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Assessing ESG Governance Risks in Digital Transformation: A Fuzzy FMEA Approach for the Textile Sector

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Abstract: The need for digital transformation has become increasingly essential among companies operating within export-oriented industries; nevertheless, little research has been undertaken on how digital transformation intersects with the management of ESG risks in organizations. The present research fills this gap in the literature by utilizing a fuzzy FMEA approach for the identification, evaluation, and prioritization of ESG-related risks that accompany digital transformation within the textile industry. In total, twenty critical risk factors were determined by undertaking a literature review along with a structured expert opinion-gathering process involving five senior executives with practical experience in digital transformation projects. The findings reveal that "Security Weaknesses" constitute the most significant ESG governance risk, exposing firms to data breach liability, regulatory sanctions, and compromise of sustainability disclosure integrity. "Inappropriate Technology Selection" and "Excessive Expectations from Digitalization" reflect systemic deficiencies in board-level oversight and stakeholder communication, both of which are fundamental ESG governance requirements. This study offers a practical guide for emerging market firms integrating digital transformation into sustainability governance frameworks by providing a repeatable and auditable ESG risk prioritization methodology. Thus, future research is encouraged to expand the framework to other sectors and integrate ESG rating criteria directly into the FMEA scoring process.

Keywords: Digital transformation, ESG, fuzzy FMEA, risk assessment, sustainability compliance, sustainability accounting.

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INTRODUCTION

Many manufacturing companies explore how to use faster and more accurate digital management systems that support generative artificial intelligence (GenAI) instead of traditional methods. Internet of Things (IoT), big data, robotic process automation (RPA), and artificial intelligence (AI) investments are considered the most important digital technology investments in manufacturing businesses (Bouncken & Kraus, 2022). Big data are very large data sets that are used to make predictions, see trends, and create sample models. IoT is the process where devices produce data and share this data with a predefined location over the internet without the need for human intervention. AI is used to provide predictive and preventive functions of data analysis through learning algorithms (Yang, Fu, & Zhang, 2021). Blockchain applications in businesses include such topics as lower transactional costs, risk reduction, supply chain provenance, real-time data analytics, and resource integration (Tan & Salo, 2023). RPA has the potential to increase agility in business process management by initiating rapid business process changes in organizations by simplicity and flexibility (Schmitt & Hörner, 2021). Businesses must prioritize digital transformation activities to avoid being eliminated from the market in increasingly competitive conditions. Beyond competitive pressures, however, digital transformation also carries significant Environmental, Social, and Governance (ESG) implications.

In addition to its advantages, digital transformation also presents challenges and risks for businesses. According to Albukhitan (2020), the most fundamental problems that companies may face are the organizational culture's resistance to change, budget constraints, employees' lack of knowledge, security issues, and an inflexible organizational structure. Failure mode and effects analysis (FMEA) is a widely used systematic assessment tool in the field of project management and risk control (Althaqafi, 2024; Bhosale & Umap, 2024; Soria-Quijaite, Ramos-Sandoval, Abal, & Ramirez, 2025). FMEA is a method that makes businesses identify potential failure modes and analyze their impact on systems, thereby facilitating the implementation of preventive measures to reduce project risks (Li, You, Aktas, Dong, & Yang, 2025). Traditional approaches may not be able to effectively and efficiently model risk. For these situations, fuzzy logic analysis is an effective tool as it can work with ambiguous problems. Uncertainty can be resolved with a fuzzy approach using fuzzy rules.

There are various studies, such as Von Ahsen, Petruschke, and Frick (2022); Beiranvand (2024), and Zeng, Tam, and Tam (2010), that use or combine the FMEA methodology to manage ESG risks. While FMEA traditionally focuses on technical failures, ESG offers a broader and more social framework, leading to some research gaps in the literature: A significant gap remains in the literature regarding how social sustainability risks, components within ESG, can be translated onto FMEA's "Severity" and "Occurrence" scales. Similarly, in terms of Governance (G) and Strategic mismatch, FMEA is generally operational or design-oriented. Studies analyzing issues such as "transparency, corruption risk, and board structure" within the governance aspect of ESG using FMEA methodology are very limited. There is also a methodological gap regarding how corporate governance failures can be linked to operational processes. There is a significant research gap in the application of a structured fuzzy FMEA framework to the unique socio-technical challenges posed by digital transformation in the textile industry.

The purpose of this study is to enable businesses to assess digital transformation risks from an ESG governance perspective, support decision-making, reduce uncertainties in the digital transformation process, and help them create a more sustainable and accountable transformation roadmap. The analysis was applied to the textile industry. The study has six parts. In the introduction section, the aim of the study and the importance of FMEA were summarized. The second part includes determining risk factors from the literature. The methodology indicated in the third part is crucial for the analysis. The analysis results were shown in the fourth part. The discussion section is in the fifth part. In the last part, the results of the study were presented as a conclusion.

Identification of Risk Factors from Literature

A structured literature review was conducted to determine the extent to which various risk factors influence ESG practices in businesses for the digital transformation process. The keyword combinations used in databases are (Failure Mode and Effects Analysis' AND 'ESG') and ('FMEA' AND 'ESG'). Based on the literature review, the criteria-setting process was carried out. Table 1 contains the risk factors and their definitions determined as a result of the literature review.

