Building human-centric organisations with Industry 4.0 technologies in the Industry 5.0 era: A micro and meso level perspective

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Abstract
Manufacturing organisations are adopting Industry 4.0 (I40) technologies. Such technologies enable extensive automation and digitalisation of production and interaction with workers. Although the literature demonstrates how to use I40 technologies to develop autonomous production, little is known about the organisational aspects at the individual (micro) and organisational (meso) levels to build a human-centric organisation. This goal is also echoed by the Industry 5.0 policy proposed by the European Commission. Therefore, we address this research limit by conducting a literature review summarising the organisational aspects at the individual (micro) and organisational (meso) levels to build a human-centric organisation with I40 technologies. The micro-level aspects include worker training, workers with digital and social skills, commitment to workers' needs, and hiring candidates with a digital mindset. Meso-level aspects are related to developing decentralised structures, promoting cross-organisational communication about I40 technologies' goals and implications, fostering a lean culture, and conducting pre-I40 adoption organisational analysis.

Keywords
industry 4.0, industry 5.0, operator 4.0, literature review, organisational aspects, human-centric organisation, lean

1. Introduction

Over the last years, novel advanced technologies for manufacturing have become increasingly popular among scientists, researchers, and practitioners [10]. Such technologies are labelled "Industry 4.0" (I40), and they are different from traditional manufacturing technologies because they may automate operations and digitalise the information flow [3]. They can also be equipped with control systems enabling cooperation and worker interaction [9].

Most of the literature explores I40 implementation from a techno-centric perspective. This perspective privileges I40 technology contribution to organisational performance, neglecting workers' roles [1]. This literature stream is rich in examples of how I40 technologies can use their automation and digitalisation capabilities to build autonomous systems [4, 5]. Further studies show how I40 technologies can be used to develop digital twins and automatically detect malfunctions without workers' interventions [6]. Still, when production is highly automated, the organisation theory points to developing an organisation with centralised decision-making [52, 53].

Against this backdrop, this study wants to contribute to the literature exploring how I40 technologies can be used to develop human-centric organisations where workers use such technologies and remain in the organisation. We focus on the needed organisational aspects at the individual (or micro) and organisational (or meso) levels.

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This study is motivated by two reasons. The first motivation is practical because the European Union encourages organisations to enter the Industry 5.0 era by developing human-centric organisations to avoid I40 technology job disruption [2, 8]. The second motivation is on the literature side. From a technical perspective, various studies show how to design I40 technologies to enable interaction with workers – e.g. by control systems or exoskeletons [11, 13]. However, the organisational aspects of building human-centric organisations remain fragmented in the scientific literature and barely analysed. Based on this premise, we raise the following research question: "What are the organisational aspects at individual and organisational levels to build a human-centric organisation with Industry 4.0 technology in the Industry 5.0 era?"

Consequently, we address the research question by conducting a literature review to summarise the various organisational aspects at micro and meso levels to build a human-centric organisation with I40 technologies.

The article has the following structure. We present in section 2 the theoretical framework and the methodology in section 3. We illustrate the results of our literature review in Section 3, which are then discussed in Section 4. We conclude the article in section 5.

2. Theoretical Framework: Industry 4.0

The I40 technological revolution was initiated in 2011 by the German Government, which launched an industrial plan to improve manufacturing firms' efficiency by adopting advanced technologies, such as robots, the Internet of Things, and Big Data Analytics [4]. Nowadays, the label I40 is used as an umbrella term for such technologies [5]. Since no comprehensive list embraces the various I40 technologies [10], we illustrate them by highlighting their technological capabilities. I40 technologies can automate operations and some decision-making activities [3]. This is possible since I40 technologies automatically collect and digitalise data about operations [5].

Moreover, I40 technologies enable interactions with workers because control systems provision them. [13] illustrate the "Operator 4.0" theorising eight human-computer interactions with I40 technologies [12]. In line with this, empirical studies indicate that workers can act as machine supervisors and expert assembly operators. The former may block I40 technologies in case of issues or change their operations using their embedded control systems [7]. The latter is guided by an assembly system or virtual reality to conduct operations along the production line [9].

