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Towards Industry 5.0 Challenges for The Textile and Apparel Supply Chain for The Smart, Sustainable, and Collaborative Industry in Emerging Economies

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Abstract
Industrial revolutions often seek to strengthen the separation of human and machine labor by going one step further, toward automation and digitalization, and the transfer of tough and dangerous occupations to robots. As it strives to include robots in people's daily activities and work, the introduction of concepts such as I5.0 is a step forward in enhancing human-machine interaction and provides some possibilities and challenges for firms. Therefore, this article mainly focuses on studying and concretely examining the challenges faced by businesses transitioning from I4.0 to I5.0 by providing case examples from the textile and apparel supply chain. After a detailed review of the current literature related to the I5.0 challenges, the I5.0 challenges were listed in general. Then, the fuzzy Decision-making trial and evaluation laboratory approach has adopted into the challenges to reveal causal interactions between them thus, prioritizing the substantial challenges to be focused on to influence the entire textile and apparel supply chain.

Keywords Industry 5.0 · Collaborative industry · Human-centric · Challenges · Industrial revolutions · Human-machine interaction

1 Introduction

Industrial revolutions are intended for separating worker's and automated device's labor and pass over occupations to robotics that are tough and risky for the workers (Fazal et al., 2022). The First Industrial Revolution in history, which could be linked return to the 1780s, began in regard to the production of mechanical energy using water, fossil fuels, and steam. In the 1870s, firms using assembly lines and mass manufacturing embraced electrical energy which is referred to Second Industrial Revolution. Then, the Third Industrial Revolution initiated the mechanization idea in industrial industries in the 1970s using information technology (IT). In the fourth period of the revolution, the Internet of Things (IoT) and cloud computing are utilized to develop cyber-physical systems, which serve as a real-time interface between physical and virtual realms.

The industry 4.0 term (I4.0) was initially introduced in Germany in 2011. The notion I4.0, "smart manufacturing," and "industrial internet of things" (IoT) all referred to the combination of data and operational technology in order to track physical production methods and utilize data to generate a prediction, correction, and adaptable suggestions to

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save operational costs (Tay et al., 2021). In other words, integrating technologies such as the Internet of Services (IoS) and the Internet of Things (IoT) into production operations are named I4.0, which is the fourth industrial revolution (Yüksel, 2020). IoT, IoS, Cyber-Physical Systems (CPS), and Smart Factories, Big Data Analytics (BTA), Data Mining (DM), Blockchain, Augmented Reality, Artificial Intelligence (AI) are I4.0's main building blocks.

The deployment of I4.0 has benefited from many technologies, including Virtual Reality, Augmented Reality, Digital Twins, COBOTS (collaborative robots), Computer Simulations, etc. These technologies support the development of supply chains, smart products, and manufacturing processes Therefore, firms have undergone a digital transformation using the four technological pillars which are artificial intelligence (AI), blockchain technologies (BT), cloud computing, and big data. With all these advances I4.0 contribute to the supply chain; people are expected to contribute high-value activities to manufacturing standards during the upcoming industrial revolution. The Fifth Industrial Revolution is already underway, even if I4.0 is still in its youth.

Although we proceed to realize the advantages of the "smart production" era, practitioners and researchers have recently started highlighting the vital role that labors play as a component of human-centric Cyber-Physical Production System (CPPS) (Krugh & Mears, 2018), along with the significance of developing industrial processes and systems for incorporating and encapsulating social aspects (Longo et al., 2020; Hancock et al., 2013). Therefore, we can claim that in contrast to previous industrial revolutions, which focused on the economical side of sustainability, Industry 5.0 (I5.0) emphasizes Human-oriented social expectations (Leng et al., 2022). Basically, I5.0 is a forward-thinking notion of the industry's future toward a strong, resilient, and human-centered manufacturing system (Breque et al., 2021), which presents a vision of the industry's flourishing development (Huang et al., 2022).

The rise of concepts such as IoT and I5.0 presents new opportunities and difficulties for businesses (Aslam et al., 2020) and human-machine interaction (HMI) because it will put robotics very close to every human's daily life. (Nahavandi, 2019). Industry 5.0 can be described as an idea that developed a few years ago and has been actively debated amongst stakeholders from research organizations and financing organizations (Huang et al., 2022). I5.0 is a stride forward in the refining of human-machine interaction (Sharma et al., 2022; Faruqi, 2019). The main objective of I5.0 is to change existing manufacturing factories and develop these factories into new digitized systems in order to improve/superior manufacturing facilities in which people communicate with machines (Sharma et al., 2022; Javaid et al., 2020).

I5.0 has various benefits. For instance, it can boost production efficiency through outsourcing routine and dull work to intelligent machines and those requiring critical-thinking humans. (Maddikunta et al., 2022). Moreover, I5.0 has the potential to considerably raise industrial productivity and encourage adaptation amidst people and intelligent machines, allowing for interactive accountability and continuous tracking of operations. Aside from the advantages in the manufacturing industry, I5.0 also has advantages in terms of sustainability since it strives to establish a renewable energy-powered sustainable system (Adel, 2022). As a result, we can claim that I5.0 has gained traction in recent years as a human-centric design approach in which people and cobots engage in a shared working environment, attempting to overcome the issues revealed by I4.0. (Huang et al., 2022; Xu et al., 2021).

This study stands out for its attention to the difficulties involved in moving from I4.0 to I5.0 within the textile and apparel supply chain while providing sector-specific insights and perspectives. While the majority of the current literature on I5.0 concentrates on the future agenda, advantages, and promising solutions, our research takes a practical approach by analyzing the actual difficulties faced by businesses in this particular industry. Additionally, this study introduces the use of the DEMATEL method with fuzzy logic to order the identified problems and identify the relationships that cause them, offering a methodical way to comprehend the intricate relationships at play. With the help of this novel methodology, we hope to provide a thorough analysis that will allow us to identify and rank the most pressing problems that must be solved to successfully apply I5.0 throughout the textile and apparel supply chain. This study also incorporates a number of complementary theories on industrial revolutions, smart manufacturing, human-machine interaction, and sustainability to provide a solid theoretical foundation for our analysis and to improve the broadness and accuracy of our conclusions. This study advances knowledge in the area of I5.0 and offers beneficial insights for practitioners, researchers, and stakeholders in the textile and apparel industry by fusing these original elements—sector-specific focus, novel methodology, and comprehensive theoretical framework.

Under this motivation, I5.0 contains various promising opportunities with different technology alternatives for many industries and it is an emerging field that requires more research attention. Most of the studies in current literature related to I5.0 technologies generally points out the future agenda with the benefits, advantages, promising solutions, and prospect by looking at retrospect. Thereat, this article primarily focuses on studying and concretely applying the challenges faced by businesses transitioning from I4.0 to I5.0 by providing case examples from the textile and apparel supply chain. For this purpose, existing literature related to I5.0 technologies scrutinized, and the challenges that I5.0 technologies contain have been revealed to examine. After determining the I5.0 challenges in general, because of the limited literature, the Decision-making trial and evaluation laboratory (DEMATEL) method with fuzzy logic has adopted into the challenges to reveal causal interactions amidst them thus, prioritizing the substantial challenges to be focused to influence the entire textile and apparel supply chain. For this aim, related Research Questions (RQs) are submitted below:

RQ1: What are the major forthcoming I5.0 challenges for organizations to overcome in order to successfully transition from I4.0 to I5.0?
RQ2: How might I5.0 technology help with these challenges in the textile and apparel supply chain?

