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Employees Upskilling Challenges and Strategies for the Adoption of Industry 4.0 Environment

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Abstract

Bangladesh faces certain challenges incorporating Industry 4.0, which integrates automation, Artificial Intelligence (AI), the Internet of Things (IoT) and Advanced Data Analytics. The study aims to investigate the major challenges employees face in industries in Bangladesh and as well as the challenges faced by the industries implementing Industry 4.0. This study also presents some strategic approaches that company can implement to support employees in adopting Industry 4.0 environment. Data were collected from two major industries in Bangladesh. The major challenges were determined, then by further research 17 criterion were selected and analyzed by industry experts. Some strategies were found out from Systematic Literature Review. IFS-TOPSIS and IFS-VIKOR methods were used to rank the final strategies. By identifying Spearman's Rank Correlation Co-efficient finally top three strategies were determined which are practical, feasible, accessible to cope up with Industry 4.0 environment for both the employees and industries. This research provides actionable insights that prioritize continuous learning environment in organizations and a framework for upskilling the employees from the very beginning of their career.

Keywords
Industry 4.0, Employees, Challenges, Strategies, Upskilling

1. Introduction
Industry 4.0, which integrates automation, artificial intelligence (AI), the Internet of Things (IoT) and advanced data analytics, has transformed industrial operations. This technological shift is altering not only manufacturing and

production techniques but also the skills required in the workforce. Enhancing the skills of individuals and employees has become vital for the effective implementation and sustainability of these advanced technologies as industries strive to adapt. This research aims to investigate the challenges that companies face in upskilling their workforce and to identify practical strategies to prepare them for the demands of an Industry 4.0 environment. The increasing disparity between workforce preparedness and technological advancements renders this issue critical. Without proactive upskilling initiatives, automation and digitalization pose a significant risk of rendering a large portion of the workforce obsolete, even though they promise improved efficiency and competitiveness (Hutagalung & Aldianto, 2024). It is particularly essential to bridge the skills gap in countries like Bangladesh, where labor-intensive industries are prevalent, to maintain economic resilience and global relevance. Previous studies have acknowledged the widening digital skills gap and highlighted challenges such as the need for institutional collaboration, resistance to change and the absence of structured training programs. However, most research offers broad solutions without addressing the specific challenges faced by organizations in developing countries (Alqudhaibi, et al., 2025). This gap calls for targeted research into the real-world challenges and adaptable strategies relevant to local workforce dynamics and industries. By employing MCDM methods approach—merging a literature review with empirical data from industry stakeholders—this study contributes to the growing body of knowledge. It aims to provide valuable insights for businesses, educational institutions, and policymakers to support organizational strategies.

1.1. Objectives

- To identify the primary challenges workers face in their efforts to acquire new skills for the Industry 4.0 landscape.
- To analyze the gap between the skills required by Industry 4.0 technologies and the existing competencies of employees.
- To explore the frameworks and strategic approaches that companies implement to support employees in adapting to Industry 4.0. that anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations.

2. Literature Review

A comprehensive review of several studies reveals a diverse range of models and frameworks developed to address the multifaceted challenges of Industry 4.0. These contributions encompass critical dimensions, including cybersecurity, organizational strategy, and human resource development. In the context of infrastructure resilience, (Alqudhaibi et al., 2025) outlined strategic approaches for manufacturing management aimed at safeguarding operational continuity amid escalating cybersecurity threats. Complementing this technical focus, (Shaddiq et al., n.d.) introduced a control-oriented model that examines the behavioral and productivity impacts of Industry 4.0 technologies on employees within technology start-ups, emphasizing the need for adaptive human resource management under rapid digital transformation.

Focusing on employee retention, (Macpherson et al., 2024) presented the Employee Value Proposition (EVP) as a strategic tool to enhance affective commitment and intention-to-serve among public service personnel. (Müller et al., 2017) proposed integration strategies for small and medium-sized enterprises (SMEs), identifying them as vital mechanisms for organizational adaptation and global competitiveness. At the national level, (Jurnalita et al., 2024) emphasized that robust employee training and development are core enablers for sustainable economic growth through an adaptive national workforce.

