of employer keywords, along with comparing against academic perspectives, forms the foundation of our unique methodology. We have demonstrated that with the use of LLM, it is possible to address the challenges associated with measuring and mapping complex terms/patterns, such as well-being in the workplace. Specifically, we have demonstrated the effectiveness of LLM in identifying various labour market characteristics without relying on a pre-defined dictionary. LLM’s ability to grasp human language’s context, subtleties, and nuances minimises the chances of misinterpreting data. As a result, LLM opens up new possibilities for developing and improving labour market taxonomies and accurately identifying different dimensions in large datasets like vacancy data.

Our research contributes to enhancing data analysis in the context of Industry 5.0, providing valuable insights into the well-being aspects of the workforce and facilitating informed decision-making in this dynamic field. Through empirical analysis, this study examines the well-being aspect of human-centricity from the employer’s perspective using vacancy data.

The data-driven approach reveals seven human-centric dimensions from the employers’ perspective. Most of these dimension overlaps with academia, but there are also gaps. For instance, employers highlight the need for family emotional support, which considerably influences the overall mental well-being of the worker, while academia points to the danger of unethical use of wearable devices that might cause emotional stress of being constantly monitored, which was lacking in the employers’ side. As a result, this research opens up opportunities to bridge these gaps and create a more comprehensive understanding of human-centricity in the context of well-being and Industry 5.0 workplaces.

The data analysis showed that self-realisation (via offering training opportunities) and work format (via offering a friendly/team environment) are prioritised by employers to attract job seekers. However, a considerable share of employers may not see it relevant to emphasise well-being conditions to attract potential workers explicitly. This evidence suggests the need for greater awareness and attention to employee well-being across the board. Organisations may benefit from implementing well-being initiatives and communicating them effectively to attract and retain top talent in an increasingly competitive labour market.

Thus, this paper showcases the importance of harnessing technology and data in policymaking. Policymakers can explore innovative ways to collect and analyse data to gain deeper insights into workforce trends and needs. These new analysis methods can inform evidence-based policymaking, leading to more effective and targeted interventions to support the workforce. As Industry 5.0 continues to evolve, policymakers must stay vigilant to address the potential challenges and risks associated with the increasing use of technology in the workplace. Furthermore, policymakers can devise strategies to provide support and resources to workers facing these challenges and promote well-being in the digital era.

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CRedit authorship contribution statement

Andrius Grybauskas: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Jeisson Cárdenas-Rubio:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Data availability

Data will be made available on request.

Appendix A

See Fig. 11.

Appendix B

See Fig. 12.

Appendix C

See Fig. 13.

Appendix D

See Fig. 14.

Appendix E

See Fig. 15.