By addressing these research questions, we hope to shed light on the specific difficulties organizations may encounter as they make the switch to I5.0 as well as the potential solutions offered by I5.0 technologies. Additionally, rather than solely relying on predictions for the future, our study aims to contribute to the developing field of I5.0 by concentrating on real-world applications and case studies. This study has the potential to help organizations adopt I5.0 technologies in a successful manner while taking into account the particular traits of the textile and apparel supply chain.

The search requests were carefully refined based on input from and expert feedback to ensure the literature review's relevance and currency. In the beginning, a thorough search strategy was created to find relevant research concerning Industry 5.0 and its difficulties. However, in order to capture the most recent advancements and take into account the field's dynamic nature, industry, academic, and research organization experts are consulted in the textile and apparel sector. The search requests were specifically targeted at recent publications, cutting-edge research, and emerging trends in the context of the textile and apparel supply chain through their valuable insights and suggestions. By incorporating advice from experts, we made sure that our literature review took into account the most recent and pertinent sources, improving the precision and applicability of our findings. This commitment to providing a thorough and current review of the literature, addressing the uniqueness of the research gap, and offering beneficial insights that are in line with the changing conditions of Industry 5.0 in the textile and apparel sector is demonstrated by the iterative process of tailoring the search requests based on expert feedback.

The remaining of this research study is as followings: Section two investigates the literature for current studies of I5.0 and compiles a list of challenges. The third section of the study points out the methodology of the paper, the fuzzy logic, and the steps of DEMATEL. The fourth section contains a real-life case example and the implementation stage of the study. Depending on that the results of the case study will be enlightened and explained further in section five. The results of the study will be discussed, and implications will be given in section six. Lastly, the study will be concluded with some remarks.

2 Literature Review

2.1 Challenges of the I5.0 Technologies

Despite the challenges of I4.0 still plaguing enterprises, Industry 5.0, the following industrial revolution, is already upon us thanks to incredibly swift technological advancements in the sectors of information technology and IoT (Aslam et al., 2020; Paschek et al., 2019). The foundation of I5.0 is the idea of robot and human collaboration, where they cooperate rather than compete to achieve a common goal (Sharma et al., 2022; Breque et al., 2021; Nahavandi, 2019). Additionally, the idea of I5.0 provides a unique viewpoint and highlights the significance of innovation and research in aiding the industry in its long-term impact on society (Xu et al., 2021; Breque et al., 2021). Considering this, I5.0 is currently being envisioned as a means of merging the particular uniqueness of expertise of people with powerful, wise, and precise technology (Maddikunta et al., 2022). However, with its new perspective, I5.0 will assist to overcome the problem of a mismatch between industrial and societal requirements (Leng et al., 2022). In this context, the challenges that arose with the emergence and development of the I5.0 has scrutinized throughout the existing literature and listed below (See Table 1).

Human-robot collaboration (HRC) (Li et al., 2021; Liu & Wang, 2020) might be one of the most promising and difficult research topics for achieving human centricity in industrial systems (Huang et al., 2022). It is a process that combines and complements human intellect with machine intelligence, allowing for never-ending invention while eliminating the need for a massive sensory network, storage systems, and processing (Huang et al., 2022; Li et al., 2022). Therefore, if the proper limitations are not in place, human-robot collaboration could result in several problems; as a result, legislation that governs robot and human collaboration should explicitly define the difference between a machine and a robot (Demir et al., 2019). Legalization and standardization will aid in preventing any significant problems between firms, society, and technology. Despite the existence of generic norms for innovation policy, automation, industry norms, laws, and regulations are still necessary for the full adoption of every industrial

Table 1 The Challenges of Industry 5.0

Number of challenges	Challenges	Description	References
C1	Standardization and legalization of technologies	I5.0 technologies need to be standardized and made legal in order to ensure the safe and responsible integration of cutting-edge technologies like AI, robotics, and IoT into industrial processes, which is difficult given how complex and dynamic these technologies are.	(Sharma et al., 2022; Nahavandi, 2019; Xu et al., 2018; Leitão et al., 2016)
C2	Interoperability in semantics	Semantic interoperability, which is hampered by a lack of a common language and standards, refers to the capacity of I5.0 technologies to communicate and analyze data efficiently.	(Sharma et al., 2022; Xu et al., 2018; Lu, 2017)
C3	Automation and digitization of process	To implement I5.0 technologies, organizations must weigh the advantages of greater productivity and efficiency against the expenses and disruption caused by switching to new systems and workflows.	(Sharma et al., 2022; Horváth & Szabó, 2019; Xu et al., 2018; Colombo & Harrison, 2008)
C4	Ineffective change management and resistance to change	I5.0 technologies' uptake faces obstacles due to ineffective change management and resistance to change since these technologies demand a fundamental transformation of industrial processes, which raises doubt among stakeholders and employees. To successfully use these technologies, organizations must prioritize effective communication, cooperation, and participation while simultaneously addressing worries about job displacement and skill gaps.	(Sharma et al., 2022; Sharma et al., 2020a, 2020b, 2020; Demir et al., 2019; de Souza Jabbour et al., 2018; Müller et al., 2018)
C5	Ethics issues in robotic systems	Concerns about the responsible use and deployment of robots and autonomous systems in Industry 5.0 are referred to as ethical issues in robotic systems. These concerns present an impediment to the adoption of these technologies because organizations must weigh the ethical implications of their use against the potential advantages of increased productivity and efficiency.	(Huang et al., 2022; Sharma et al., 2022; Longo et al., 2020; Nieuważny et al., 2020; Demir et al., 2019; Nahavandi, 2019)
C6	Inadequate laws, rules, legislation, and certification	To protect human rights, confidentiality, security, and environmental sustainability while using I5.0 technologies, organizations, and governments must create universal norms and rules.	(Maddikunta et al., 2022; Sharma et al., 2022;; Xu et al., 2021, Demir et al., 2019; Ding 2018; Xu et al., 2018; Stegemann, 2016)
C7	Increased error rates resulting from total automation between human-machine	A difficulty for I5.0 technologies is the rise in error rates brought on by the complete automation of human-machine interactions. Organizations must assure the reliability, security, and resilience of autonomous processes and structures while also addressing possible difficulties with responsibility and liability.	(Sharma et al., 2022; Maddikunta et al., 2022; Ding 2018)
C8	Inadequate green efforts or innovation	Due to a lack of attention and investment, insufficient green initiatives or innovation impede the widespread implementation of environmentally responsible and sustainable I5.0 technologies and practices.	(Sharma et al., 2022; Huang et al., 2022; Xu et al., 2021; Ahsan & Rahman 2017)