Table 1: Risk Factors about ESG Practices in Digital Transformation

Code	Related ESG Dimension	Risk Item	Supporting Literature	Definition
R1	G	Lack of Support from Senior Management	Albukhitan (2020); Markus (2004) and Oliveri, Chiacchio, D'Urso, Munnia, and Russo (2023)	Leadership is a central theme in the digital transformation process. Support from senior management is particularly important in initiating the project, acting as an advocate for change, exploring process options offered by new technology, designing and implementing non-technological changes, modifying their own management systems and behaviors as needed to achieve benefits, and providing essential design input and oversight for the IT project.
R2	S	Lack of Interdepartmental Collaboration	Naciri et al. (2025)	The lack of effective interdepartmental collaboration, human resources training, IT updates, and funding support disrupts the balance between innovation and sustainability, reducing productivity and eliminating competitive advantage.
R3	S	Lack of IT Competence	Albukhitan (2020), Fonseca and Picoto (2020), and Subriadi and Najwa (2020)	To facilitate the adoption and use of information technologies, it is necessary to identify the required competencies. A significant risk factor arises if business employees lack the skills to use new digital tools, if there is insufficient technical expertise within the team, and if leadership is inadequate in managing digital transformation.
R4	G	Inappropriate Technology Selection	Albukhitan (2020) and Becker and Schmid (2020)	In addition to this, choosing the appropriate technology is crucial for a business organization. Making the decision to choose a particular technology on the basis of either its cost or popularity will cause strategic misalignment.
R5	G	Financial Budget Constraints	Albukhitan (2020) and Seppänen, Ukko, and Saunila (2025)	One of the main problems companies may face during digital transformation is budget constraints. Effectively allocating resources and prioritizing investments in digitalization projects can be challenging, especially for organizations with limited budgets. Furthermore, the long-term sustainability of digital initiatives requires ongoing investment in maintenance, upgrades, and staff training, which increases the financial burden.
R6	G	Resistance to Change from a Managerial Perspective	Albukhitan (2020)	This risk factor identifies "resistance to change" from organizational culture, which is driven by management.
R7	S	Employee Resistance to Change	Cieslak and Valor (2025) and Valtonen and Holopainen (2025)	The risk is that staff will be unwilling to use the new digital systems. Employee resistance can largely be attributed to their perceptions of insecurity in the workplace; this perception may stem from a lack of necessary skills to use digital technology or a fear of being replaced by such technologies.
R8	S	Inadequate Digital Training and Skill Development	Kodaloğlu, Kodaloğlu, and Elbir (2025) and Xu, Zheng, Zhang, Sun, and Liu (2025)	The lack of adequate training for employees in digital tools poses a risk. Systematic training in digital skills and intelligent support systems increases employee adoption of digital transformations and their acquisition of competencies in these areas.
R9	E	Low Level of Process Automation	Dogan, Arslan, Cengiz Tirpan, and Cebi (2024); Gupta, Bag, Modgil, De Sousa Jabbour, and Kumar (2022), and Nguyen, Shu, and Hsu (2016)	RPA is best suited for routine, rule-based, and uniform processes. They are also suitable for tasks that require little judgment and have low exception rates. Processes that do not meet these criteria will not be suitable for RPA and will not provide sufficient benefits to justify the investment. The nature of automation, which is key to efficiency and environmental performance, has been considered as an FMEA analysis factor in sustainable production.
R10	G	Inflexible Company Structure	Albukhitan (2020)	It relates to hierarchical barriers and slow decision-making processes.

Code	Related ESG Dimension	Risk Item	Supporting Literature	Definition
R11	G	Security Weaknesses	Subriadi and Najwa (2020) and Türegün (2025)	Data leaks, cyberattacks, privacy breaches.
R12	G	Unrealistic Project Planning	Li et al. (2025); Shirouyehzad, Dabestani, and Badakhshian (2011)	Insufficient timing, resource planning errors.
R13	G	Poor Selection of External Consultants	Bhosale and Umap (2024) and Linderoth, Elbanna, and Jacobsson (2018)	Working with inexperienced consultants or those who do not know the industry.
R14	S	Lack of Operational Knowledge	Alabi (2025)	For digital transformation to be successful, employees need to effectively integrate new technologies into their daily tasks. Research has shown that technology adoption is influenced by various factors, such as perceived benefits, ease of use, organizational support, and training.
R15	S	Failure to Consider Customer Expectations	Song, Rong, and Tang (2024) and Yüksel, Kalan, and Işık (2022)	This can be defined as the transformation not being shaped according to customer needs.
R16	S	Low Employee Engagement and Motivation	Hassan, Negash, and Hanum (2024)	Reluctance to embrace digital transformation, lack of ownership.
R17	G	Unclear Digital Transformation Goals	Al Maazmi, Piya, and Araci (2024) and Oludapo, Carroll, and Helfert (2024)	Unmeasurable, unclear, or unrealistic goals.
R18	G	An Early and Unplanned Beginning of Transformation	Cyfert, Dyduch, Szumowski, and Prause (2025)	Initiating the process when the infrastructure, culture, and expertise are not ready.
R19	G	Excessive Expectations from Digitalization	Shi and Herniman (2023)	The belief that digital transformation will provide enormous benefits in the short term.
R20	G	Failure to Build an Effective Project Team	Li et al. (2025) and Subriadi and Najwa (2020)	This can be described as the inability to build a team with the right skills and in the right roles.