In the automotive sector, (Macpherson et al., 2024) contributes a focused model for talent retention, highlighting the need to incorporate employees' perspectives into organizational policies. Workforce agility is addressed by (Sony et al., 2022), who develop an employee adaptability roadmap based on critical dimensions required for successful Industry 4.0 implementation. Reinforcing the importance of continuous learning, (Purwono et al., 2024) argues that ongoing training, re-skilling, and up-skilling are fundamental to enhancing employee performance.

At the structural and policy level, (Miah et al., 2024) identified key driving success factors and challenges influencing workforce employability and skills, proposing a comprehensive policy framework to strengthen industrial readiness. (Hutagalung et al., 2024) addressed organizational readiness, offering solutions for strategic alignment, technology adoption, and employee engagement to improve a company's Industry 4.0 Readiness Index (INDI 4.0). (Alhloul et al., 2022) proposed a methodological model for identifying new essential skills and competencies required for the future labor force, aligned with Industry 4.0 requirements.

(Özlem et al., 2023) analyzed employee perception of Industry 4.0 in the textile industry, stressing the importance of aligning human understanding with technological transformation. (Ahmed et al., 2024) proposed an integrated F-AHP and VIKOR model for ranking key Industry 4.0 technologies, positioning them as effective marketing strategies for business growth in emerging economies. Finally, (Hearn et al., 2023) presented a set of Learning Principles—such as valuing learning and management development—to guide manufacturing ecosystems in achieving a successful transition through education and training.

Collectively, these studies reveal that Industry 4.0 success depends on the integration of technological innovation, organizational adaptability, and workforce transformation. The reviewed literature demonstrates that resilient infrastructure, strategic human capital development, and continuous learning remain central to sustaining competitiveness in the evolving digital era.

2.1 SWOT Matrix

This matrix is analyzed from the literature review, a synthesis of 14 papers visually represents the cross-analysis of internal factors (Strengths and Weaknesses) and external factors (Opportunities and Threats) (Figure 1).