Table 1 (continued)

Number of challenges	Challenges	Description	References
C9	Lack of security, privacy in data circulation	In order to use I5.0 technologies, organizations must guarantee the privacy, availability, and integrity of data while simultaneously defending the rights of stakeholders and individuals.	(Adel, 2022; Maddikunta et al., 2022; Leng et al., 2022; Demir et al., 2019; Wells et al., 2014).
C10	Profitability & Scalability	Because developing a sustainable business model and the capacity of I5.0 technologies and processes to scale effectively and efficiently present hurdles, businesses must show the financial sustainability of their investments in cutting-edge technology.	(Maddikunta et al., 2022; Xu et al., 2021; Sharma et al., 2020b).
C11	Heterogeneity of the system	The adoption of I5.0 technologies is hampered by the heterogeneity of industrial systems and processes because these problems must be resolved for effective communication and collaboration between various systems, devices, and stakeholders.	(Leng et al., 2022; Xu et al., 2021)
C12	Transformation of human-centric value-driven technology	The establishment and application of I5.0 technologies and processes must be coordinated with societal values and requirements in order to serve the common good and advance human welfare. This is known as the transition of human-centric value-driven technology.	(Leng et al., 2022; Gurbaxani & Dunkle, 2019; Paschek et al., 2019)
C13	Development of lifelong learning and worker training to address skill gaps	To provide the workforce with the skills and abilities it needs to adapt to the changing nature of work in I5.0, lifelong learning and worker training are essential. In order to guarantee that employees can effectively operate, manage, and maintain sophisticated technology and processes, this calls for a continual and dynamic process of improving and retraining.	(Adel, 2022; Leng et al., 2022; Raj et al., 2020; Demir et al., 2019; Nahavandi, 2019; Paschek et al., 2019)
C14	Social Values Evaluation (time, right policies, ethical issues, moral codes)	Assessing and resolving the social and ethical consequences of I5.0 technologies and processes is the task of ensuring that they are consistent with societal values, norms, and principles. To guarantee openness, accountability, and responsible innovation, a multidisciplinary approach is necessary.	(Leng et al., 2022; Xu et al., 2021)
C15	Requires high investment	To guarantee that the benefits of I5.0 are broadly available and sustained, a significant investment is needed in infrastructure, research, and development. For smaller businesses with less resources, this may act as an entry challenge.	(Adel, 2022; Sharma et al., 2022; Xu et al., 2021; Paschek et al., 2019)

revolution; thus, it is necessary to implement the more precise requirements for this new period (Maddikunta et al., 2022).

Besides, scalability is one of the properties of Industry 5.0, but a more serious obstacle is making machines or robots and humans a partner by doing their job together (Maddikunta et al., 2022; Sharma et al., 2020b). For this purpose, to implement I5.0 for businesses, staff must ensure effective machine-to-machine and operator-to-machine interaction (Adel, 2022). Thus, people must improve their competence abilities because when working with modern robots, personnel have to figure out how to collaborate with smart machines and robot creators (Adel, 2022; Narvaez Rojas et al., 2021).

Adopting I5.0 is also costly (for example, innovative technologies necessitate large investments, UR Cobots are not cheap, training human employees for new occupations is costly, and so on). In order to boost production and efficiency, smart machines and highly skilled workers are required (Adel, 2022). Especially, investment in prototyping collaborative robots which includes funding for prototype robotics that can imitate people and recognize and evaluate human intent, as well as a pick-to-light system and a human-machine interface (Sharma et al., 2022) requires a high amount of investment.

Another critical issue that I5.0 faces is security, which is a challenge for I5.0 since confidence in ecosystems is vital (Adel, 2022). As we progress toward increasingly digital computing, security vulnerabilities in the heterogeneity of the system and the usage of cloud services for managing various industrial and user data must be examined (Maddikunta et al., 2022). I5.0 exhibits multi-system heterogeneity and multi-sector symbiosis, posing significant obstacles to the administration of information and data across diverse devices (Leng et al., 2022). Strong security requirements are necessary since I5.0 operations are heavily reliant on ICT systems to prevent security issues (Adel, 2022). Since I5.0 relies on data sharing over the Internet to link machines to people, developers with other partners, and while exchanging information for tracking and supervision, this information has to be kept private to ensure the security of the cloud manufacturing environment (Maddikunta et al., 2022; Wells et al., 2014).

Even though I5.0 is a relatively new and evolving idea, there are enough research in the literature to analyze and outline I5.0 issues for our study. After the detail investigation of the literature related to the issue of the I5.0 concept and its challenges, as presented above, we have recorded and listed the existing challenges of I5.0 in general. The challenges were determined generally since it is difficult to find a sector-based challenge set considering the subject is still unexplored. This challenge set can be customized and used by different sectors in future studies, and it may also be crucial for the generalizability of the study's findings. After determining these challenges in general, we prioritize these challenges depending on our team composed by the academicians, and grouped the similar challenges, and eliminated the numbers into 15. The relevant challenges might span nearly every dimension (economic, social, environmental, legal, etc.), which was one of the factors used to narrow down the challenge sets.

2.2 Literature Review of I5.0 Research

Outside the boundaries of I4.0 ecosystems, this new wave, dubbed I5.0, is anticipated to combine large-scale production with individualized user experiences (Verma et al., 2022).

A novel study on BC as a risk enabler in I5.0 was suggested by Verma et al. (2022). The authors looked at the major motivators and prospective applications using a descriptive survey technique and research questions, and then proposed an architectural viewpoint of BC-based I5.0 in many application verticals. Leng et al. (2022) also addressed the future implementation route, prospective applications, key enablers, and problems of actual I5.0 scenarios in their paper. Similarly, Noor-A-Rahim et al. (2022) envisioned the possibility of IRS technology application in a prospective smart manufacturing environment to help I5.0 become more prevalent. By examining current digital platforms and their shortcomings, a conceptual framework for an enhanced digital system for the adaptive management of enterprises inside the ensuing generation of digitalization in the impending I5.0 era was developed by Gorodetsky et al. in 2020.

Javaid & Haleem (2020) concentrate on the evolution of all industrial era and distinguishes between I4.0 and I5.0 by highlighting the key aspects and competence of I5.0 in the manufacturing area and evaluating and briefly discussing seventeen major elements of I5.0. Kasinathan et al. (2022) envision a scenario in which Society 5.0 and I5.0 are connected to construct smart cities, in which possibilities of reaching Sustainable Development Goals are improved owing to relationships between the Sustainable Development Goals and the integrated framework.

Akundi et al. (2022) aimed to recognize and examine the different concepts and research directions of what I5.0 is using text mining methods in order to comprehend the viewpoint of what I5.0 is its evolvement, and the technologies and subject areas that facilitate achieving Industry 5.0. Ghobakhloo et al. (2022) created and released the I5.0 reference model which describes the technological and functional elements of this phenomena. To determine the roles of I5.0 sustainable development, they also carried out a content-centric examination of the literature. The I5.0-enabled structure for sustainable growth was created with this goal in mind, and the sequential linkages between the functions were identified using the interpretative structural modeling (ISM) technique.