A multidisciplinary expert panel was established to ensure a valid and reliable assessment of digital transformation risks within the context of the textile industry. While there is no definitive rule in the literature regarding the minimum number of experts required for fuzzy FMEA studies, previous research indicates that a panel of 5 to 10 experts is generally sufficient for reliable risk prioritization, provided they possess adequate industry experience (Dawood et al., 2021; Saihi, Ben-Daya, & As' ad, 2024). Key factors that were considered while selecting experts included: (i) practical knowledge in digital transformation efforts, (ii) knowledge within the specific industry (textile manufacturing), and (iii) having eight to ten years of professional experience so that the credibility of the process can be established.

This consisted of five senior professionals who met the above criteria. Following is the distribution of the expert panel as per the commonly adopted norm within the literature, which ensures an appropriate mix of practical and theoretical perspectives: 80% of the panel includes industry practitioners, whereas 20% of the panel includes academics (Saihi et al., 2024). Therefore, in this study, four out of five experts belonged to industry (80%), and one expert was from academia (20%).

The industry practitioners consisted of general managers and operations directors of textile manufacturing companies that have completed or are in the process of digital transformation. The fifth panel member specializes in digital transformation and risk management. All panel members have at least ten years of professional experience. Table 2 summarizes the composition of the expert panel.

Table 2: Composition and Contributions of the Expert Panel

Expert Category	Number	Areas of Expertise	Contributions
Academics	1	Digital Transformation, Risk Management, Fuzzy Logic	Theoretical foundation, methodological rigor, and risk identification based on literature.
General Manager Level	2	Textile Production, Strategic Management, Digital Transformation	Practical applicability, contextual validity, and real-world risk assessment.
Operations Directors	3	Production Management, Supply Chain, Technology Adoption	Operational insights, implementation experience, process-based risk assessment.

The expert panel has two main tasks: (i) identifying and validating twenty risk factors through a systematic literature review and expert interviews; (ii) assigning linguistic scores to each identified risk factor using a predefined scale in terms of the three dimensions of FMEA: Occurrence (O), Severity (S), and Detection (D).

A modified Delphi method was used in three rounds to refine and validate the proposed risk factors. Fuzzy logic is an effective method for evaluating complex systems involving uncertainty, and expert knowledge is considered a fundamental input source in structuring such systems. In the first round, 20 risk factors (Table 1) derived from a systematic literature review were presented to the expert panel.

Fuzzy logic can be considered a reliable approach to assessing systems with uncertainties. Keeping a number of experts involved at a level of three to seven is an efficient way to make an evaluation more focused and increase its reliability (Kucukaltan, Irani, & Aktas, 2016). Based on this approach, the panel was comprised of five experts representing their respective disciplines. Both qualitative and quantitative comments were provided concerning the clarity, completeness, and relevance of the selected risk factor for the field of textiles. In the first round, no additional risk factors were suggested because the initial list compiled from the literature seemed relevant enough for the task.

The second round involved application of the modified Delphi technique in which experts assessed 20 risk factors in terms of the three categories of FMEA, O, S, and D. Disagreements emerged during the evaluation process; however, all issues were solved based on the criteria of the modified Delphi technique. The main goals were reaching consensus in terms of scoring risk factors and identifying the rationale behind each expert's judgment in order to promote knowledge sharing between panelists. In this round, some risks were clarified. For example, “Financial Budget Constraints (R5)” was expanded to cover not only initial expenses but also expenses associated with maintenance, upgrading, and staff training.

In the third round, experts agreed on the final definitions and priority ranking of 20 risk factors. As a result of this three-stage process, a total of 20 criteria were identified across the three ESG dimensions (Environmental, Social, Governance), as shown in Table 1. Additional dimensions or criteria weren't added, as the panel confirmed that the current set was sufficient and valid for fuzzy FMEA analysis.

METHODS

FMEA is commonly employed as an analytical technique in risk analysis. Na’amnh, Salim, Husti, and Daróczi (2021) showed that risk assessment models using fuzzy inference outperform traditional methods, with the fuzzy model having better decision-making capabilities. Its methodology aims to identify, assess, and rectify potential flaws, weaknesses, or oversights in processes, systems, designs, or services. The risks that businesses may encounter during the digital transformation process were analyzed using FMEA. This is one of the most used techniques in risk management by decision makers. Analyzers are used by experts in FMEA. Experts identify the failure modes based on their experience. O, S, and D scores of twenty risk items were determined. To aggregate the individual expert assessments into a single, robust input for the fuzzy inference system, the arithmetic mean of the five experts' scores for each O, S, and D parameter was calculated and rounded to the nearest integer.