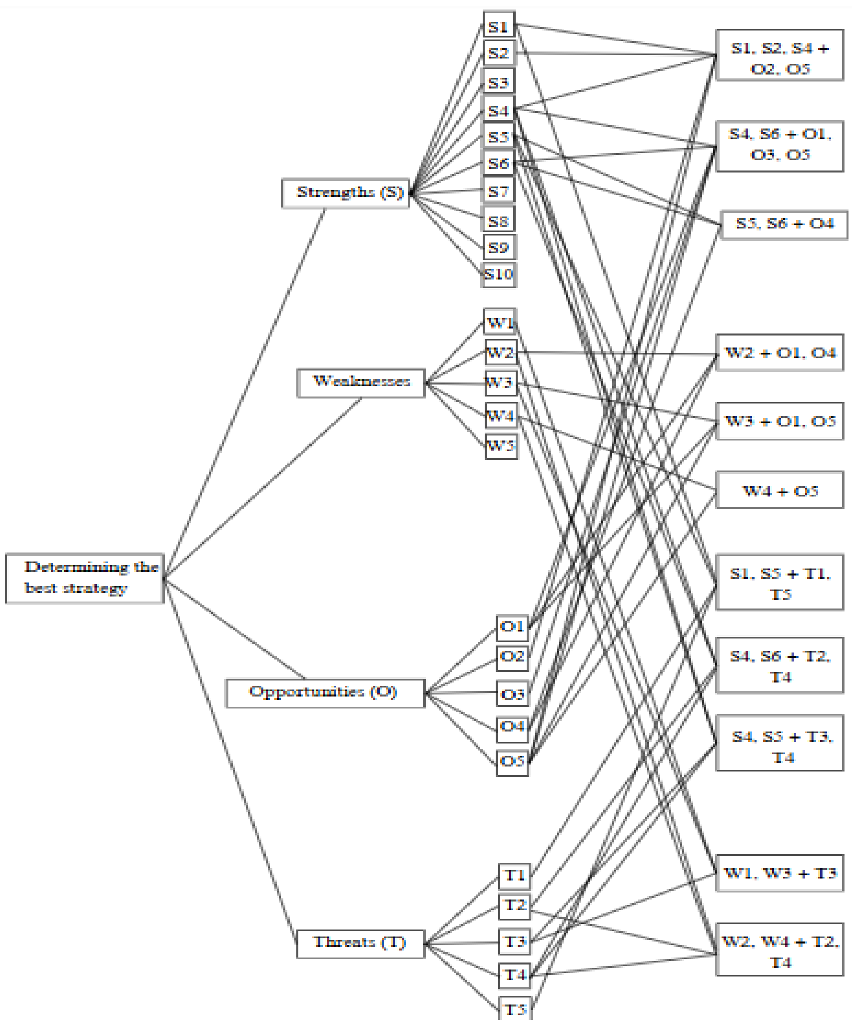

Figure 1. SWOT Matrix for Strategic Planning

3. Methodology

In order to check the difficulties and strategic priority to prepare for the labor force in the context of industrial 4.0, this study used a structured decision -making process. A total of 17 relevant criteria have been found from SWOT Analysis & six feasible solutions have been proposed on the basis of SWOT MATRIX. Two famous companies, Coca-Cola Bangladesh and Japan Tobacco International (JTI), have provided data. For this survey, three industry experts made decision: two of JTI and one from Coca-Cola. Three methods of making a multi-sophisticated criteria (MCDM) according to the intuitive sets (IFS) have been used: IFS-TOPSIS and IFS-VIKOR and to ensure intensive and equivalent assessment. Using these techniques, alternative options have been classified according to the weight of experts' criteria and comments. The most appropriate and resilient classification of the selected options after the sensitivity analysis is made to evaluate the consistency of the results according to the different priorities of the manufacturers deciding.

This study considered six strategies from SWOT Matrix to address upskilling challenges for Industry 4.0:

1. International Collaboration and Cross-Sector Collaboration for Industry 4.0 Employee Upskilling Studies.
2. Practical Frameworks for Implementing Staff Upskilling Initiatives and Monitoring Their outcome.
3. Using Policy to Encourage Industry 4.0 Workforce Skills and Reform the Educational System.
4. Continuous Research to Keep Employee Training Relevant Despite Rapid Technological Development.
5. Training Routes and Plans for Workforce Upskilling and Industry 4.0 Adoption
6. Organizational Readiness for an Effective Industry and Cultural Shift 4.0 Transition of the Workforce.

Research has been able to focus on practical and most important solutions in the current situation due to these limits, from institutional restrictions, temporary consideration, depending on resources and obstacles at the political level.

3.1 Proposed Solution

This study proposes a robust decision-making framework integrating **Intuitionistic Fuzzy Sets (IFS)** with three prominent MCDM techniques: **TOPSIS** and **VIKOR**. The approach is designed to handle uncertainty and imprecise expert judgments in evaluating our strategies. The overall process consists of five key phases:

Phase 1: Criteria and Strategy Definition

A total of 17 SWOT-based criteria—covering Strengths, Weaknesses, Opportunities, and Threats—were identified through expert consultation and literature analysis. Six strategic alternatives for our study were selected (Table 1).

Table 1. Linguistics terms with respect to criteria

Linguistic Terms	IFNs
Very good (VG)	[1.00,0.00,0.00]
Good (G)	[0.85,0.05,0.10]
Medium good (MG)	[0.70,0.20,0.10]
Fair (F)	[0.50,0.50,0.00]
Medium poor (MP)	[0.40,0.50,0.10]
Poor (P)	[0.25,0.60,0.15]
Very Poor (VP)	[0.00,0.90,0.10]

Phase 2: IFS-Based Data Conversion

In this phase, expert evaluations for each strategy against the identified criteria were collected using Linguistic terms (e.g., “Very Good”, “Medium”, “Poor”), reflecting subjective and uncertain judgments. These linguistic ratings were then converted into Intuitionistic Fuzzy Numbers (IFNs), each consisting of:

Membership degree (μ): The degree to which the alternative satisfies a given criterion.
Non-membership degree (ν): The degree to which the alternative does not satisfy the criterion.
Hesitation degree (π): Capturing uncertainty or hesitation, calculated as $\pi = 1 - \mu - \nu$

The use of IFS enables a more flexible and realistic representation of decision-makers' opinions by explicitly incorporating their hesitation and imprecision. The resulting IFS decision matrix served as the foundation for applying the TOPSIS and VIKOR methods in later phases.