3. Research Design

We conducted a narrative literature review to fulfil the research objectives [14, 15]. The search for academic literature was performed with keywords in the Scopus database in May 2022. This database was privileged for its broad coverage of disciplines and publishers [16]. The following keywords and searched terms were considered: “industry 4.0” OR “industry of the future” AND “organisation” OR “organisational" AND “human-centric” OR “human” OR “workers” OR “employees”. All methodological approaches were considered to reach the heterogeneity among existing studies about human-centric organisations using I40 technologies [17]. Therefore, the review included articles but also book chapters mobilising literature review, quantitative, qualitative, and mixed methods. To enhance this heterogeneity, the study also cross-fertilised different kinds of literature and topics around the research subject (e.g., finance, management, innovation, operations, production). By consulting the title and abstract, the authors extracted 58 papers. The in-depth reading of the selected documents allowed to opt for 37 papers in the scope of this study. To capture the organisational aspects of companies using I40 technologies, one of the co-authors conducted an in-depth qualitative analysis of organisational practices prioritised and mobilised by companies to achieve such an organisation. The analysis was conducted on two levels: the micro level aiming at the organisational aspects regarding the workers and the meso level aiming at the aspects regarding the organisation of companies using I40 technologies. To validate the results of the analysis, the authors organised several rounds of discussion that finally led to a consensus.

4. Results

This section illustrates the organisational aspects derived from the literature review, distinguished at micro and meso levels.

4.1. Organisational aspects: micro level

Several tendencies emerged from the analysed literature regarding the micro-level organisational aspects that can lead companies using I40 technologies towards a human-centric organisation.

Considering the undeniable impact that I40 technologies bring into the workers' routine, the existing literature highlights the importance of enhancing their digital expertise [18]. Generally, digital expertise encompasses both software (data analysis skills or programming language) and hardware skills (digital and automation devices) [19, 20]. Since *"the technology is not intelligent per se"*, in-depth knowledge of processes coupled with lean philosophy helps in achieving such expertise [21, p.22]. However, the digital expertise of workers should be balanced with a strong social capital capable of teamwork and leveraging workers' needs [22, 54]. The manipulation of I40 technologies requires agile decision-makers who combine technical skills with critical thinking and systematic vision of situations (personal competencies), information sharing and networking (interpersonal competencies) and the ability to innovate [19, 54]. Moreover, it's crucial to encourage workers' capacities to access and exploit external knowledge [23]. By creating favourable conditions to efficiently capture, transform, integrate, and leverage internal and external knowledge, a company enhances both its own and its workers' competitive position [23].

From a human-centric production standpoint, knowledge represents a highly precious resource for companies, where their management facilitate and bolster the overall knowledge advancement of the socio-technical system [27]. Thus, regular training is encouraged to become a part of workers' routines [24-26, 54]. Training that anticipates the implementation of I40 technologies allows companies to avoid the techno-centric vision by addressing the rapid turnover of job tasks and adapting an ageing workforce to future job demands [27, 28]. Training can take various forms, such as workshops, scenario-based learning, hands-on experience, e-learning and mentoring [54]. To properly organise the culture of regular training, companies also evaluate their capacity to free up time for mastering the skills necessary to interpret, leverage, and effectively use the data provided by these technologies [28, 29]. In doing so, they encourage their workers to focus on continuous improvement and system upgrades instead of constantly firefighting and maintaining daily operations [30]. In parallel with regular training, it is important to commit to workers' needs by addressing their concerns regarding digitalisation and social security and involving them in decision-making [34-36]. By supporting workers' ideas and suggestions, companies can achieve workplace time flexibility that enhances work-life balance and overall satisfaction with the working environment [27, 33, 37].

Besides reskilling or upskilling their workers, companies may also consider recruiting the profiles experienced in I40 [31, 32]. As the introduction of I40 technologies can lead to the necessity of defining and launching new job profiles [19, 33], mixing different backgrounds can become a solution to address more and more complex problems [23]. By enabling digital confidence throughout various socio-economic workforce sectors and enhancing the employability of disadvantaged, minority, and ageing workgroups, companies axe their human resources management towards sustainable practices [26].