The evaluation of the S, O, and D factors is highly subjective. Severity refers to the seriousness of the consequences of the potential failure mode on the customer/user. Occurrence refers to how frequently a cause arises, leading to failure modes. Detection is the ability of the existing control to detect and consequently prevent a certain cause (Ivančan & Lisjak, 2021). Risks with the highest fuzzy risk priority number (FRPN) values are assumed to be important risks and should get high-priority handling compared to the risks with low RPN values. Equation 1 shows the traditional FMEA calculation. Risks with the highest RPN values are assumed to be important risks and should get high-priority handling compared to risks with low RPN values (Sankar & Prabhu, 2001).

$$RPN = O \times S \times D \qquad (1)$$

Three membership functions are defined for each input variable: Low, Medium, and High. The parameters of these triangular membership functions are as follows in Equations 2, 3, and 4.

$$\mu_{Low}(x) = \begin{cases} 1, x = 0 \\ \frac{5-x}{5}, 0 \leq x \leq 5 \\ 0 \leq x \leq 5 \end{cases} \qquad (2)$$

$$\mu_{Medium}(x) = \begin{cases} \frac{x}{5}, 0 \leq x \leq 5 \\ \frac{10-x}{5}, 5 \leq x \leq 10 \\ 0, x < 0 \; or \; x > 10 \end{cases} \qquad (3)$$

$$\mu_{High}(x) = \begin{cases} \frac{x-5}{5}, 5 \leq x \leq 10 \\ 1, x = 10 \\ 0, x < 5 \end{cases} \qquad (4)$$

The rules are applied using the minimum operation for the conjunction "and" and the maximum operation for the conjunction "or." The fuzzy rule base for the 27 risk factors is shown in Equation 5.

$$\mu_{Result}(y) = \max_{i=1}^{27}, [\, min(\mu_{o,i}), \mu_{S,i}(x_2), \mu_{D,i}(x_3)] \qquad (5)$$

The center of gravity (COG) method was used in the clarification process and is shown in Equation 6 below.

$$y * = \frac{\int y.\mu_{Result}(y)dy}{\int \mu_{Result}(y)dy} \qquad (6)$$

The FRPN is obtained by multiplying the defuzzified output value by 100 in Equation 7. Thus, the FRPN value is expressed as a score on a scale of 0–100, similar to the traditional RPN.

$$FRPN = y^{*} \times 100 \qquad (7)$$

Figure 1 shows the process of the fuzzy FMEA method. For the determined input variables, minimum values were used for the "and" method, and maximum values were used for the "or" method. The center of gravity method was preferred for the defuzzification process. In the developed model, three membership functions, namely low, medium, and high, were defined for each of the O, S, and D input values. The parameters of these triangular membership functions were determined as [0 0 5], [0 5 10], and [5 10 10], respectively, covering a universe of discourse from 0 to 10.