For instance, Bedi et al. (2021) noted how the garment sector has adopted cutting-edge technology including artificial intelligence (AI), blockchain, 3D printing, cloud computing, and data analytics in their investigation of the I5.0. The problems of I4.0 are also highlighted in this study, which also suggests a creative framework for implementing Industry 6.0 in the wake of the pandemic. Similarly, Raja Santhi & Muthuswamy (2023) explored I4.0's enabling technologies and imagines how they will serve as the cornerstone of the fifth industrial revolution. The necessity for I5.0 technologies and the socioeconomic issues posed by the technologies were also covered. The study also discussed the possible usage of Industry 5.0's technologies from the viewpoint of researchers and industry leaders, as well as how they can circumvent Industry 4.0's drawbacks. Furthermore, Gupta et al., (2019) aimed to determine whether there is a direct link among intelligent supply chain characteristics and information flexibility in the system in the context of an organization's information processing capabilities. To achieve operational excellence, this study must build a solid connection across the information system's flexibility and the smart value chain, as well as the environmental capabilities of an organization's information processing. In order to manage the effects of supply chain disruptions brought on by the COVID-19 epidemic in a developing nation and to establish operations that are strong and inclusive, Karmaker et al., (2023) set out to explore the problems of applying I5.0 in supply chain networks. Moreover, the implications of the I5.0 phenomena on the supply chain were discussed by Frederico (2021). To address the most recent and groundbreaking idea of the I5.0 phenomena in the supply chain context, a subject that has not yet received much attention, this essay intends to provide scholars and practitioners with insightful new information. Dwivedi et al., (2023) observed 16 possible factors for I5.0 and CSC synergy and builds a mixed model utilizing the Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) and the modified Total Interpretive Structure Model (m-TISM).

3 Proposed Methodology

The DEMATEL method (Decision-Making Trial and Evaluation Laboratory) is a multi-criteria decision-making tool that enables the selection of measures and efforts to address the most pressing problems or opportunities. It has been widely utilized to extract the texture of a complicated problem to apply DEMATEL, an extended approach for constructing and assessing complex causal interactions among various factors and issues. (Abdel-Basset et al., 2018). Its main advantages include giving decision-making a structured and methodical approach, enabling stakeholder involvement and consensus-building, and assisting companies in determining the dominant forces behind and challenges to the widespread adoption and application of new technology or procedures. Since DEMATEL doesn't require a lot of information, it may quickly suggest the important criteria and how they interact with one another (Yazdi et al., 2020). Given these benefits, the DEMATEL method has been effectively applied to assess indirect relations in numerous industrial domains, covering advertising approaches, R&D efforts, e-learning assessment, manager skills, control systems, and aviation safety issues (Liaw et al., 2011; Lin & Wu, 2008; Tzeng et al., 2007; Chiu et al., 2006; Hori & Shimizu, 1999). The main argument that led to the DEMATEL method being preferred in this study is to determine if there is a cause-and-effect link between them by examining the I5.0 challenges reported in the literature. In order to have a greater influence on the entire system, it is intended to prioritize the search for answers to high-impact challenges by examining any information on how, if at all, different challenges are impacted by one another. In this scenario, challenges that directly affect other criteria are given priority, and by concentrating on this aspect, challenges that will arise as a result of it may be avoided. As a consequence, many of the challenges may be handled by recognizing, highlighting, and addressing factors that have an effect on different groups of issues. However, by doing we have used a fuzzy scale to eliminate the vagueness of human judgments. Thereby, the fuzzy DEMATEL was used in this section of the study to deal with ambiguous language, human concepts that are formed by the diversity of the components, and other issues (Kayikci et al., 2021). Predetermined challenge criteria were evaluated for causal relationships for applying the fuzzy DEMATEL. For this purpose, the methodology of the paper is as follows (see Fig. 1).

3.1 Fuzzy Logic

In 1965, Zadeh introduced the fuzzy set theory. This theory is suitable for addressing the incoherence and unreliability of data pertaining to numerous parameters (Zadeh, 1965). Most of the human language uses ambiguous words like "equally," "moderately," "strong," "very strongly," "very," and "considerable degree." DMs use such terminology to examine unclear acts and objects. The instabilities that occur with dealing with the linguistic judgment of data can be addressed by DMs using fuzzy set theory. Additionally, the theory makes it possible to employ coding and scientific procedures in the fuzzy space (Sagnak et al., 2021). There exist fuzzy numbers with triangular, trapezoidal, and other shapes.

Triangular fuzzy numbers and the membership function;

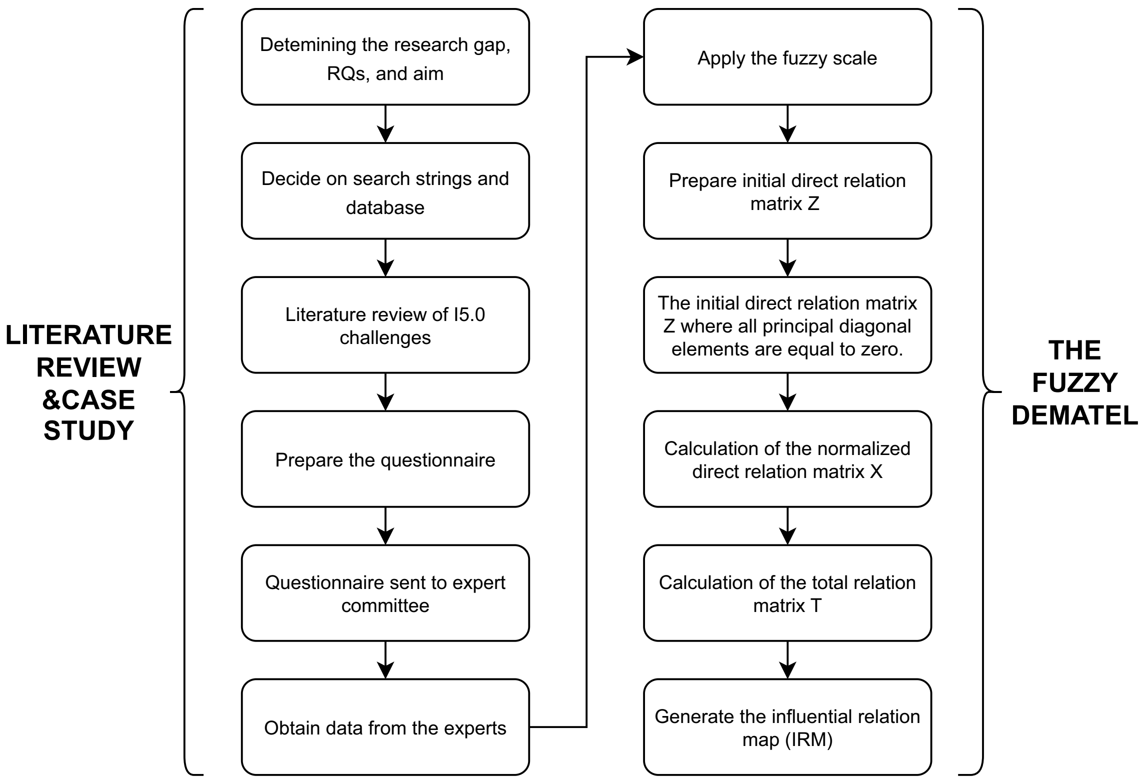
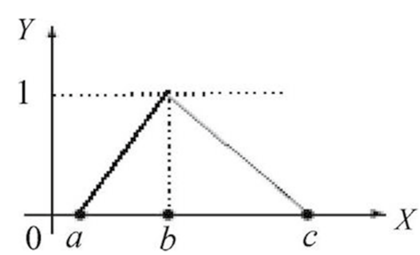