Phase 3: Weight Determination by Experts opinion
The weight was taken from industry experts opinion to determine the importance of each criterion. Experts ranked criteria, and the relative weights were calculated using adjustment coefficients and normalization steps. This ensured dynamic and expert-informed weighting of all 17 criteria.

Phase 4: Strategy Evaluation and Ranking
Three MCDM methods were employed to evaluate and rank the six strategies based on the IFS-based decision matrix:
1. IFS-TOPSIS
This method identifies the best alternative based on its closeness to the Positive Ideal Solution (PIS) and distance from the Negative Ideal Solution (NIS).
Positive Ideal Solution (A^+) and Negative Ideal Solution (A^-) are calculated as:

$$A^+_j = (max_i\ \mu_{ij}\ ,\ min_i\ \nu_{ij}\ )$$
$$A^-_j = (min_i\ \mu_{ij}\ ,\ max_i\ \nu_{ij}\ )$$

Separation Measures from A^+ and A^-:

$$D_i^+ = \sqrt{[\ (1 / 4n) \times \Sigma_j\ (\ (\mu_{ij} - \mu_j^+)^2 + (\nu_{ij} - \nu_j^+)^2\ )\ ]}$$
$$D_i^- = \sqrt{[\ (1 / 4n) \times \Sigma_j\ (\ (\mu_{ij} - \mu_j^-)^2 + (\nu_{ij} - \nu_j^-)^2\ )\ ]}$$

Closeness Coefficient (CC): $CC_i = D_i^- / (D_i^+ + D_i^-)$

The alternative with the highest Closeness Coefficient (CC_i) is ranked best (Rouyendegh, Yildizbasi & Üstünyer, 2020).

2. VIKOR

The VIKOR method provides a compromise ranking by balancing both the overall utility and the individual regret of each strategy.

Best and Worst values for each criterion: $f_j^* = max_i\ (x_{ij});\quad f_j^- = min_i\ (x_{ij})$

Utility Measure (S_i): $S_i = \Sigma_j\ [\ w_j \times (f_j^* - x_{ij}) / (f_j^* - f_j^-)]$

Regret Measure (R_i): $R_i = max_j\ [\ w_j \times (f_j^* - x_{ij}) / (f_j^* - f_j^-)]$

VIKOR Index (Q_i): $Q_i = v \times (S_i - S^*) / (S^- - S^*) + (1 - v) \times (R_i - R^*) / (R^- - R^*)$

Where:
$S^* = \min_i (S_i)$, $S^- = \max_i (S_i)$
$R^* = \min_i (R_i)$, $R^- = \max_i (R_i)$; v is the weight of the strategy stability (commonly $v = 0.5$)

The strategy with the lowest Q_i is identified as the most suitable compromise solution *(Taherdoost & Madanchian, 2023)*.

Phase 5: Validation through Sensitivity Analysis
To test the robustness of the model, sensitivity analyses were conducted under one conditions: Modifying Weight Importance in TOPSIS and VIKOR analysis.

Phase 6: Result Comparison
To validate the consistency of the obtained rankings across two different methods and sensitivity scenarios, Spearman's Rank Correlation Coefficient (ρ) was applied. This non-parametric statistical measure evaluates the degree of agreement between two sets of rankings.

The formula is expressed as: $r_k = 1 - (6 \Sigma d_i^2) / (n(n^2 - 1))$
where, d_i = difference between the rank of the ith alternative in two methods or scenarios, n = total number of alternatives considered.

4. Result and Discussion

4.1 Data Collection

As mentioned earlier, three industry experts made decision (Table 2- Table 9): two of JTI Bangladesh and one from Coca-Cola. We are referring to them as DM1, DM2, DM3. (See Appendix).