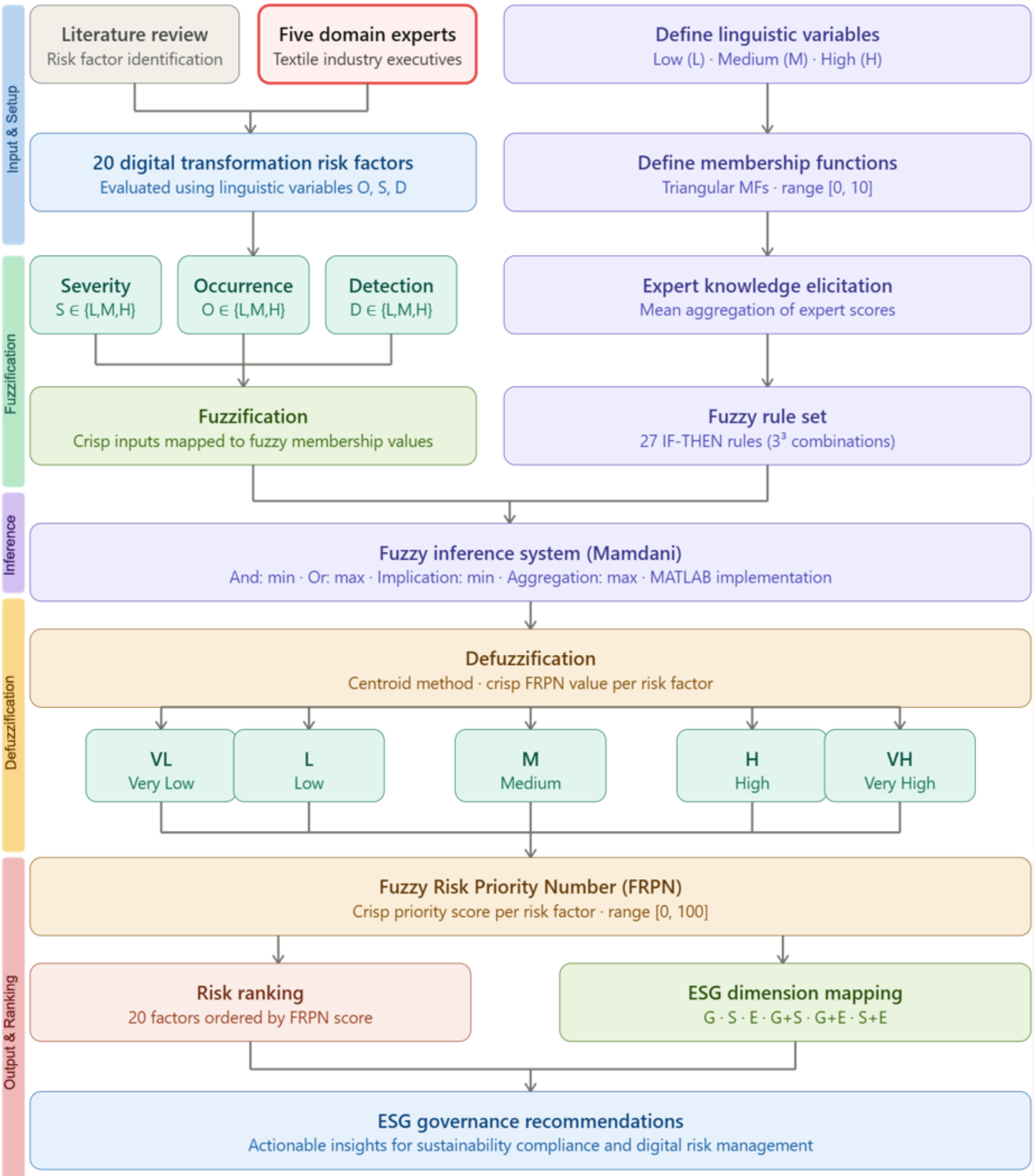

Figure 1: Fuzzy FMEA Process

Figure 2 shows the universe of discourse defined for the three input variables of the fuzzy FMEA model: O, S, and D. Each variable takes continuous values in the range [0,10]. This range allows experts to base their linguistic evaluations (low, medium, high) on a numerical basis and is consistent with common practices in the literature (Balaraju, Raj, & Murthy, 2019). Low values (0-3) represent rare/insignificant/easily detectable risks, while high values (7-10) represent frequent/serious/difficult-to-detect risks. This range forms the basis of the triangular membership functions ([0 0 5], [0 5 10], [5 10 10]) defined in the article.

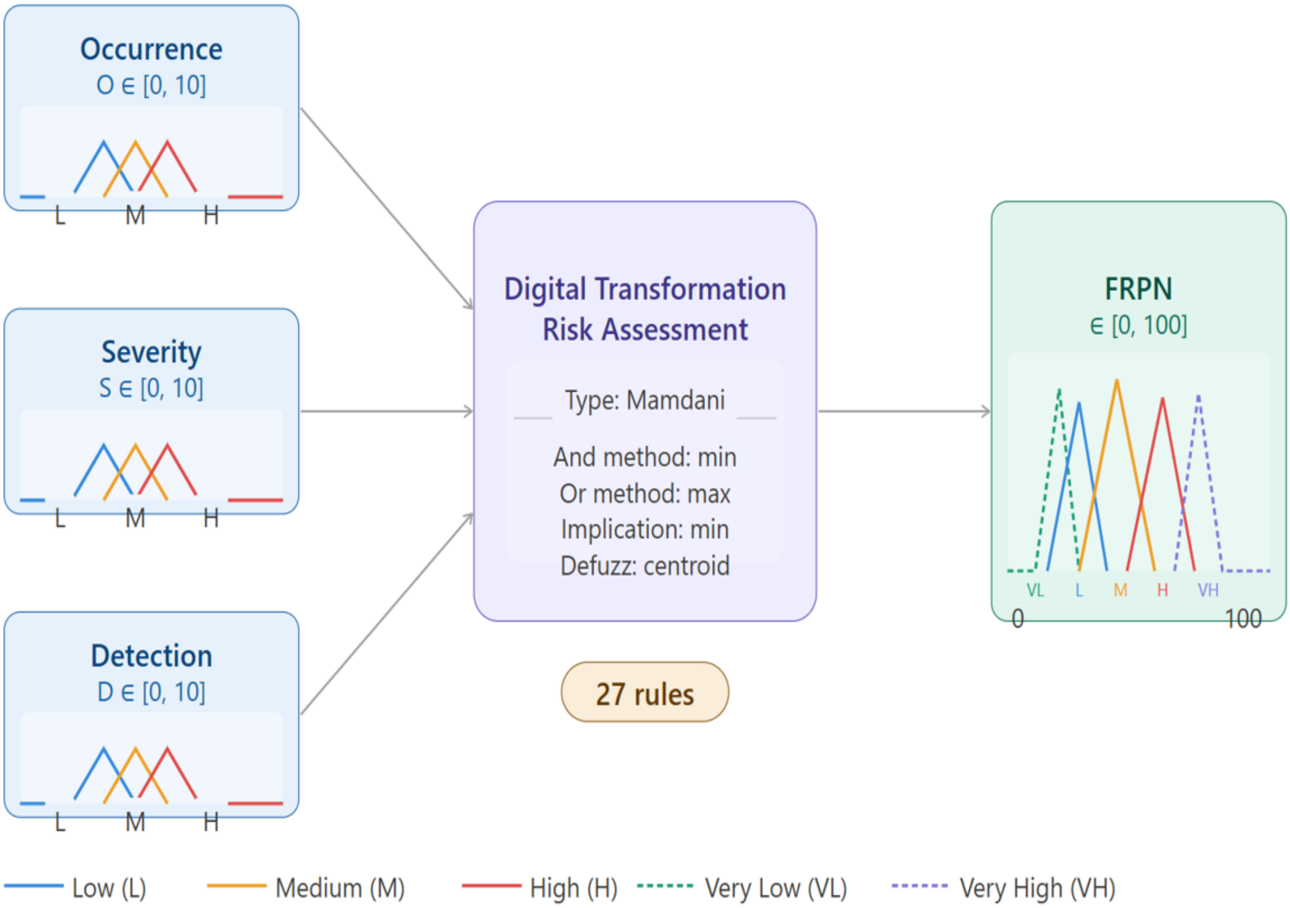

Figure 2: Fuzzy Model of Digital Transformation Risks

Occurrence is the probability of an exact failure happening during a given period of time (Balaraju et al., 2019). It indicates how frequently digital transformation risk may occur over time. Figure 2 defines the membership functions for the occurrence input variable, translating it into linguistic terms such as "Low," "Medium," and "High."