Fig. 1 The Methodology of the Study

$$\mu(x) = \begin{cases} 0, & x \le a \\ \dfrac{x-a}{b-a}, & a < x \le b \\ 1, & x = b \\ \dfrac{c-x}{c-b}, & b < x \le c \\ 0, & x \ge c \end{cases}$$



Basic fuzzy operations;

$$\tilde{A} \bigoplus \tilde{B} = \left(a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4\right)$$

$$\tilde{A} \bigotimes \tilde{B} = \left(a_1 b_1, a_2 b_2, a_3 b_3, a_4 b_4\right)$$

$$\tilde{A} \ominus \tilde{B} = \left(a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1\right)$$

$$\tilde{A} \varnothing \tilde{B} = \left(\frac{a_1}{b_4}, \frac{a_2}{b_3}, \frac{a_3}{b_2}, \frac{a_4}{b_1}\right)$$

To determine the separation between two trapezoidal fuzzy values, the vertex method is advised. The spacing within two trapezoidal fuzzy values is ascertained using the vertex approach as follows:

$$d_v\left(\tilde{m}, \tilde{n}\right) = \sqrt{\frac{1}{4}\left[\left(m_1 - n_1\right)^2 + \left(m_2 - n_2\right)^2 + \left(m_3 - n_3\right)^2 + \left(m_4 - n_4\right)^2\right]}$$

3.2 The Fuzzy Dematel Method

Let $A_{ij} = \left(l_{ij}^n, m_{ij}^n, r_{ij}^n\right)$;; denote the extent to which criterion i influences criterion j and the number of fuzzy questionnaires (n = 1, 2, 3,..., p). The CFCS method has five-step algorithm as follows:

Step 1. Normalize the values:

$$xl_{ij}^{k} = \left(l_{ij}^{k} - \min l_{ij}^{k}\right) / \Delta_{\min}^{\max},$$

$$xm_{ij}^{k} = \left(m_{ij}^{k} - \min l_{ij}^{k}\right) / \Delta_{\min}^{\max},$$

$$xr_{ij}^{k} = \left(r_{ij}^{k} - \min l_{ij}^{k}\right) / \Delta_{\min}^{\max},$$

Where $\Delta_{\min}^{\max} = \max r_{ij}^{k} - \min l_{ij}^{k}$.

Step 2. Calculating the values for the right and left:

$$xls_{ij}^{k} = xm_{ij}^{k} / \left(1 + xm_{ij}^{k} - xl_{ij}^{k}\right),$$

$$xrs_{ij}^{k} = xr_{ij}^{k} / \left(1 + xr_{ij}^{k} - xm_{ij}^{k}\right).$$

Step 3. Calculating the total value of the crisps:

$$x_{ij}^{k} = \left[xls_{ij}^{k}\left(1 - xls_{ij}^{k}\right) + xrs_{ij}^{k} xrs_{ij}^{k}\right] / \left[1 - xls_{ij}^{k} + xrs_{ij}^{k}\right]$$

Step 4. Calculating crisp values:

$$z_{ij}^{k} = \min l_{ij}^{k} + x_{ij}^{k} \Delta_{\min}^{\max}.$$

Step 5. The integrated crisps' final values:

$$z_{ij}^{k} = \frac{1}{p}\left(z_{ij}^{1} + z_{ij}^{2} + \dots + z_{ij}^{p}\right).$$

The definitions and procedures for DEMATEL have been modified:

Step 1: Creating the initial Z matrix of direct relationships. The first direct relation matrix must be computed; hence a pair-wise comparison level is required. In order to determine how any two elements, interact, it is necessary to ask respondents to identify the direct correlation that used an integer scale that is divided into four categories. Table 4 displays the comparison scale of the fuzzy DEMATEL approach along with "No influence (0)," "Low impact (1)," "Medium influence (2)," "High influence (3)," and "Very high influence (4)."

Step 2: Pair-wise comparisons yield the initial total relation matrix Z, which is an a$[n \times n]$ matrix. The degree to which the criterion Di affects the criterion Dj has been ranked by respondents in terms of effects and directions, where z_i, j denotes the decision maker's judgements. The acquired information has been added to a matrix with principal diagonal members equaling zero.

$$z_{ij} = \frac{1}{l}\sum_{k=1}^{l} z_{ij}^{k}, \quad i,j = 1,2,\dots,n.$$

$D_1 D_2 \quad \dots D_n$

$$Z = \begin{array}{c} D_1 \\ D_2 \\ \vdots \\ D_n \end{array} \begin{bmatrix} 0 & z_{12} & \dots & z_{1n} \\ z_{21} & 0 & \dots & z_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ z_{n1} & z_{n2} & \dots & 0 \end{bmatrix}$$

Step 3: The normalized direct relation matrix X can be calculated and established using the formula below:

$$X = \frac{Z}{s},$$

$$s = \left(\max_{1 \le i \le n} \sum_{j=1}^{n} z_{ij}, \max_{1 \le i \le n} \sum_{i=1}^{n} z_{ij}\right)$$

The matrix X's components are all in accordance with,

$$0 \le x_{ij} < 1$$

$$0 \le a$$

$$\Sigma n_j = 1$$

$$x_{ij} \le 1,$$

and one or more i's such that, $\Sigma n_j = 1 \; z_{ij} \le s$.

Step 4: Calculating the total relation matrix T, which has the following definition

$$T = X + X^2 + X^3 + \dots + X^h = X(1 - X)^{-1},$$

when $h \to \infty$,
where I is an identity matrix.

Step 5: Generating the influential relation map procedure (IRM). The sums of the rows and columns are calculated independently in this phase and are designated as C and R within in the matrix of total relation.

$$R = \left[r_i\right]_{n\times 1} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} ; \; C = \left[c_j\right]_{1\times n} = \left[\sum_{i=1}^{n} t_{ij}\right]_{1\times n}^{T},$$

Step 6: Developing the causal diagram. By linking the datasets and adjusting the C from R, a causal diagram can also be created. The horizontal axis is represented by the formula $(R + C)$ and is called "Cause". The ratio $(R + C)$ shows how significant the criteria are to the system as a whole. On the other hand, the vertical axis is represented by the formula $(R - C)$ and is called "Effect." A net cause results if $(R - C) > 0$, but a net receiver or outcome occurs if $(R - C) < 0$.