4.2. Organisational aspects: meso level

From a meso perspective, the academic literature stresses the crucial role of decentralising the functions within companies using I40 technologies [22, 29, 54]. A flat hierarchy with a low number of hierarchical levels, a wide span of control and a short process of decision-making allows companies to enhance the lean culture and react quickly to the changing market environment [19, 38]. As a result, a decentralised hierarchy structure often leads to enhanced entrepreneurial spirit as well as a fast and adaptable process of decision-making [22, 54]. Nevertheless, such transformation might take time, especially for companies with highly centralised organisational structures [39, 40]. Fears related to loss

of control and decentralised decision-making can create reluctance among top management towards the implementation of I40 technologies, consequently hindering the crucial development of a digital culture necessary for sustainable I40 progress [26]. Therefore, certain scholars highlight the crucial role of keeping organisational structure centralised, especially in the case of SMEs [41]. By centralising the organisational functions, companies establish the information flow about the importance of introducing the change to achieve higher rates of acceptance of innovation initiatives [41]. In doing so, they effectively align their organisational structure, including corporate strategy, work organisation, and human resources, and synergistically enhance the use of I40 technologies [42].

Another trend prevailing in the analysed studies lies in performing organisational and structural changes in existing work practices parallelly, even in advance, to implementing I40 technologies [43, 50]. To evaluate the suitability of I40 technologies, companies should possess a holistic view of human, organisational and cultural factors that pave the way towards such transformation [21, 44]. To do so, companies can rely on self-assessment readiness tools to analyse the conditions, attitudes, and resources at all levels of their system [50]. However, companies often neglect the importance of discussing the goals and main transformations intended to be achieved due to I40 implementation [26, 34, 44]. Thus, companies are encouraged to communicate transparently and clearly about the implications and advantages of I40 for the organisation and production and how new technologies can coexist with an older, predominantly manual machine park [44]. Parallelly, effective internal communication, nurtured by frequent and effective exchanges among employees, promotes a mutual adjustment and allows embracing the scope of the learning curve that the implementation of I40 technologies might require [25, 40, 45].

Such efforts should become a part of the internal innovation process based on the continuous improvement of the whole company [30, 46]. Termed as a lean culture [19], the collective endeavour to collaborate and actively engage in change enables companies to cultivate greater flexibility and respond swiftly to evolving market conditions [38].

Such an adaptive culture allows a more in-depth understanding of organisational capabilities and collective structures while integrating digitalisation initiatives [44]. One of the fundamentals of such culture lies in openness and willingness for change [29, 47]. While these factors are encouraged by management teams in the majority of companies, in SMEs, they are tightly related to the commitment of CEOs to innovate [23, 47]. As a matter of fact, when the CEO shows dedication to innovative technologies, the entire organisation will embrace their direction, resulting in little to no resistance [23].

5. Discussion and future research avenue

Our analysis identified key organisational aspects essential for achieving a human-centric organisation with I40 technologies at the micro and meso levels (See Figure 1). Thus, we contribute to the literature by filling the research gap related to summarising such aspects [11, 13].

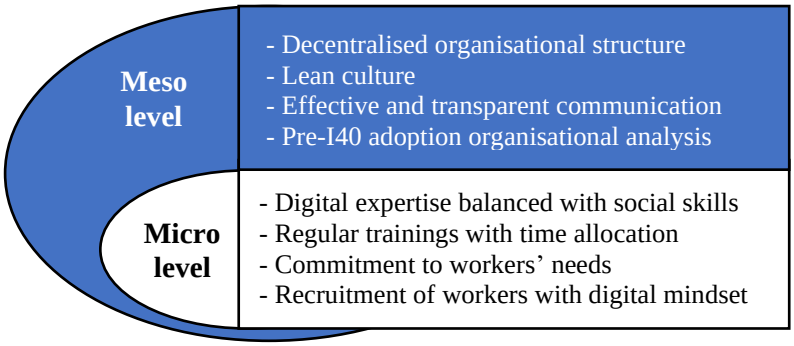

Figure 1 Organisational aspects at micro and meso level to build human-centric organisation with I40 technologies.

The traditional techno-centric vision of I40 adoption does not consider organisational aspects at the micro level because I40 technologies are used to supplant or marginalise workers' contribution to the organisational performance and develop autonomous production [1,4,5]. In contrast, our study

demonstrates that micro and meso organisational aspects are crucial to building a human-centric organisation.