Quantifying the consequences of failure is crucial for understanding the severity associated with failure type. Severity can lead to system damage, injury, or even death. The degree and nature of severity play a critical role in determining the importance of the failure's impact (Renjith, Kalathil, Kumar, & Madhavan, 2018). The membership functions of risk severity in the digital transformation process are expressed in linguistic terms such as “Low,” “Moderate,” and “Large.” Detectability is the rating of the probability of detecting a failure mode with existing controls in FMEA. The membership functions of the detection input variable translate it into linguistic terms such as “Low,” “Medium,” and “High” during the digital transformation process (Panyukov, Nenashev, Demoretskii, & Kozlovskii, 2024).

Five triangular membership functions were defined for the FRPN output variable: very little, low, medium, high, and very high to provide a more intuitive scale for managers (ranging from 0 to 100); the defuzzified output value was multiplied by a scaling factor of 100. This transformation maintains the relative prioritization of risks while presenting the FRPN in a format similar to traditional RPN scoring. The rule base was determined to analyze the digital transformation risks in this model using fuzzy logic. A fuzzy-logic model was developed in MATLAB software.

Table 3 shows the twenty-seven rules created for the model. The rule base was constructed based on the logical premise that Risk Priority increases with higher Occurrence, Severity, and lower Detection capability.

Table 3: Model Rules Table

Rule Number	O	S	D	FRPN	Rule Number	O	S	D	FRPN
1	L	L	L	VL	15	M	M	H	M
2	L	L	M	VL	16	M	H	L	L
3	L	L	H	L	17	M	H	M	M
4	L	M	L	VL	18	M	H	H	H
5	L	M	M	VL	19	H	L	L	L
6	L	M	H	L	20	H	L	M	M
7	L	H	L	L	21	H	L	H	H
8	L	H	M	L	22	H	M	L	L
9	L	H	H	M	23	H	M	M	H
10	M	L	L	VL	24	H	M	H	VH
11	M	L	M	VL	25	H	H	L	M
12	M	L	H	L	26	H	H	M	H
13	M	M	L	VL	27	H	H	H	VH
14	M	M	M	L					

RESULTS AND DISCUSSION

Figure 3 shows the output generated by the twenty-seven rules. For instance, when the inputs are O=5, S=5, D=5 (Medium for all), the defuzzified output is calculated as 0.275. After applying the scaling factor of 100, this corresponds to an FRPN of 27.5, which is consistent with the “Low” risk classification. If the occurrence, severity, and detection values are determined as medium, then the FRPN is low. At the same time, the visual expressing the relationship between the occurrence, severity, and detection input values and the FRPN output values on a 3D surface was given.

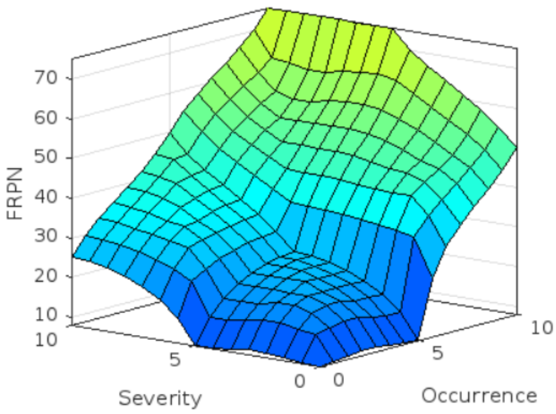

Figure 3: Model 3D View

This research has some limitations. Findings and discussions are limited to a fuzzy logic model and panel experts' opinions. An examination of Table 4 reveals that “Security Weaknesses” is the highest-risk item, with an FRPN score of 57.6. Risks related to “Inappropriate Technology Selection” and “Excessive Expectations from Digitalization” are identified as the second-highest risk items, with an FRPN score of 46.9. When the calculated FRPN values are ranked, 13 different risk levels emerge. According to the fuzzy FMEA method, the “Low Level of Process Automation” risk item was at the 13th risk level with the lowest FRPN score of 30.3.

Table 4: Digital Transformation Risks

Rank	Risk item	FRPN Score
1	Security Weaknesses (R11)	57.6
2	Inappropriate Technology Selection (R4)	46.9
2	Excessive Expectations from Digitalization (R19)	46.9
4	Employee Resistance to Change (R7)	46.7
5	Resistance to Change from a Managerial Perspective (R6)	46.0
5	Lack of Interdepartmental Collaboration (R2)	45.8
5	Failure to Consider Customer Expectations (R15)	45.8
5	Unclear Digital Transformation Goals (R17)	45.8
5	An Early and Unplanned Beginning of Transformation (R18)	45.8
10	Financial Budget Constraints (R5)	41.7
11	Lack of IT Competence (R3)	39.5
12	Unrealistic Project Planning (R12)	38.8
12	Failure to Build an Effective Project Team (R20)	38.8
14	Inflexible Company Structure (R10)	38.3
14	Lack of Operational Knowledge (R14)	38.3
16	Inadequate Digital Training and Skill Development (R8)	35.4
16	Low Employee Engagement and Motivation (R16)	35.4
18	Lack of Support from Senior Management (R1)	34.8
19	Poor Selection of External Consultants (R13)	33.3
20	Low Level of Process Automation (R9)	30.3