Table 2. Alternative Vs Criteria Matrix (DM1)

Alt\ Cri	C_1	C_2	C_3	…	C_{17}
A_1	(0.9,0.1,0.0)	(0.7,0.2,0.1)	(0.6,0.3,0.1)	…	(0.7,0.2,0.1)
A_2	(0.7,0.2,0.1)	(0.9,0.1,0.0)	(0.9,0.1,0.0)	…	(0.7,0.2,0.1)
A_3	(0.6,0.3,0.1)	(0.7,0.2,0.1)	(0.9,0.1,0.0)	…	(0.9,0.1,0.0)
A_4	(0.7,0.2,0.1)	(0.6,0.3,0.1)	(0.7,0.2,0.1)	…	(0.6,0.3,0.1)
A_5	(0.6,0.3,0.1)	(0.6,0.3,0.1)	(0.6,0.3,0.1)	…	(0.9,0.1,0.0)
A_6	(0.7,0.2,0.1)	(0.4,0.4,0.2)	(0.6,0.3,0.1)	…	(0.7,0.2,0.1)

Table 3. Alternative Vs Criteria Matrix (DM2)

Alt \ Cri	C_1	C_2	C_3	…	C_{17}
A_1	(0.7,0.2,0.1)	(0.7,0.2,0.1)	(0.6,0.3,0.1)	…	(0.6,0.3,0.1)
A_2	(0.7,0.2,0.1)	(0.9,0.1,0.0)	(0.7,0.2,0.1)	…	(0.7,0.2,0.0)
A_3	(0.6,0.3,0.1)	(0.7,0.2,0.1)	(0.9,0.1,0.0)	…	(0.9,0.1,0.0)
A_4	(0.7,0.2,0.1)	(0.7,0.2,0.1)	(0.7,0.2,0.1)	…	(0.6,0.3,0.1)
A_5	(0.6,0.3,0.1)	(0.6,0.3,0.1)	(0.6,0.3,0.1)	…	(0.9,0.1,0.0)
A_6	(0.6,0.3,0.1)	(0.4,0.4,0.2)	(0.6,0.3,0.1)	…	(0.7,0.2,0.1)

Table 4. Alternative Vs Criteria Matrix (DM3)

Alt \ Cri	C_1	C_2	C_3	…	C_{17}
A_1	(0.9,0.1,0.0)	(0.7,0.2,0.1)	(0.6,0.3,0.1)	…	(0.6,0.3,0.1)
A_2	(0.7,0.2,0.1)	(0.9,0.1,0.0)	(0.7,0.2,0.1)	…	(0.7,0.2,0.1)
A_3	(0.6,0.3,0.1)	(0.7,0.2,0.1)	(0.9,0.1,0.0)	…	(0.9,0.1,0.0)
A_4	(0.7,0.2,0.1)	(0.7,0.2,0.1)	(0.7,0.2,0.1)	…	(0.6,0.3,0.0)
A_5	(0.6,0.3,0.1)	(0.6,0.3,0.1)	(0.6,0.3,0.1)	…	(0.9,0.1,0.0)
A_6	(0.7,0.2,0.1)	(0.4,0.4,0.2)	(0.6,0.3,0.1)	…	(0.7,0.2,0.1)

Table 5. Criteria Vs Criteria Matrix

Criteria Vs Criteria	C1	C2	C3	…	C17
C1	[1.00, 0.00, 0.00]	[0.70, 0.20, 0.10]	[0.50, 0.50, 0.00]	…	[0.40, 0.50, 0.10]
C2	[0.40, 0.50, 0.10]	[1.00, 0.00, 0.00]	[0.85, 0.05, 0.10]	…	[0.25, 0.60, 0.15]
…	…	…	…	…	…
C17	[0.40, 0.50, 0.10]	[0.25, 0.60, 0.15]	[0.25, 0.60, 0.15]	…	[1.00, 0.00, 0.00]

Table 6. Aggregate weight of criteria method

DM1		DM2		DM3	…	Aggregate weight		
U	…	U	…	U	…	U	V	PI
0.75	…	0.75	…	0.70	…	0.73	0.20	0.06
0.70	…	0.70	…	0.50	…	0.63	0.28	0.08
0.90	…	0.75	…	0.75	…	0.80	0.16	0.03
0.75	…	0.70	…	0.70	…	0.71	0.20	0.08
…	…	…	…	…	…	…	…	…
0.90	0.10	0.75	…	0.70	…	0.78	0.16	0.05