It is important to recognise that technological advancements require a balanced approach regarding workers' skills [19, 25]. While I40 technologies demand proficiency in digital tools and processes, they also underscore the importance of interpersonal and personal competencies such as critical thinking, teamwork, and adaptability. By fostering both digital and social skills, companies can ensure that their workforce embraces digital transformation and effectively collaborates, innovates, and navigates the evolving work landscape.

Proposition 1: *Workers with digital and social skills are required to build human-centric organisations with I40 technologies in the Industry 5.0 era.*

The dynamic nature of I40 technologies raises the importance of cultivating the internal capacity to adjust to changes and cultivate multifaceted knowledge [28, 30]. By providing ongoing learning opportunities, companies empower their employees to continuously develop their expertise and keep up with the rapidly changing job tasks. Such knowledge advancement equips the workforce with the necessary skills and knowledge to operate efficiently and embrace new challenges in an ever-evolving technological landscape.

Proposition 2: *Training for workers is required to build a human-centric organisation with I40 technologies in the Industry 5.0 era.*

Otherwise, companies may recruit workers from the labour market according to their needs [31, 32]. Although new job profiles may emerge from working with I40 technologies, the preferred workforce should have a digital mindset that can be reinforced in organisations with training and human resource practices [23].

Proposition 3: *Hiring workers with a digital mindset is required to build a human-centric organisation with I40 technologies in the Industry 5.0 era.*

When I40 adoption follows a techno-centric perspective, some studies point out that organisations using autonomous systems may have centralised decision-making; the top management is the only organisational member involved in the decision-making process, and workers only conduct few manual activities in the production [1,5,52, 53]. In contrast, one of the main organisational aspects at the meso level for a human-centric organisation with I40 technologies is the development of a decentralised structure [40]. It implies an organisation with few hierarchical levels, a wide span of control and collaborative decision-making where workers are involved [19, 38].

Proposition 4: *Decentralisation of functions and decision-making are required to build human-centric organisations with I40 technologies in the Industry 5.0 era.*

SMEs should pay attention to developing a decentralised organisational structure because this practice is complex [41]. Thus, SMEs should first centralise the decision-making, setting a clear direction and strategy for I40 adoption. Then, as the workforce gains familiarity with new technologies and develops the necessary skills, decision-making can gradually be decentralised, empowering employees to take on greater responsibilities and embrace the benefits of a more agile and adaptable organisational structure.

In this regard, effective and transparent communication is fundamental for a human-centric approach within companies using I40 technologies [49, 50]. By effectively communicating the I40 adoption goals, benefits, and implications, companies can establish a shared understanding among employees, fostering a sense of collaboration. Transparent communication helps manage expectations and address I40 concerns and resistance to change, enabling a smoother transition to new work practices and organisational structures.

Proposition 5: *Effective and transparent communication is required to build a human-centric organisation with I40 technologies in the Industry 5.0 era.*

Together with this cross-organisational communication effort, it is recommended to conduct an organisational analysis before I40 adoption. To understand how work practices and organisational structure may change due to these novel technologies, companies may elaborate a pilot scenario with consultants or assess by themselves the existing enablers and barriers [34]. By assessing Industry 4.0 readiness together with such organisational dimensions as strategy, leadership, governance and people, companies can ensure a smoother shift towards fixed goals and prevent unforeseen issues [50].

Proposition 6: *An organisational analysis is needed before I40 adoption is required to build a human-centric organisation with I40 technologies in the Industry 5.0 era.*

A further aspect at the meso level is related to lean culture. It is characterised by a focus on efficiency, continuous improvement, a high level of willingness to learn, and the promotion of creativity and idea generation [55]. However, this culture cannot be simply established, but it should be enacted proactively to ensure a solid ground for I40 implementation. By emphasising the need to cultivate dynamic capabilities for effectively appropriating, adapting, integrating, and reconfiguring internal and external resources, companies enhance their organisational competencies for adopting I40 technologies [56]. Enabled by constant debate among managers and workers, a proactive lean culture can be enacted by top management commitment to I40 to motivate workers and encourage cultivating their expertise to operate with I40 technologies.