Table 4 ranks twenty digital transformation risks according to their FRPN scores and correlates them with ESG dimensions. Four key findings can be extracted from Table 4. First, risks with the highest FRPN scores (primarily security vulnerabilities) are governance (G) weighted; this indicates that the main reasons for digital transformation failure are a lack of strategic leadership and accountability. Second, the environmental (E) risk factor, which is directly addressed by "Low Level of Process Automation (R9)", has several additional secondary environmental risks, such as "Inappropriate Technology Selection (R4)" and "Inflexible Company Structure (R10)". The FRPN ratings of environmental risks reveal that these factors receive lower priority than those in other categories, according to experts. Third, social (S) risks appear to be abundant; their FRPN scores are mostly medium-high (between 35-47), with "Employee Resistance to Change (R7)" and "Lack of Interdepartmental Collaboration (R2)" worth mentioning among them. Lastly, dual-dimension risks show that there is an interrelation between ESG dimensions in that social and environmental risks may result from poor corporate governance.

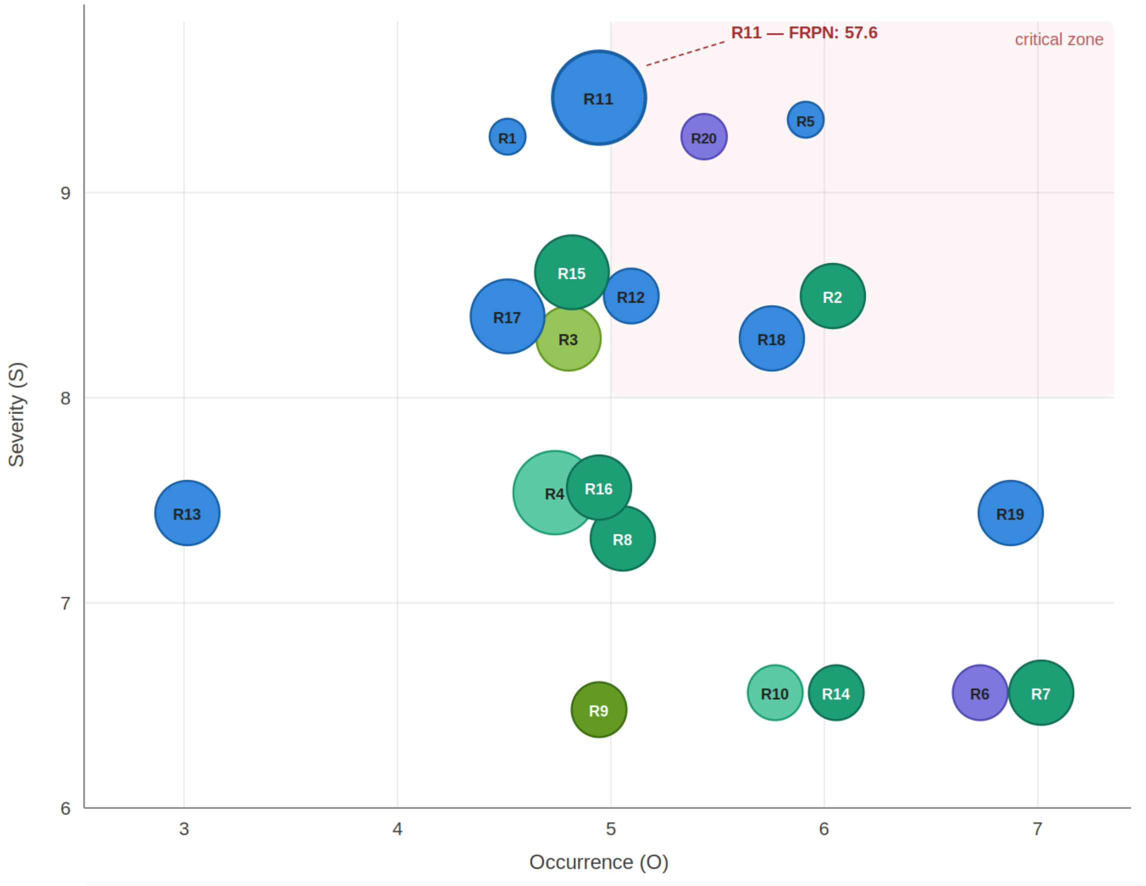

Figure 4: ESG Risk Bubble Chart

Figure 4 illustrates the O-S relationship using a bubble chart where the size of the bubble demonstrates the detection difficulty (D) level, whereas colors represent different ESG dimensions. First, as indicated by the chart, three findings about corporate governance may be formulated. First, risks related to governance (blue bubbles) cluster at high severity levels ($S \geq 7$), among which "Security Weaknesses (R11)" are the most significant because of their high D level (D=8). It may be considered a silent crisis. The second finding is that environmental risks (green bubbles) cluster at low S values ($S \leq 6$) and seem underrepresented, indicating a possible compliance weakness in the face of regulations such as the EU CSRD. Finally, social risks (orange bubbles) demonstrate a rather large dispersion of S values, with cultural risks (for example, "Employee Resistance to Change-R7") clustering in the high-risk region, whereas education-related risks cluster at low S values. Cross-concentration revealed by the analysis proves the fact that a fuzzy FMEA model reflects realistic tradeoffs in risk.