4.2 Result Analysis

A comparison of six strategies (S1 through S6) using the VIKOR Method and the Proposed Method (TOPSIS) is shown in the table. The Spearman's ranking correlation coefficient of 0.771429 indicates a strong association between the two approaches in the strategies' rankings. The strategies (S1-S6) were ranked using TOPSIS and VIKOR methods. The results are detailed in Table 7 comparative analysis between TOPSIS and VIKOR rankings revealed a 77% agreement, indicating strong consistency in their strategic preference. So our recommended ranking is the one which is achieved by **TOPSIS** Method.

Table 7. Ranking of Strategy by IFS TOPSIS method

	Si+	Si-	Ci*	RANK
A1	1.04	1.11	0.51	4
A2	1.27	0.67	0.35	5
A3	0.52	1.32	0.72	1
A4	1.24	0.60	0.33	6
A5	0.57	1.32	0.70	2
A6	0.69	1.23	0.64	3

Table 8. Ranking of Strategy by VIKOR method

	Si	Ri	Qi	Rank
S1	2.58	0.23	1.00	5
S2	2.54	0.23	0.92	4
S3	2.20	0.18	0.09	2
S4	2.54	0.23	0.92	4
S5	2.12	0.18	0.00	1
S6	2.14	0.22	0.40	3

Table 9**.** Spearman Rank Correlation Co-efficient (Comparing Between the Ranking of 3 MDCM Methods)

	S1	S2	S3	S4	S5	S6
Proposed method	4	5	1	6	2	3
VIKOR Method	5	4	2	4	1	3

Table 10. Variation in the weights of the impacts

	0%	5%	10%	15%	20%
C1	0.55	0.51	0.45	0.39	0.33
C2	0.39	0.34	0.29	0.23	0.18
C3	0.65	0.58	0.51	0.44	0.37
C4	0.56	0.50	0.45	0.39	0.33
C5	0.39	0.34	0.29	0.23	0.18
C6	0.57	0.51	0.45	0.39	0.33
C7	0.40	0.34	0.29	0.23	0.18
C8	0.23	0.18	0.13	0.08	0.03
C9	0.40	0.34	0.29	0.23	0.18
C10	0.57	0.51	0.45	0.39	0.33
C11	0.65	0.58	0.51	0.44	0.37
C12	0.03	0.19	0.25	0.11	0.16
C13	0.08	0.03	0.28	0.24	0.21
C14	0.65	0.58	0.51	0.44	0.45
C15	0.56	0.50	0.45	0.39	0.33
C16	0.65	0.58	0.51	0.44	0.37
C17	0.65	0.58	0.51	0.45	0.38

Reduced Weight Table for Sensitivity Analysis by 0%,5%, 10%, 15%, 20%, (Table 10) and used strategy ranking, sensitivity graph for TOPSIS Method (Mim, Islam & Raza, 2025) is obtained below in Figure 2 and Figure 3-

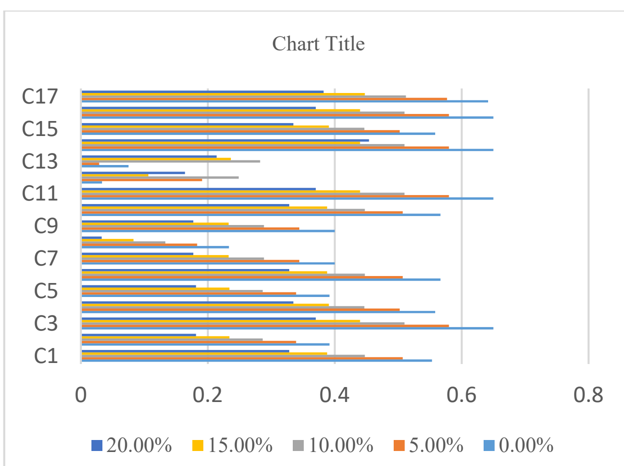

Figure 2. Changing impacts weight.

