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Artificial intelligence, robotics, and logistics employment: The human factor in digital logistics

DIGITAL LOGISTICS WORK AND RESEARCH GAP

Supply chain management is impacted profoundly by digitalization in the forms of artificial intelligence (AI) or robotics applications (Bell & Griffis, 2011; Choi et al., 2021; Fragapane et al., 2021; Klumpp & Zijm, 2019). However, research is scarce regarding the impacts on logistics employment—but obviously, logistics is facing the most severe change since industrialization as digital applications are affecting every industry and all supply chains (Vijayakumar et al., 2021). Various studies investigate the substitutability of jobs by computers, robotics, and machines (e.g., Autor, 2015; Frey & Osborne, 2013). However, automating human work must be worthwhile and sustainable. The special topic forum is forwarding the discussion with regard to current developments addressing digital applications in logistics work. This editorial is about the human factor—but not only on the individual level but showing that humans and human–human interaction are relevant on all levels of supply chains through social interactions. There is a lack of theoretical foundations to explain current developments and to consider the role of the human factor (Sgarbossa et al., 2020), and this translates into restricted concrete empirical investigations. In particular, the following levels of analysis are of interest in order to reveal effects regarding the relevance of the human factor and its effects for digital logistics:

- At the *individual level*, the respective workers and their perceptions, beliefs, and attitudes toward AI and robotics are decisive for adoption processes (Rogers, 2003; Ruiner & Debbing, 2021; Schraeder et al., 2006; Venkatesh & Davis, 2000). Moreover, frameworks such as self-determination theory (Ryan & Deci, 2000) and the job demands-resources model (Bakker & Demerouti, 2007) help to understand the impact of changes on the motivation and well-being of workers. It might be even of interest to analyze and measure their cognitive stress levels (Hagemann et al., 2022). This is also connected to the relevant question of workplace safety as critical field in transportation and logistics (Choo & Grabowski, 2018). Equally important is the concept of self-efficacy (Bandura, 1997), whether workers feel competent in using new technologies or learning how to use them and are able to use their intuition when making decisions (Carter et al., 2017). This also relates to worker perception regarding autonomy and control in digitalized work contexts as two sides of one coin (Mazmanian et al., 2013; Ruiner & Klumpp, 2021; Stohl et al., 2016).
- At the *peer group level*, the collaboration of different group members at one location like a depot or warehouse is considered. In this context, size and structure of teams as well as cohesion and social norms are expected to change in the course of implementing AI and robotics into work organization since workers have the opportunity on the one hand to check their own performance and compare it with that of their colleagues (Collins et al., 2016). This can, for example, serve as an incentive to improve performance and promote competition within teams. On the other hand, there is a higher transparency of performance so that supervisors can monitor the activities of individual workers and intervene in work processes (Langfred, 2000).
- At the *organizational level*, organizations and their inherent structure of departments are of interest. It is expected that organizational structures, work design, and goal setting alter in the course of digitalization (Lam, 2005; Wilkesmann & Wilkesmann, 2018). From a transaction cost perspective (Williamson, 1975), it can be explained that organizational structures are changing as a result of the increasing digital transparency and the engagement of external workers. Above all, issues of efficiency and social sustainability in light of the Second Machine Age (Brynjolfsson & McAfee, 2014) or Industry 4.0 concept developments (Marsh, 2012; Rifkin, 2014) as well as the potentials of AI and robotics for organizational performance need to be further investigated—so far, the discussion focuses on the opportunities for saving personnel costs and staff reduction (Lovergine & Pellero, 2018). The perspective on organizations as complex systems of many different functions, workers, and teams is neglected so far but relevant to understand the interdependencies and interactions within.
- In a fourth *supply chain level* perspective, the system of

different organizations providing logistics services is in the center. In this context, the human factor is also seen as crucial due to the important roles within dedicated parts of the supply chain. For example, Awaysheh et al. (2021) outline the important role of human work in delays throughout the whole supply chains. This can be connected to the basic observation regarding the bullwhip effect in supply chains as a major initiation point of supply chain management itself: The human factor is seen as one of the causes of bullwhip effects in inventory and order levels due to the human safety motivation and based on missing transparency throughout the supply chain (Yao et al., 2020).

Consequently, digital transformation in supply chains affects different levels of logistics work. A conceptual framework is required to investigate the changes addressed and to highlight the role of the human factor within these processes.