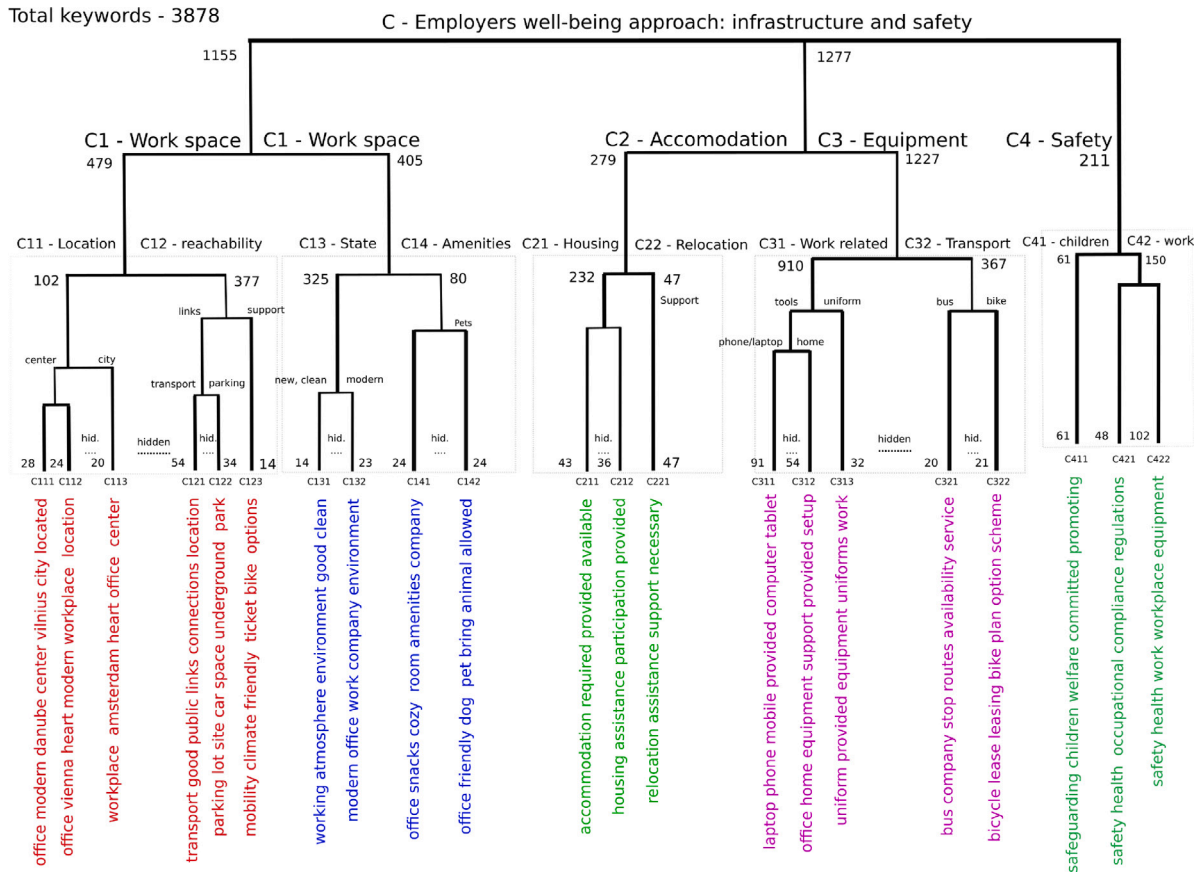


Fig. 11. Infrastructure and safety. **Note.** The numbers near the levels represent the number of sentences or expressions recorded for that level. The branch output, e.g., C111, depicts cluster topic centroids. The abbreviation of hid. refers to many hidden topics, which are not possible to depict due to their large size.