Table 2 Profession Profile of the Selected Experts

Expert number	The profession of the experts	Years of expertise	Sector
1	Procurement Specialist	14	Textile and apparel industry
2	Strategic Planning Manager	11	Textile and apparel industry
3	Material Quality Assurance Specialist	17	Textile and apparel industry
4	Manufacturing Engineer	12	Textile and apparel industry
5	Marketing Manager	10	Textile and apparel industry

4 Case Study and Results

This study's case study section investigates and outlines the potential challenges that businesses confront when they migrate from I4.0 to I5.0. The textile and apparel industries were chosen for this case study because they are the second most significant growing market after agriculture. Furthermore, due to the heterogeneity of the system and processes, the production stage of the goods causes significant pollution, waste generation, and extensive use of automation and digitalization. The general challenges investigated subsequently were utilized in the textile and apparel supply chain. The reason why sector-specific challenges were not used is that the literature on I5.0 was sparse and expanding throughout the study's implementation period. Therefore, searching for sector-based challenges was difficult, and the challenge criteria set was studied in general. As a consequence of the literature research, a questionnaire was designed that evaluated and contained 15 challenges and

Table 3 Correspondence of normal values into linguistic terms

Normal values	Linguistic terms	Abbreviations
0	No influence	NO
1	Very low influence	VL
2	Low influence	L
3	High influence	H
4	Very high influence	VH

Table 4 The Fuzzy Linguistic Scale

Linguistic terms	Normal values	Abbreviations	Triangular fuzzy numbers
0	No influence	NO	(0, 0, 0.25)
1	Very low influence	VL	(0, 0.25, 0.5)
2	Low influence	L	(0.25, 0.5, 0.75)
3	High influence	H	(0.5, 0.75, 1.0)
4	Very high influence	VH	(0.75, 1.0, 1.0)

Table 5 Initial Direct Relation Matrix Z

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	Sum
C1	0,00	0,64	0,91	0,45	0,97	0,97	0,40	0,03	0,45	0,18	0,73	0,97	0,27	0,45	0,09	7,51
C2	0,69	0,00	0,60	0,24	0,36	0,14	0,40	0,03	0,45	0,45	0,73	0,64	0,67	0,09	0,36	5,85
C3	0,69	0,55	0,00	0,24	0,18	0,41	0,97	0,14	0,36	0,73	0,97	0,97	0,64	0,27	0,78	7,87
C4	0,47	0,55	0,64	0,00	0,19	0,97	0,86	0,86	0,55	0,97	0,81	0,91	0,36	0,40	0,82	9,36
C5	0,66	0,45	0,18	0,58	0,00	0,97	0,41	0,34	0,97	0,09	0,27	0,45	0,73	0,67	0,03	6,80
C6	0,82	0,36	0,27	0,73	0,97	0,00	0,18	0,47	0,64	0,27	0,03	0,27	0,73	0,59	0,41	6,73
C7	0,58	0,55	0,50	0,34	0,42	0,38	0,00	0,14	0,19	0,59	0,32	0,38	0,28	0,32	0,41	5,39
C8	0,42	0,24	0,45	0,34	0,49	0,51	0,34	0,00	0,09	0,49	0,23	0,36	0,42	0,47	0,45	5,30
C9	0,76	0,53	0,67	0,91	0,97	0,97	0,86	0,14	0,00	0,27	0,50	0,86	0,22	0,54	0,34	8,54
C10	0,55	0,45	0,97	0,33	0,14	0,27	0,69	0,97	0,31	0,00	0,18	0,76	0,73	0,63	0,97	7,94
C11	0,97	0,78	0,73	0,27	0,36	0,41	0,97	0,45	0,55	0,45	0,00	0,55	0,67	0,45	0,73	8,33
C12	0,67	0,82	0,82	0,77	0,40	0,40	0,73	0,45	0,86	0,91	0,36	0,00	0,73	0,50	0,97	9,39
C13	0,76	0,97	0,86	0,69	0,36	0,36	0,67	0,36	0,73	0,81	0,69	0,86	0,00	0,67	0,45	9,25
C14	0,19	0,36	0,22	0,37	0,72	0,72	0,27	0,64	0,64	0,18	0,09	0,50	0,46	0,00	0,14	5,51
C15	0,36	0,27	0,58	0,82	0,41	0,53	0,91	0,91	0,09	0,97	0,45	0,76	0,73	0,27	0,00	8,07
															MAX	9,39

Table 6 Total Relation Matrix T

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C
C1	0,25	0,29	0,33	0,25	0,30	0,32	0,29	0,17	0,26	0,23	0,26	0,36	0,25	0,23	0,21	4,00
C2	0,27	0,18	0,27	0,19	0,20	0,20	0,25	0,14	0,21	0,22	0,23	0,28	0,25	0,16	0,21	3,26
C3	0,33	0,29	0,26	0,24	0,23	0,27	0,36	0,19	0,25	0,30	0,30	0,38	0,30	0,22	0,30	4,22
C4	0,35	0,32	0,36	0,25	0,26	0,37	0,39	0,29	0,29	0,36	0,31	0,41	0,31	0,26	0,33	4,87
C5	0,29	0,25	0,24	0,25	0,19	0,31	0,26	0,18	0,28	0,20	0,20	0,28	0,27	0,23	0,18	3,61
C6	0,30	0,23	0,24	0,26	0,28	0,21	0,24	0,20	0,25	0,22	0,17	0,27	0,27	0,23	0,22	3,59
C7	0,24	0,21	0,23	0,18	0,19	0,20	0,18	0,14	0,17	0,21	0,17	0,23	0,19	0,16	0,19	2,89
C8	0,22	0,18	0,22	0,18	0,19	0,21	0,21	0,12	0,15	0,20	0,16	0,22	0,20	0,18	0,19	2,82
C9	0,35	0,30	0,34	0,32	0,32	0,35	0,36	0,20	0,23	0,27	0,26	0,38	0,27	0,26	0,26	4,48
C10	0,31	0,27	0,35	0,25	0,22	0,26	0,33	0,27	0,23	0,23	0,22	0,35	0,30	0,25	0,31	4,15
C11	0,36	0,32	0,34	0,25	0,25	0,28	0,36	0,22	0,27	0,28	0,21	0,34	0,30	0,24	0,29	4,33
C12	0,37	0,35	0,39	0,33	0,29	0,32	0,38	0,26	0,33	0,36	0,27	0,33	0,35	0,27	0,35	4,96
C13	0,38	0,36	0,39	0,32	0,28	0,31	0,37	0,24	0,32	0,34	0,30	0,41	0,27	0,29	0,30	4,87
C14	0,20	0,20	0,20	0,19	0,22	0,24	0,20	0,19	0,21	0,17	0,14	0,24	0,21	0,14	0,16	2,91
C15	0,30	0,26	0,32	0,30	0,25	0,29	0,36	0,27	0,22	0,33	0,24	0,36	0,31	0,22	0,22	4,25
R	4,53	4,02	4,47	3,75	3,66	4,14	4,54	3,08	3,67	3,93	3,44	4,85	4,04	3,33	3,72	

