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Human Factors and Change Management: a case study in Logistics 4.0

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Abstract. Although the benefits and advantages are emerging more clearly, the transition of traditional manufacturing and logistics systems to Industry and Logistics 4.0 paradigms is still challenging for companies. In particular, the change management strategies suggested and employed so far lack consideration of the role of human factors to support a successful transition. Starting from the analysis of a case study conducted in a medium-sized Italian manufacturing company, this article aims to show how the critical consideration of the human factors involved in a change of operational processes in a logistics 4.0 perspective is crucial to achieve the objectives set. The article discusses the main strategies to consider from the beginning and the overall impacts on all the job profiles, tasks, and human factors involved to prevent potential resistance and inefficiencies in the implementation phases.

Keywords: Logistics 4.0, Human Factors, Change Management, Case study.

1 Introduction

The manufacturing paradigm of Industry 4.0 has been dominating the debate on the introduction of new technologies in manufacturing in both academic and industrial circles for several years so far. However, many studies now state that the full achievement of Industry 4.0 goals has not yet taken place [1] and that most companies are still fully addressing the transition [2]. This slowdown in exploiting the full potential of 4.0 technologies has several causes, mainly related to the fact that companies are advancing in adopting digital technologies without being ready from an organisational perspective [3]. Mainly, failures are due to employee resistance, lack of clearly defined and achievable objectives, scarce management support and commitment, and poor communication [4]. To overcome these problems, several tools and theories have been developed to support companies during the change process. In particular, among the most effective and widely adopted theories, there is change management, i.e. “a structured approach to facilitating a transition from a current state to a future state” [5]. Change management theory suggests different actions to implement in order to facilitate the transition from

a traditional to an innovative state, such as defining leadership, generating awareness, defining a clear vision and strategy of change, improving communication, identifying short-term goals, identifying and managing resistance to change, monitor and consolidate change [4]. While Industry 4.0, however, focuses its importance on technology and change management theory puts the organisation at the centre, the connecting element between the two, as indicated by socio-technical models, remains uncovered: the human factors (HF) [6], which are intended as “all physical, psychological, and social characteristics of the humans, which influence the action in socio-technical systems” [7]. Taking physical, cognitive and organisational HF into consideration, such as repetitive movements, memory and team work capabilities in the digital transformation of work, can avoid negative consequences for individual employees, production organisations, and society as a whole [8]. This research work’s objective is to analyse the HF involved in a case study of a Logistics 4.0 change process in order to prevent possible future problems and identify possible solutions to be implemented. In particular, this paper analyses the introduction of different technological innovations (i.e., a warehouse management system, wearable devices, and fast rotation storage) applied incrementally in the logistics sector (i.e., warehouse organisation) in a medium-sized Italian manufacturing company. The paper is structured as follows. Section 2 contains an overview concerning change management challenges in Industry 4.0 and a focus on the Logistics 4.0 context. Section 3 presents the methodology of the case study analysis adopted, while Section 4 reports on the elements analysed in the case study. Finally, Section 5 reports a discussion with the main insights deduced from the case study, and finally, Section 6 summarises the conclusions of the research work.

2 Background

2.1 Change management in the Industry 4.0 era

Despite promising valuable competitive advantages, the transition of manufacturing companies to Industry 4.0 constitutes a complex and resource-intensive process [2]. Indeed, it is now quite commonly recognised that a successful transformation to manufacturing and logistics models adhering to the Industry 4.0 paradigm involves a variety of dimensions that relate to implementable technologies and, above all, several organisational changes in a broad sense [9]. Industry 4.0 transformation initiatives can rightly be considered change initiatives, understood as processes of transition from a less digitalised state to a more digitalised one, requiring specific change management approaches [4]. Starting from the seminal works of Lewin [10], managerial literature offers several models to design, manage and reinforce the change process. Attempts to apply these models to Industry 4.0 transformation already exist: change dimensions have been adopted in Industry 4.0 assessment [11], and some roadmaps and frameworks for successful digital transitions have been proposed according to change management strategies (e.g. [2]). Nevertheless, in the literature on the digital transformation change process, it emerges the lack of in-depth studies about how to support the business transformation with suitable organisational evolutions [12]. Indeed, Industry 4.0 contains

technical and social (human-related) aspects [13]. For this reason, human-centred design is beginning to be increasingly adopted [14] to achieve the expected results in terms of productivity and efficiency, without intervening in problems related to the workforce, both in terms of the necessary skills and the actual acceptance of the process transformation in a 4.0 perspective. Thus, anthropocentric approaches are helpful to understand in advance the evolution of the human roles in the change process and promote the development of production and logistics systems in which technologies valorise human capacities, and socially sustainable interactions between machines and humans occur [15].