Fuzzy FMEA technology has been applied in the course of research to understand digital transformation risks beyond technical failures and to uncover shortcomings of ESG practices.

According to the results obtained, risks in question here are not operational, but those linked to poor leadership and governance. The importance of "Security Weaknesses" (R11) as the first-tier risk (FRPN=57.6) speaks clearly for that. Following the rising importance of regulatory compliance from GDPR and CSRD of the

EURO, the data breach today can no longer be regarded as a technical problem – it is seen as a corporate governance failure that undermines the credibility of sustainability disclosures, destroys reputation, and brings financial and other penalties. The importance of this type of risk for ESG reporting is underlined by high values of its severity (S=9) and difficulty of detection (D=8) noted by experts. This is how silent crises arise as a risk. Silent crisis means a risk that a company cannot control because it requires the involvement of its board members.

"The Inappropriate Technology Selection" (R4) and "Excessive Expectations from Digitalization" (R19) are classified as second-tier risks, emphasizing the governance aspect of ESG. It means that companies lack appropriate due diligence and transparency of communication at the board of directors' level, which causes decision-making mistakes and overpromises to stakeholders.

This concurs with the findings in Albukhitan (2020), where organizational and strategic factors are established as critical barriers; however, this goes beyond those findings by relating these barriers to ESG governance concepts such as accountability and transparency.

The high ranking of social risks such as "Employee Resistance to Change" (R7) demonstrates that the "human factor" is a critical component of ESG. It is not merely a human resources issue, since it directly impacts the return on digital investments and reflects a weak organizational culture, a key social metric in ESG assessments.

Among the most notable results is the rather low priority assigned to "Low Level of Process Automation" (R9, FRPN: 30.3). Although automation is directly related to resource efficiency and environmental performance, the low priority may indicate that experts do not consider such risk very likely or important, while other governance and social risks appear to be more critical for textile companies at present. However, under the conditions of the EU Green Deal and the future introduction of carbon pricing in the European Union, textile firms may face considerable compliance risks related to the lack of process automation.

Green accounting helps businesses assess environmental benefits and identify opportunities for waste reduction, recycling, and reuse, thereby reducing the consumption of natural resources and promoting a circular economy (Rahman & Islam, 2023).

The research presented here fills the gap in the existing literature on sustainability integration into FMEA as noted by Von Ahsen et al. (2022). The results are practical and directly applicable to managers working in the textile industry. The authors recommend treating digital transformation not as a project related solely to IT, but as an integral part of the corporate sustainability strategy of a company. It is important that boards of directors integrate cybersecurity into ESG governance and regularly report on the integrity and resilience of their data. The research findings are consistent with other studies emphasizing the significance of integrating sustainability strategy and technology. As shown by Pradnyani, Wasita, and Mendra (2025) in their empirical study of SMEs in Bali, the positive effect of fintech adoption on business sustainability is further strengthened in companies that implement a sustainability strategy. Therefore, our results suggest that the true potential of digital transformation cannot be achieved without a holistic sustainability framework.

In addition to traditional metrics like ROI, managers need to consider ESG-related aspects, such as human capital development (R7, R8) and environmental efficiency (R9) when planning technology investments.

Companies that adopt green accounting practices are more likely to operate sustainably because they can identify and address environmental risks and opportunities more effectively. Green accounting focuses on the environmental costs and benefits of different business activities. By incorporating these into financial reporting and decision-making processes, it takes them into account in calculating ROI and evaluating financial performance (Nicholls, 2020; Safitri, Sari, & Gamayuni, 2019).

CONCLUSION

For the current study, the fuzzy FMEA method was used to determine the critical risks for digital transformation among enterprises in the textiles sector within the ESG governance framework. It is important to mention that the main priority risk identified was "Security Weaknesses," whose detection difficulty level, combined with the high impact associated with digital transformation, makes it crucial in terms of ESG governance: cyberattacks affect stakeholder trust, bring the company into conflict with laws (under GDPR), and, in particular, may affect the credibility of ESG sustainability reporting. This means that businesses carrying out their digital transformation process should secure their networks and systems before making them available. Two other highly ranked risks ("Inappropriate Technology Selection (R4)" and "Excessive Expectations from Digitalization (R19)") are directly related to management oversight and stakeholder engagement, two major aspects of the ESG governance framework. On the social front, risks like "Employee Resistance to Change (R7)" and "Insufficient Digital Training and Skill Development (R8)" mean that staff engagement and human capital development are necessary elements of an ESG-based digital transformation strategy.

In terms of practical implications, this study provides a replicable method of prioritizing ESG risks for emerging-market organizations; future research is advised to extend the proposed framework to other industries and include ESG rating criteria in the FMEA process.

The recommendation for practitioners involves integrating ESG factors into the management of digital transformation projects, since employee engagement, data security, and alignment become important determinants of project success, rather than secondary issues. If digital transformation is to remain sustainable, then its implementation has to focus not only on the efficient use of resources and profitability, but also on the resilience and social accountability of operations.

It is important to emphasize the limitations of this research, which is industry-specific; thus, the results may not be applicable in other contexts. Moreover, perceptions of risk will inevitably change due to new technology and ESG regulations.

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TRANSPARENCY: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
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