Proposition 7: *Embracing a lean culture is required to build a human-centric organisation with I40 technologies in the Industry 5.0 era.*

To conclude, the aforementioned seven propositions present a potential foundation for future scholarly investigations. Ascertaining their validity and exploring their implications could significantly contribute to the advancement of knowledge regarding human-centric organisations using I40 technologies in Industry 5.0 era.

Researchers may first validate our propositions with quantitative studies using a large sample of organisations. We recommend sample of firms operating in Europe since Industry 5.0 policy was proposed in Europe in 2021, and such firms may already start the development of human-centric organisations with I40 technologies. By focusing on several countries with different levels of progress regarding Industry 4.0 implementation, the researchers might discover new patterns and enrich our findings with more detailed observations.

Researchers may also investigate singularly our propositions. Regarding micro-level organisational aspects, research avenues may develop a competence framework for digital and social skills, the needed training and human resource practices to empower workers. Moreover, future research can focus on elaborating a comprehensive list of job profiles for human-centric organisations with I40 technologies. Finally, future studies can explore the role of leaders in the enactment of human-centric organisations. As a matter of fact, all the proposed micro-level organisational aspects require a constant guidance in form of a leadership in order to benefit properly from I40 technologies.

Regarding meso-level organisational aspects, researchers may investigate through a more in-depth examination the changes in the organigram, such as the development, the integration or the deletion of units and the consequent patterns to move from a centralised to a decentralised organisation. Another insightful contribution may lay in joining the communication sciences and management fields to explore the communication activities within human-centric organisations using I40 technologies. While existing studies seldom focus on the cornerstones of effective communication [25, 30, 46], future research on these aspects can develop a framework to help companies in their transition to the human-centric organisation. Finally, researchers can focus on a more in-depth investigation of organisational factors at micro and meso level, allowing companies to develop a lean culture.

5.1. Theoretical and practical implications

Our findings contribute to ongoing discussion in socio-technical systems and I40 production. It seeks to raise the awareness and put core human needs, interests, and well-being at the heart of complex I40 production [57-60]. At micro level, our study emphasises the importance of keeping the balance between digital and social skills, organising regular training alongside time allocation, and hiring workers with a digital mindset. At meso level, our study indicates that decentralised organisational structures might encourage collaboration and shared decision-making but should be integrated carefully within SMEs. Conducting a pre-I40 adoption organisational analysis enhanced with effective and transparent communication can also help companies use I40 technologies to achieve a human-centric organisation.

Our study also holds practical implications. Managers can use this study as a guideline to adopt I40 technologies to build human-centric organisations. The study stresses the organisational aspects that managers often overlook during I40 technology selection, namely the competencies needed by workers to effectively use the novel I40 technologies. It also stresses generally overlooked organisational practices, such as the analysis of the impacts on the organisational structures and the existing work

practices after I40 implementation. Policymakers can use this study to develop funding opportunities related to organisational aspects of I40 adoption that may be provided in conjunction with the traditional financial incentives for the purchase of novel I40 technologies in the industry 5.0 era.

5.2. Limitations

Our study has limitations. Although one of the main strengths of narrative literature review consists in the flexibility of the research process, its weakness is related to the implicit biases of the author and is limited to emergent cited literature [17]. As there is a lack of studies that summarise the micro and meso organisational factors, we intentionally covered a small sample of papers that allowed us to focus on the most essential organisational factors. Thus, systematic review or future qualitative research can enhance the findings with new data.

6. Conclusion

Our study aimed to address the gap of lacking studies with a holistic view on micro and meso-level organisational aspects that help build a human-centric organisation with I40 technology in the Industry 5.0 era. By conducting a literature review, we mobilised previous studies to embrace the key organisational factors regarding workers and organisations for the development of human-centric organisations based on I40 technologies. Micro-level organisational aspects refer to worker training, workers' digital and social expertise, commitment to workers' needs, and hiring candidates with a digital mindset. Meso-level aspects are related to developing decentralised structures, promoting cross-organisational communication about I40 technologies' goals and implications, fostering a lean culture, and conducting pre-I40 adoption organisational analysis.

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