2.2 Logistics 4.0

Logistics has been one of the sectors most affected by 4.0 technologies due to the continuous need for process optimisation and cost reduction. Logistics 4.0 is defined as “the logistical system that enables the sustainable satisfaction of individualised customer demands without an increase in costs and supports this development in industry and trade using digital technologies” [16]. Logistics, however, like the manufacturing sector in general, suffers from the same problems described in the introductory section concerning managing the transition from traditional to 4.0 logistics. In particular, the process of technology adoption and the motivations driving this choice have not yet been extensively analysed in the literature. The role of HF or the need for new organisational structures in Logistics 4.0 has not yet been fully explored [16, 17]. Furthermore, there are some areas of logistics, such as reverse logistics or outbound logistics, where 4.0 technologies have not yet been widely exploited. Among all the gaps still present both at the academic level and in industrial application, we decided to explore in this research work the issue related to the role of HF in managing change towards a Logistics 4.0. This issue is of paramount importance also in the light of the European Union's indications to move towards a more resilient, sustainable and above all human-centered Industry and consequently Logistics 5.0 [18]. In particular, the design of human-centered logistic processes and activities helps to prevent possible problems that can be generated in the workforce, by making more evident the areas in which it is necessary to intervene with targeted action of training and empowerment of workers.[8].

3 Methodology

To explore the role of the HF involved in a change process, we opted for a single case study research. Indeed, case research is useful in exploratory research to develop ideas that can be conceptualised and tested afterwards [19]. In particular, a single case study is suitable if the purpose of the research is connected to new concepts and knowledge [20]. In the specific research presented in this paper, we based the single case study on the approach provided by [21]. In particular, the industrial case presented aims to take a snapshot of the different stages of a company's change process following the decision to improve its order management and the subsequent technological introductions and

modifications to its logistics processes. The choice of this company for the development of the industrial case study has been made according to the [21]'s single case study rationale selection of the "common case". The objective of the common case is to capture the circumstances and conditions of an everyday situation that could provide novelty aspects about the processes related to some theoretical interest [21]. In order to overcome the main single case study limitation, we have adopted some strategies which, if used in the research process, contribute to enhance the validity and reliability of the case study. They have been employed to ensure congruence among literature, data collection, and analysis [11]: in particular, construct validity, internal validity, and reliability were addressed. Construct validity allows identifying correctly the operational measures for the concepts being studied. According to [21], in order to guarantee internal validity, we have developed a case study protocol. As a further element to guarantee the reliability of the research, experienced investigators, whose main values are sensibility, adaptability and ability for clarification, conducted the case study [22]. Indeed, all the authors have experience in adopting the single and multiple case study methodology.

4 Case study

4.1 Problem statement

The company selected for the single case study is one of Italy's largest bottling plants and packaging machines manufacturers. It designs and manufactures a wide range of machines and systems for bottling and packaging food and beverages, household cleaning products, personal care products, chemical and pharmaceutical products. The scope of the analysis encompasses all the company's logistical processes, including issuing batch orders, receiving and stowing orders within the company, handling materials, picking components, and storage of materials and work-in-progress. In the past, these processes were characterised by several problems that caused inefficiencies. Firstly, the company issued an excessively high number of orders, even for small quantities of components. This was a severe problem, especially considering the company's geographical location, which is located in a mountainous area that is difficult to reach, with high shipment costs. In addition, production components orders and spare parts orders were issued separately, causing a further increase and duplication in the number of orders to manage, which generated inefficiency due to the huge number of material acceptances and quality checks at the entrance. Incoming orders then had to be allocated to the correct areas of the company, which resulted in a high number of material and goods movements, with relevant risks of damage to the material and safety risks for operators. Indeed, the company operated with a Just-In-Time approach, ordering materials as and when customers required them. However, this approach finally resulted in delays in deliveries to customers and thus low service level, mainly concerning spare parts. All these problems could be traced back to the batch sizes used by the company to re-order materials. The logistics operators defined the batch sizes based on their own experience. Therefore, this process could easily be subject to discretionary decisions and human error. In addition, the materials and components used by the company are

not standard, with dimensions ranging from a few centimetres to many metres. This increased the complexity of handling and storing materials within the company. All these problems led the company to invest in improving its logistics processes. As most of the issues were due to the small batch sizes, the company designed and implemented a management system to optimise their computation. The designed Warehouse Management System (WMS) aimed at optimising the batch size, taking into account the stock level, the trimestral budget and the bill of materials of the company's products. The main objective of these changes was to improve business efficiency by reducing the number of orders issued, shipments, and material handling. Secondly, the implementation of the WMS had the potential to improve effectiveness by reducing disservices due to delays.

4.2 Adopted solutions

As mentioned in the previous paragraph, the design and implementation of a WMS allowed for solving the problems caused by suboptimal batch sizes. In implementing this technology, the work of the operators in charge of batches definition was fully replaced by an automatic algorithm. The implementation of the WMS had an impact on the orders-issuing process and other logistics processes. This resulted in the need to integrate and implement other technologies to enable the achievement of the company's objectives. In conjunction with the implementation of the WMS, indeed, other technologies have been introduced: some of them, such as tablets, currently support the operators' activities, while others, such as automated warehouses, are full automation technologies (Table 1). All these technologies interact with each other and especially with the WMS.