HUMAN FACTOR IN DIGITAL LOGISTICS—CONCEPTUAL FRAMEWORK

With this editorial, we aim to shed light on the role of the human factor in digital logistics. This has been already established in general (Neumann et al., 2021; Schorsch et al., 2017) as well as regarding specific perspectives like, for example, addressing the important role of human intuition (Carter et al., 2017) or cost developments (Fager et al., 2021). For a detailed and comprehensive analysis, we apply an interdisciplinary perspective drawing on economic and social sciences. Starting from the observation of technological innovations such as AI, robotics, and digital technologies and their implementation into supply chains, it can be expected that this impacts work and employment in the field of logistics. It is also evident that a change in work content and job demands is expected, which also depends on the design of human–computer interaction (HCI). HCI is a broad field that covers any interaction between humans and machines such as operating computers, handheld scanners, and mobile devices (Grudin, 2012). Depending on the interaction with machines, humans will refrain more and more from operational tasks and have to migrate their capabilities and attention toward supervisory tasks. It is likely that this affects individual psychological outcomes such as motivation, work engagement, and job satisfaction and also team and organizational decisions and processes (Cummings & Bruni, 2009; Klumpp et al., 2019; Lee et al., 2015). However, this also impacts the cooperation among colleagues and with supervisors. Considering the different levels of change, we propose a conceptual framework for analyzing the relevance of the human factor for digital logistics work. The core topic of the structure is the question of HCI. For this area, we distinguish between four relevant levels as outlined below (see Figure 1).

As the human factor in digital logistics work is of outstanding relevance, we expect that this conceptual framework enables researchers to identify critical gaps and frame their individual research. In this context, it is especially relevant to focus not only on individuals in logistics contexts but to also consider that individuals and organizations operate in dynamic and complex interdependent systems and that thus (social) interactions matter for the implementation and success of digital transformation in business practice (D'Aleo & Sergio, 2017). Social interaction is an exchange between two or more individuals, which further influences the perspectives, positions, and actions of the interacting individuals. Through interactions, people design rules, institutions, and systems, which give further orientation and form perceptions (Weber, 1978). Besides the examples to be seen in the papers included within this special topic forum, we can outline the importance of a differentiated analysis of such interactions for the implementation and success in digital

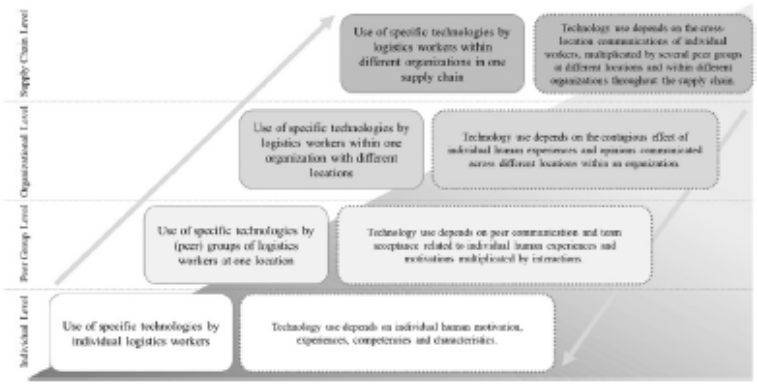

FIGURE 1 Human factor impact (HFI) in digital logistics

logistics (Cerulo, 2009). This can be exemplified regarding different professional groups, from driving professions to intralogistics personnel. Besides blue-collar workers, also white-collar logistics professions such as dispatchers or team leaders are susceptible to the mechanisms of social interaction with the four levels of HFI. This is even more relevant in the context of digitalization as transparency, communication, and interconnectedness are enabling closer connections and increased possibilities for social interaction.

AI, ROBOTICS, AND LOGISTICS EMPLOYMENT—CONTRIBUTIONS AND AVENUES FOR FUTURE RESEARCH

Regarding the relevance of the human factor in digital logistics work, the call for a special topic forum attracted four profound and future-oriented contributions. They allow for a broad overview regarding the topic of "Artificial Intelligence, Robotics and Logistics Employment" based on a range of disciplines and applying various research methods. Moreover, and considering the wide range of logistics settings, the contributions address different functional sectors like ports, intralogistics, and internal marketing in supply chains. To provide a brief introduction to the papers connected, we refer to the conceptual framework developed.