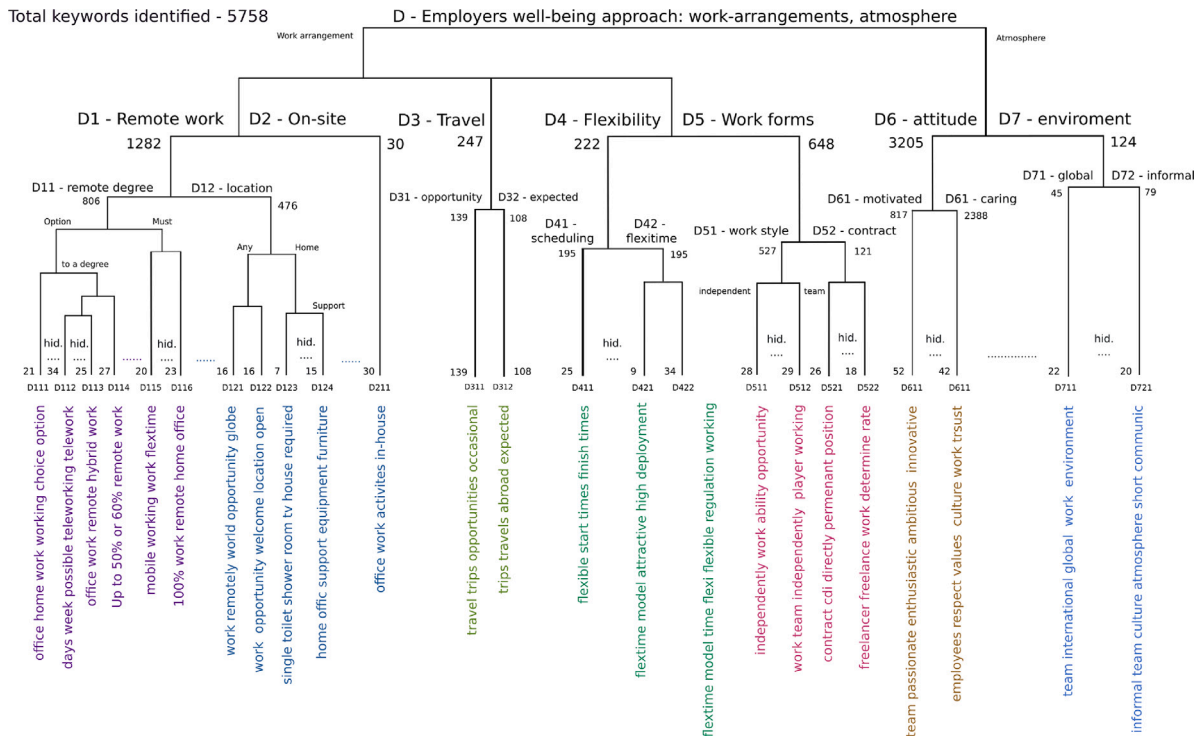


Fig. 12. Work arrangements, atmosphere. **Note.** The numbers near the levels represent the number of sentences or expressions recorded for that level. The branch output, e.g., D111, depicts cluster topic centroids. The abbreviation of hid. refers to many hidden topics, which are not possible to depict due to their large size.