Table 7 The Causal Diagram's Prominence and Relation Axis

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
C	8,53	7,28	8,70	8,62	7,27	7,73	7,43	5,90	8,15	8,08	7,77	9,81	8,91	6,24	7,97
R	-0,53	-0,75	-0,25	1,12	-0,05	-0,56	-1,66	-0,27	0,81	0,21	0,89	0,10	0,83	-0,43	0,53
C+R	8,00	6,53	8,45	9,74	7,22	7,17	5,77	5,63	8,96	8,29	8,66	9,91	9,74	5,81	8,50
C-R	9,07	8,03	8,95	7,50	7,32	8,29	9,09	6,17	7,34	7,87	6,88	9,70	8,08	6,67	7,44
	Effect	*Effect*	*Effect*	*Cause*	*Effect*	*Effect*	*Effect*	*Effect*	*Cause*	*Cause*	*Cause*	*Cause*	*Cause*	*Effect*	*Cause*

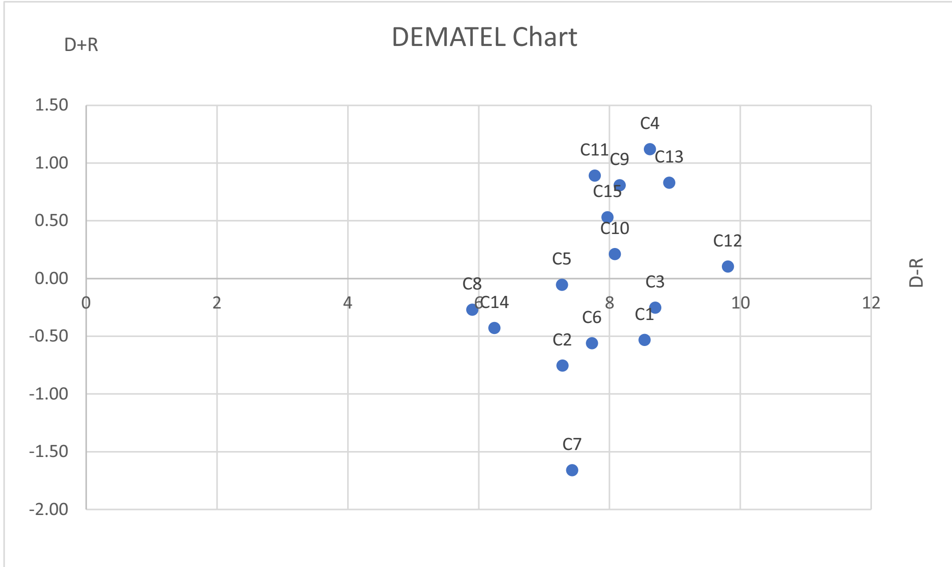
their interactions with one another for the application of the fuzzy DEMATEL approach and gathering expert opinions. The prepared questionnaire was e-mailed to five separate specialists (see Table 2 for the profile of the experts) with at least ten years of expertise in the field and representing different levels of the textile and apparel supply chain.

The fuzzy data provided by the experts are turned into linguistic values as the first stage in the Excel prepared for DEMATEL when the questionnaire responses are received from the experts. These fuzzy data were transformed into linguistic data using the scale shown in Table 3. The average score of the experts' opinions and the scores they believe are suitable were then calculated using Table 4, and the initial direct relationship matrix Z was created (see Table 5).

The C and R values were then computed using the formulas presented in the 5th stage of the revised DEMATEL method (see 2.2 section) in the methodology section, and the total relation matrix was constructed, as shown in Table 6 Finally, Table 7 displays the effect matrix or cause group (R - C) value in order to demonstrate the influencing factors. This table displays that C12: Transformation of human-centric value-driven technology are determined as the most substantial challenges amidst all challenges with sharing the same score 9,91. We can deduce that information by looking at the $(R + C)$, which the highest value gives us the most influential factor or element of the criteria set. In addition to that, the C and R degree of the C12: Transformation of human-centric value-driven technology is calculated as 9,81 and 0,10 respectively.

By looking at this table, we can create a causal diagram (see Fig. 2) as the final stage of the fuzzy DEMATEL method. On this basis, the causal diagram provides the cause and effect criteria by proposing a schematic representation. According to this causal diagram, the cause criteria can be listed as C4, C9, C10, C11, C12, C13, C15 and effect criteria can be listed as C1, C2, C3, C5, C6, C7, C8 and C14. The above-mentioned cause and effect criteria demonstrate the impact of these criteria on the system or the pace at which they are influenced. The cause criteria, for example, provides essential information regarding the ways to overcome hurdles in the textile and apparel supply chain and which criteria to focus in order to influence the whole supply chain. The impact criteria, on the other hand, highlight the vulnerable points of these challenges that require adjustment, which means that these criteria can be easily affected by the other factors. As a result, what we

Fig. 2 The Causal diagram resulted from the DEMATEL Chart



need to do to overcome these challenges and have a major impact on the entire supply chain depends on focusing on effect criteria.

In $(C-R)$ value, we see that C12: Transformation of human-centric value-driven technology has the greatest score which is 9,70. The second highest score belongs to C7: Increased error rates resulting from total automation between human-machine with 9,09 score. The greatest effect score indicates that the relevant criterion(s) has the most influence on the overall system.

In $(C+R)$ value, the highest importance degree 9,91 which corresponds to C12: Transformation of human-centric value-driven technology. Then, C4: Ineffective change management and resistance to change and C13: Development of lifelong learning and worker training to address skill gaps ranked as the second most influential effect criteria with the score of 9,74.

In R value, which referred to influenced effect, C4: Ineffective change management and resistance to change has the highest value in the ranking amidst all other criteria set. This means that the highest value of R gives us the most frequently influenced criterion among all criteria. Therefore, C4: Ineffective change management and resistance to change has the highest score with 1,12 which means that this criterion is the most influenced criterion among others. Then, C11: Heterogeneity of the system ranked as second place with the score of 0,89. Accordingly, the third criterion is C9: Lack of security, privacy in data circulation (0,81) depending on R value.

In C value, which referred to influential effect, C12: Transformation of human-centric value-driven technology (9,81) has the greatest value in the ranking among all criteria. The meaning of this, C value gives us the criterion that influences other causal factors. Then, C13: Development of lifelong learning and worker training to address skill gaps (8,91) comes second among the causal criteria.