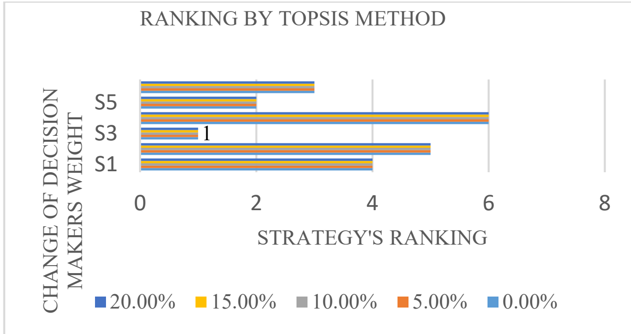

Figure 3. Ranking of strategies (achieved by TOPSIS Method) by changing weights of decision-makers.

4.4 Discussion

This study set out to explore the challenges and possible solutions for upskilling workers in the context of Industry 4.0, a rapidly evolving industrial landscape driven by automation, artificial intelligence, and digital integration. To find the best solution to workforce transformation demands, the study assessed six potential strategies across 17 crucial criteria using expert input and three trustworthy MCDM approaches (IFS-TOPSIS and IFS-VIKOR). The results, which provided helpful guidance and a deeper understanding of strategic planning for organizational readiness in the face of technological change, were corroborated by sensitivity analysis. The findings build on earlier studies that emphasized the importance of corporate culture, adaptable training methods, and the acquisition of digital skills for the successful implementation of Industry 4.0. By providing a quantitative and comparative analysis of multiple strategy options supported by professional assessments from two of Bangladesh's leading corporations (JTI and Coca-Cola), this report significantly advances the field. It is a major knowledge breakthrough to find strategy resilience using sensitivity analysis, which confirms that the top-ranked strategy remained stable when criterion weight changed. This suggests that certain upskilling techniques may withstand future uncertainty or shifts in the industrial emphasis of priorities in addition to being effective in the here and now. The study demonstrates how data-driven decision-making models can significantly enhance workforce development strategic planning in practical applications. By integrating subjectivity and expert uncertainty into MCDM techniques, fuzzy logic enhanced the findings' practicality. Furthermore, the incorporation of quantitative ranking and sensitivity analysis improves the reliability of the proposed method for wider application in similar industrial contexts. The study's limitations include reliance on only three experts, a fixed set of six strategies, and cross-sectional data that cannot capture long-term shifts. Future research should expand expert input, include longitudinal data, and test broader approaches across industries.

5. Conclusion

In conclusion, this case study's goal was to identify and analyze the primary challenges and strategic approaches for employee upskilling in the context of Industry 4.0. Experts from JTI and Coca-Cola Bangladesh assessed six strategic options based on 17 relevant criteria using three advanced MCDM techniques: IFS-TOPSIS and IFS-VIKOR. As demonstrated by the fact that "Education Reform and Policy" consistently came out on top among the evaluated strategies, particularly in the TOPSIS approach, there is an urgent need to connect national education systems and training programs with the technological demands of Industry 4.0. Sensitivity analysis was used to further confirm the ranking's stability even under different criteria weight conditions. This illustrates the effectiveness of the selected strategy and restates the importance of consistent funding for policy-driven educational reform. In order to develop a workforce that is ready for the future, the study illustrated the significance of implementation frameworks, planned upskilling roadmaps, and organizational preparedness initiatives.

5.1 Future Work

However, there are some issues with the study. First, the data came from just three experts, which may limit the generalizability of the findings to other industries or countries. Second, because the study only looked at six preset strategies, other viable options might have gone unnoticed. Despite these shortcomings, the report establishes the framework for additional research. By including longitudinal data, increasing the number of decision-makers, or testing out different tactics across industries, the findings would be improved and broadened. Improving the scalability and accessibility of real-time industrial. To validate and enhance the proposed ranking models, future studies may also employ real organizational data, such as training outcomes or employee performance metrics. Including financial, cultural, and environmental factors in the list of requirements could contribute to a more thorough comprehension of the issues. Finally, considering how Industry 4.0 technologies are still evolving, it would be beneficial to look into how training programs could be dynamically matched with emerging technologies like robots, AI, and machine learning. Plans for workforce development will remain up to date and flexible in response to future developments in the sector by doing this.

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