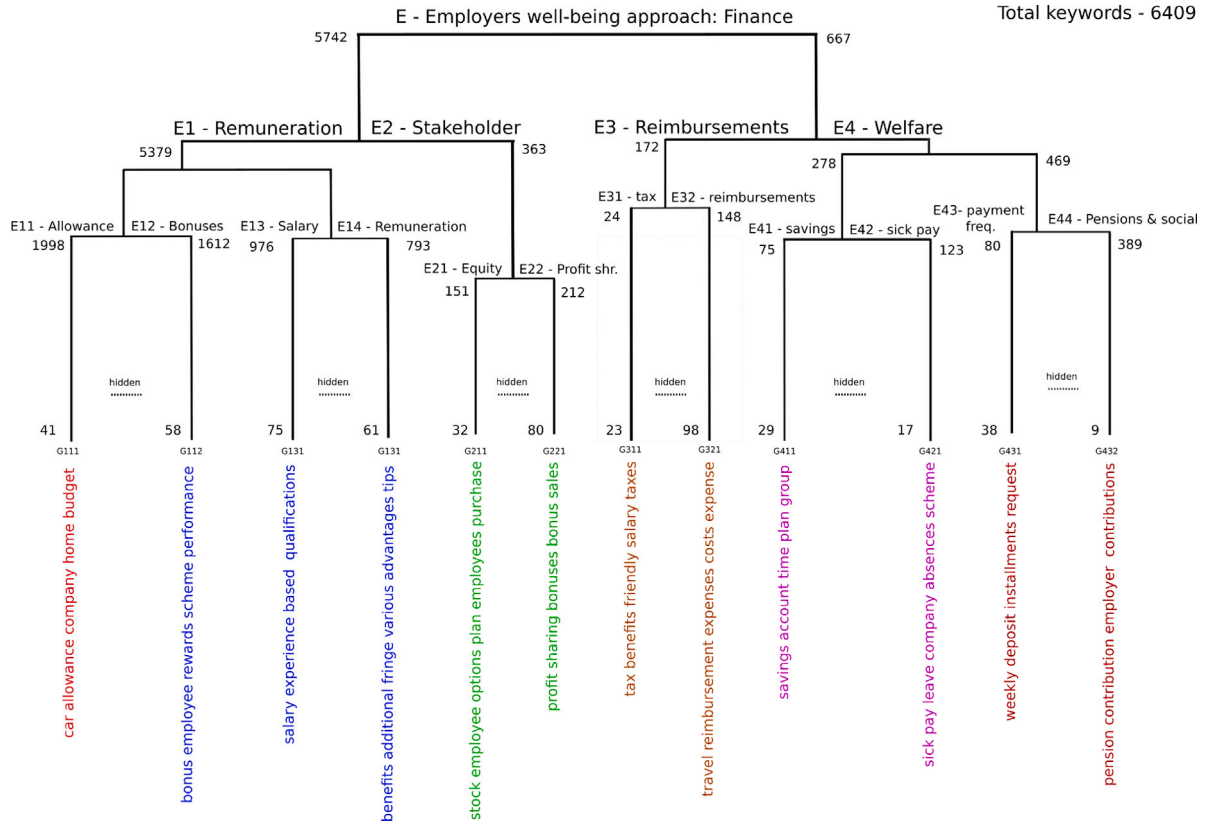


Fig. 13. Finance. Note. The numbers near the levels represent the number of sentences or expressions recorded for that level. The branch output, e.g., E111, depicts cluster topic centroids. The abbreviation of hid. refers to many hidden topics, which are not possible to depict due to their large size.

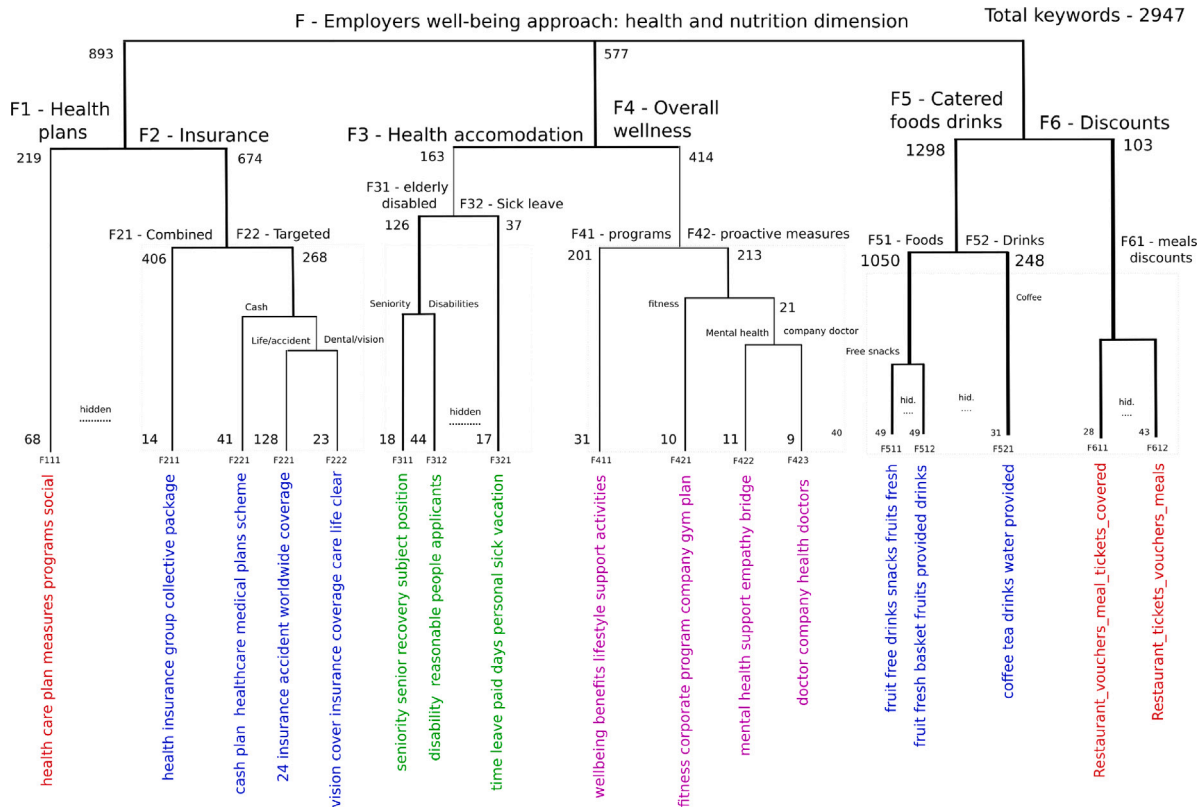


Fig. 14. Health and nutrition. Note. The numbers near the levels represent the number of sentences or expressions recorded for that level. The branch output, e.g., F111, depicts cluster topic centroids. The abbreviation of hid. refers to many hidden topics, which are not possible to depict due to their large size.