5 Discussion and Implications

The result of the study displays that C12: Transformation of human-centric value-driven technology (9,70) is the most frequently influential challenges among all cause factors which means that it has substantial effect on other effect criteria. For instance, I5.0 technologies uses collaborative robots and artificial intelligence to bring a human touch to the concept of digital transformation. But one of the key challenges of I5.0 is to make these highly automated processes more human-centered. In this context, this difficulty contains many problems that it affects. For instance, C13: Development of lifelong learning and worker training to address skill gaps is a challenge that many businesses are confronted with. Because, of the impact of cobots and digital transformation, digital twins, artificial intelligence, and so forth, the adoption of I5.0 technologies boosts factory competitiveness and optimization while also introducing new skills to the workforce. As a result, businesses should be open to new trends in this environment by attempting to provide advanced digital skills such as digital training and how they can benefit from these technologies, provide trainings, promote lifelong learning, track social skills, and keep up with these new developments.

Moreover, C4: Ineffective change management and resistance to change is another substantial challenge that requires immediate attention in order to influence the entire system. This challenge can be caused by a combination of factors such as the fact that companies have just completed the I4.0 process, they are unable to operate the system effectively, they lack adequate infrastructure, insecurity, and lack of trust, fear of failure, and poor communication, constitutes a significant barrier to companies adopting I5.0. In this context, these companies that resist adapting these new technologies to their own systems should evaluate the value that I5.0 technologies add to the entire ready-made textile and apparel supply chain, blending them with their own needs, with an agile and customer-oriented perspective. I5.0 technologies can provide many benefits and benefits to the textile and apparel supply chain such as the technical potential of this technology and automation, speeding up analysis, performing difficult and repetitive tasks, data privacy and security, and optimal decision-making features of artificial intelligence-supported robots.

6 Conclusion

Industrial revolutions often seek to strengthen the separation of human and machine labor by going one step further, toward automation and digitalization, and the transfer of tough and dangerous occupations to robots. In this context, I4.0, the previous industrial revolution, has contributed to every level of the supply chain through technical and technological advancements, as well as to people's production standards through high-value-added activities for the next industrial revolution. As it aspires to incorporate robots into people's daily activities and work, the introduction of concepts such as I5.0 is a step forward in increasing human-machine interaction and poses some potential and problems for enterprises in the HMI area. I5.0 has a variety of benefits, including the ability to increase production quality, speed, efficiency, productivity, and industrial efficiency by offloading monotonous, risky, or error-prone repetitive tasks to robots or machines, leaving people to perform critical thinking tasks.

While doing so, it promotes human-machine harmony, gives participatory responsibility and constant monitoring of activities, and employs a cobots and people working together through a human-centered design approach. In this context, this study believes that I5.0 technologies demand greater research attention since they contain numerous technological options and multiple potential opportunities for many industries, and it intends to contribute to the system by moving beyond past and future projections and giving some real-life case examples. As a result, the major pinpoint of this following paper is on studying and concretely implementing the issues encountered by organizations upgrading from I4.0 to I5.0 utilizing case studies from the textile and apparel supply chain. To that end, the available literature on I5.0 technologies has been studied and analyzed, by demonstrating the challenges of I5.0 technologies. After defining the I5.0 challenges in general, the DEMATEL approach was established that would disclose the cause-effect link between the objective reasoning and the challenges. The results of the DEMATEL method with fuzzy logic have been examined and discussed throughout the research.

The main findings of this study shed light on the significant difficulties organizations faced in the textile and apparel supply chain as they transitioned from Industry 4.0 to Industry 5.0. Making highly automated processes more human-centered is crucial in the context of Industry 5.0, as evidenced by the finding that the transformation of human-centric value-driven technology is the most important challenge. This calls for addressing issues like the creation of lifelong learning and worker training to close skill gaps and help the workforce successfully adopt new technologies. A major obstacle to the adoption of Industry 5.0 is also the difficulty of ineffective change management and resistance to change. To overcome this obstacle, businesses must assess the value I5.0 technologies bring to the entire supply chain, match them to their unique requirements, and adopt an agile, customer-focused mindset. The textile and apparel supply chain can gain from increased competitiveness, improved operations, and improved customer experiences by addressing these issues and utilizing the technical potential, automation capabilities, data privacy and security, and optimal decision-making features of Industry 5.0 technologies.

The identification of these key findings offers insightful information for businesses, decision-makers, and researchers in addition to deepening our understanding of the difficulties involved in the industry 5.0 transition in the textile and apparel sector. This study provides sector-specific knowledge that can assist in decision-making, strategic planning, and policy formulation by highlighting the unique challenges and opportunities within this industry. In order to successfully transition to Industry 5.0, businesses must prioritize human-centric strategies, make investments in programs that promote lifelong learning and skill development, and manage change well. Furthermore, the findings highlight the advantages and potential benefits that I5.0 technologies may offer to the textile and apparel supply chain, enticing stakeholders to investigate and utilize these technologies to promote innovation, efficacy, and sustainability. In conclusion, this study adds to the body of knowledge by highlighting the industry-specific factors that must be taken into account for the successful implementation and adoption of Industry 5.0 in the textile and apparel sector, as well as by offering specific insights into the opportunities and challenges associated with it.

It is crucial to recognize that the conclusions and viewpoints presented in this study are subject to industry-specific considerations, and there may not be much generalizability across different industries. Depending on the sector, its unique requirements, and the current technological landscape, the difficulties encountered during the transition from Industry 4.0 to Industry 5.0 can differ significantly. The focus of our investigation, the textile and apparel supply chain, has distinctive qualities and dynamics that might not be entirely representative of other industries. As a result, even though the conclusions and implications drawn from this study are useful when applied to the textile and apparel industry, care should be taken when applying them to other industries. In order to gain a deeper understanding and support implementations adapted to specific industries, future research projects should investigate the opportunities and challenges of a transition to Industry 5.0 in a variety of industries. We provide transparency regarding the scope and applicability of our study and highlight the need for additional research to address the industry-specific nuances and challenges associated with the adoption of Industry 5.0 technologies by acknowledging the limitations of generalizability and highlighting the sector-specific nature of the findings.

The I5.0 literature has few resources because it is still in the early stages and is still being developed, which is one of the study's shortcomings. I5.0 technologies have not yet been properly utilized by organizations because of issues such as being a novel method, expensive, lengthy infrastructure, etc. As a result, there wasn't enough information in the available literature to carry out sectoral research. For that reason, the criteria were decided in the general context and could not be regulated in a sectoral sense. The criteria specified consisted of the difficulties discovered throughout the investigation. Based on this, as I5.0 research advances with momentum across multiple industries in the future, this list of problems may be revised and expanded within an industry-specific context. Additionally, for more comprehensive findings, the expert profile of the research can be broadened to include diverse stakeholders with a range of knowledge in the textile clothing sector. Furthermore, several forms of Multi-Criteria Decision Making (MCDM) approaches may be used for the study, and by offering an alternative set of technologies like I5.0, methods like TODIM, DEA, ELECTRE, etc., can be used for the study.

Declarations

The authors affirm that they have no known financial or interpersonal conflicts that might have appeared to have an impact on the research presented in this paper.

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