The paper by Dominic Loske with the heading "*Empirical Evidence on Human Learning and Work Characteristics in the Transition to Automated Order Picking*" is discussing the important area of order picking in intralogistics. The paper is providing empirical data-based observations regarding learning curves when order pickers are introduced to new processes and technologies. It is recognized that there are specific influencing factors providing different individuals with different efficiency improvement rates in the analyzed setting. For example, it is recognized that the perception–cognition–motor–action cycle for learning-by-doing tasks can be accelerated through real-time feedback the order picking system provides. Furthermore, perceived work autonomy and feedback from the picking system are constant or perceived as greater when human decisions are accepted. Further research questions are spiked from this looking into the adaption to such individual differences of human logistics workers, leading to a "future picture" of an individualized support technology for workers. Also, logistics management in practice is inspired by these results as there might be dedicated instruments like training and support for different groups of logistics workers, enabling a more smooth and efficient transition to new digital technologies with logistics work. This paper puts a focus on the individual level but is also considering the team level as workers compare themselves and their performance also with regard to the support structures of using digital technologies.

The paper by Eric Grosse, Sven Winkelhaus, and Christoph Glock titled "*Job Satisfaction: An Explorative Study on Work Characteristics Changes of Employees in Intralogistics 4.0*" is analyzing the trend toward digitalization in logistics as a managerial challenge as it is changing the traditional, manual workplaces, for example, in intralogistics. They examine the influences of the transition toward Intralogistics 4.0 with a literature review on work characteristics and job satisfaction in a broader Logistics 4.0 context. Moreover, they apply different Intralogistics 4.0 maturity levels in a qualitative, explorative methodology to examine the perception of work characteristics that impact job outcomes such as job satisfaction, motivation, and performance with semi-structured interviews conducted across seven companies. Results highlight significant, heterogeneous changes of work characteristics related to the type of technology applied in Intralogistics 4.0—the development toward Intralogistics 4.0 workplaces does not have a simple or predefined impact on humans; instead, the individual design is relevant and can improve the workplaces with more opportunities for satisfying and motivating jobs. This positive evaluation might motivate and enable future intralogistics workplace design concepts for the benefit of workers and organizations alike. Consequently, this contribution with a focus on the individual level also shows connections to the organizational level highlighting the relevance of the human factor.

The subsequent paper by Andrea Bottalico with the title "*The Impact of Innovation on Labor in the Port Industry. A Comparison between Genoa and Antwerp*" is addressing ports and port workers as key hubs in international logistics and transportation networks. As technical and organizational innovation has been pervasive in the port industry in the last decades, work organization and employment relations were affected to a great extent. Innovation initiatives produced on specific occasions a reduction of jobs in the port segment. At the same time, new jobs were created and demanded new skills or organizational structures. As a consequence, professional and social status levels of port labor have changed. The paper describes the consequences of innovation initiatives regarding port labor and on employment relations by comparing two distinct interview-based case studies in Antwerp and Genoa as exemplary ports in the Netherlands and Italy. Results indicate aversions but also positive motivation elements regarding innovation projects from port workers. Results are also important for transfer into other logistics sectors such as road freight depots or railway operations. In this sense, this contribution addresses the individual, the team

as well as the organizational level of analysis pointing to the interconnectedness of different levels.

The final paper by Abhinav Hasija titled "*In AI We Trust: An Internal Marketing Framework of AI Technology Acceptance*" is addressing a generalized question and model regarding technology acceptance in logistics and operations. This is relevant as industry reports and recent research indicate difficulties in implementing AI solutions. This paper addresses the documented difference between AI adoption and AI use by exploring how AI technologies can be marketed within an organization. Thematic analysis techniques are applied in order to explore the marketing messages of vendors of AI-enabled software. The emergent model from the implemented data analysis highlights the prevalence of marketing messages emphasizing AI trustworthiness and suggests several marketing tactics that could be used to market AI to supply chain workers internally, improving AI acceptance and use. Based on the findings, a middle-range model of AI trustworthiness and a subsequent call for research related to the effects of AI trustworthiness on internal, upstream, and downstream activities in the supply chain is proposed. The results contribute to academic conversations related to the acceptance and use of technology in supply chains. In addition, internal marketing and communication measures are outlined for managers to use in order to increase AI acceptance and use in supply chain processes. This paper is focused on the technical side of using digital technologies at work such as designing AI as trustworthy and thus addresses all levels of analysis starting with the individual level with resulting effects on the team, organizational and supply chain level.

Altogether, the four papers highlight the importance of the human factor in digital logistics processes from different perspectives but with the unified message that human workers are even more a crucial success factor due to their roles in using the full potentials and capabilities of AI, robotics, and automated systems in logistics. Further research is warranted regarding the highlighted role of social interaction as pivoting point in technology implementation and HFI in logistics. The outlined conceptual framework in at least four different levels where the human factor is relevant through social interaction and exerts this impact from the individual up to the supply chain level is also a core interest for future inquiries.

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