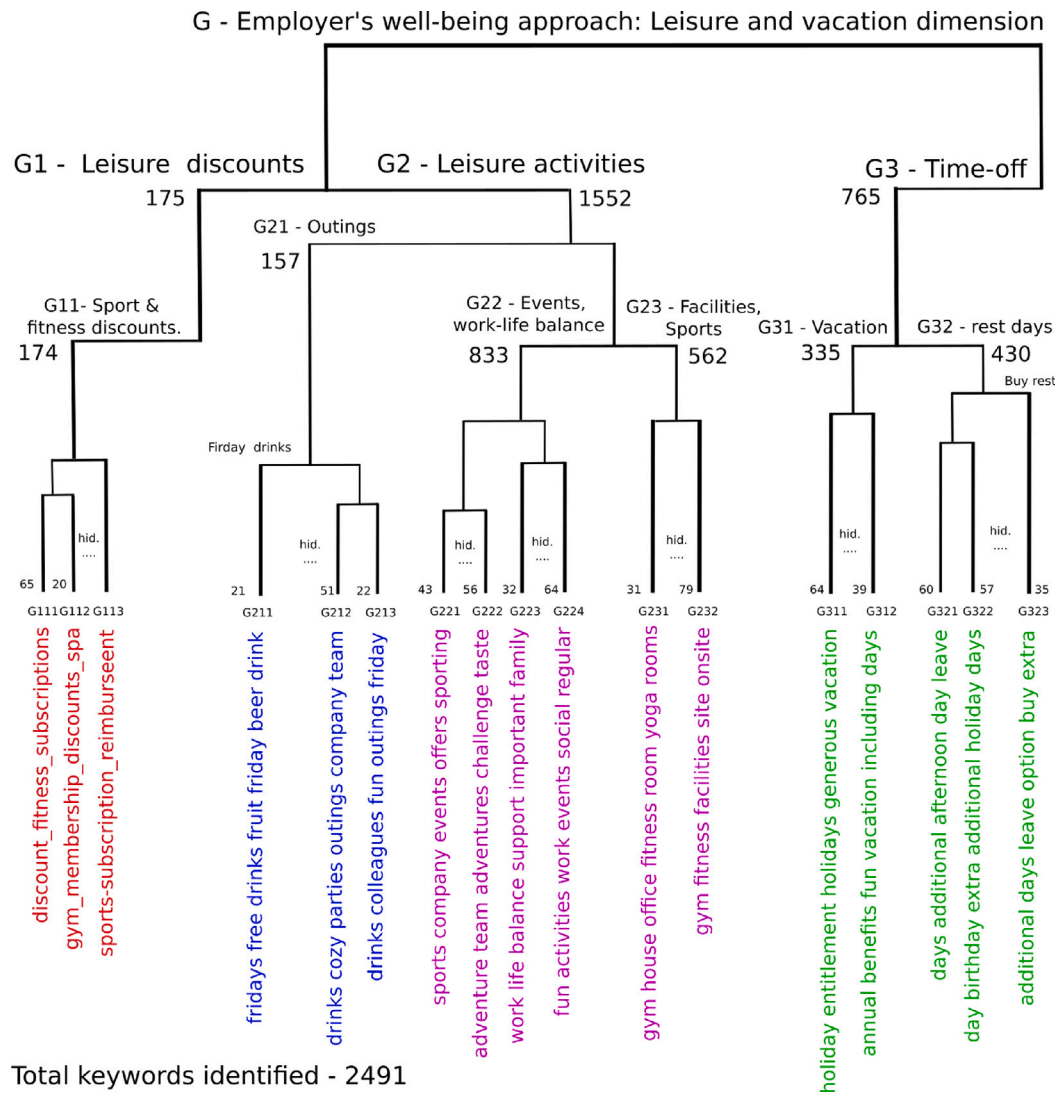


Fig. 15. Leisure and vacation. **Note.** The numbers near the levels represent the number of sentences or expressions recorded for that level. The branch output, e.g., G111, depicts cluster topic centroids. The abbreviation of hid. refers to many hidden topics, which are not possible to depict due to their large size.

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