Table 1. Implemented technologies

Technology	Type	Area	Objectives
WMS	Automation	Order Mgmt	Reducing inefficiencies, measuring KPIs.
Fast-rotation automated warehouses	Automation	Storage	Allowing optimal storage for high-turnover parts
Tablets	Support	Stowage / Picking	Suggesting the right material allocation to the receipt operators
PCs	Support	Picking	Suggesting the location of materials to pick for assembly
Printers	Support	Stowage / Traceability	Supporting the operators in the labelling and tracking of incoming material

4.3 Impacts on the human work

At first, the introduction of the WMS was designed to facilitate the operators of the purchasing and logistics management department, who, from the beginning, have responded positively to the introduction of the new technologies. Indeed, the WMS design and implementation were driven by significantly simplifying orders management.

The WMS relieved operators from sizing batches of materials and issuing purchase orders, performing these operations automatically and more precisely thanks to optimisation algorithms, able to take into account simultaneously the orders of the last 18 months, the spare parts needed, the forecast of future orders, and the current available budget of the company. Along with reducing the cognitive HF required, this also introduced a formalisation into the purchasing process that had not existed before and reduced the risk of error when purchasing materials, thereby reducing the number of orders to be placed. Although the introduction of this new technology was aimed at helping the logistics office, it also affected other departments, which were not involved initially and did not initially react positively to the change. This is the case of the warehouse operators, who did not immediately understand the usefulness of the change. Before introducing the new technologies, they were in charge of checking the incoming material, sorting it, and assigning it to one of the four storage areas in the plant. Therefore, the change required an initial period of adaptation. Nevertheless, after that, the warehouse operators finally appreciated the introduction of the new technologies, as they realised that their workload had been relieved without requiring any new skills: the optimised batch sizes resulted in a minor number of checks on incoming materials, along with handlings, which has made it possible to reduce physical HF in these tasks. Another task in which the new technologies helped the warehouse operators was materials allocation. Whereas before, the operators had to decide autonomously where to place the incoming material, with the involvement of cognitive HF, such as memory, now the WMS automatically provides, by displaying it on a tablet, the destination of the material and the occupation of the location areas, suggesting the optimal route to store the materials into the assigned locations. Having a global view of the consumption and arrival of components has made it possible to transport large size pieces directly to the assembly workbenches immediately after their arrival in the warehouse, avoiding unnecessary and repetitive transportation. Moreover, this innovation enabled a further positive result, initially unexpected by the company, in simplifying the picking task for the assembly operators. Whereas they previously wasted time by looking for the necessary materials to assemble, they can now read their exact location on a PC located directly in the assembly island, which shows each operator the picking list. Finally, to exploit the introduction of the WMS, ten vertical automated warehouses for fast-rotation storage were implemented. Nevertheless, some issues for the correct allocation of materials in them emerge. If high, medium and low rotation parts are not sorted correctly, there is a risk of queues being generated during the picking operations. The WMS automatically suggests the sorting, but the warehouse operator still makes the final decision about allocation. Therefore, these new technologies introduction has also led to the generation of a new cognitive HF for these workers.

5 Discussion and conclusion

The industrial case offered interesting insights about how process changes can affect human work and, at the same time, how proper HF analysis are crucial to drive successful change management. First, it was clear that to avoid unexpected and adverse

consequences to the technology introduction, a holistic analysis of the involved job profiles, tasks, and HF needs to be performed. Indeed, since the WMS design mainly addressed the requirements of the logistics clerks, initial resistances to change occurred concerning warehouse operators, who were not fully aware of the technology impacts and expected benefits on their work. For this reason, the human-centred design of digital solutions, such as the WMS functionalities, must be performed by taking into account the requirements of usability, accessibility and user-friendliness for all the involved roles. This also suggests that involvement and communication at a broad level to employees before the change is fundamental to achieve a successful transition. Other strategies to support the change management *ex-ante* are modeling and simulation of processes that will be affected by modifications in tasks, layouts, and operational modes in relation to implementing new technology. During the transition, then, training strategies could be helpful to make employees familiar with technological solutions, and bottom-up improvement suggestions should be encouraged to align the technologies' operational settings according to user needs. In the case company, the logistics transformation journey was not planned from the beginning. However, updates in the process changes were deployed based on new requirements that emerged from the workforce after the first WMS functionalities introduction. This suggests that, along with the development of a clear change management plan, continuous feedback analysis and emerging issues diagnosis should be carried out to timely intervene with corrective actions and maximise the benefits. Generally, as literature shows, also from the case, it emerged that adopting change management strategies is highly relevant to generate the proper awareness in the workforce and managing potential resistances, with the final result of achieving consolidated process changes and improvements. This research presents a preliminary attempt to analyse change management strategies in Industry 4.0 regarding the importance of involving HF. Although only a single case study being discussed concerning the logistics area, interesting insights about the importance of deploying suitable change management strategies taking into account all the involved tasks and HF were presented. To overcome the limitations of this first research stage, further case analysis will be carried out to produce practical roadmaps for guiding HF-based change management paths in Industry and Logistics 4.0.

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