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Original Article

Assessing the Impact of the Fourth Industrial Revolution on Sustainability and Manufacturing Performance: An Integrated Multi-Criteria Decision-Making Approach

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Abstract *- Digital technologies of the Fourth Industrial Revolution are on the ascendancy by making the processes of global manufacturing ecosystems highly intelligent, interconnected, and also embracing sustainable inclusivity along the way. The visible impact of these Digitized Transforming Enablers (DTE) on manufacturing performance, including sustainability dimensions, is highly scarce in the extant literature, even though the manufacturing firms are willing to pay for these digital technologies. To address this gap, a novel trifocal approach is proposed in the study by developing relational interdependencies among DTE, sustainability factors, and manufacturing outcomes. An expert-oriented data-driven approach is utilized in the study for a hybrid Multi-Criteria Decision-Making (MCDM) technique. It integrates the techniques of Best–Worst Method (BWM) and Decision-Making Trial and Evaluation Laboratory (DEMATEL). Cyber Physical Systems tops the list of having the highest priority weight obtained through the BWM technique. Artificial Intelligence, Internet of Things, and Big Data Analytics follow next in the list, representing their strategic importance in digital transformation. Causal factors are revealed using DEMATEL analysis. Cyber Physical Systems, Internet of Things, and Artificial Intelligence are among the causal factors, whilst Additive Manufacturing, Autonomous Robots, and Cybersecurity are acknowledged as dependent elements. The results obtained will help researchers, policymakers, and manufacturing leaders in identifying key digital technologies and formulating a structured digital transformation roadmap.*

Keywords *- Digitized Transforming Enablers (DTE), Industry 4.0, Sustainability, Manufacturing performance, Best Worst Method (BWM), Decision Making Trial and Evaluation Laboratory (DEMATEL).*

1. Introduction

The Fourth Industrial Revolution (FIR), i.e., Industry 4.0 technologies (I4.0), around the world is expediently driving the integration of digital technologies into industrial manufacturing ecosystems. The umbrella keyword "Digitized Transforming Enablers" (DTE), introduced in, includes the digital technologies of I4.0 such as the Internet of Things (IoT), Big Data Analytics (BDA), Artificial Intelligence (AI), Cloud Computing (CC), Cyber-Physical Systems (CPS), Additive Manufacturing (AM), Autonomous Robots (AR) and Cybersecurity (CYBSEC). DTE is transforming the manufacturing strategy by creating an environment that is highly automated, data-driven, and interconnected [1, 2].

Digital transformation is acknowledged as a key driver for operational manufacturing excellence and a strategic pathway for achieving environmental, economic, and social sustainability goals [3-5]. Although digital enablers are of key importance, their integration with manufacturing setups is complicated and inadequately addressed in extant literature. The manufacturing industry often struggles to determine:

1. Which digital technologies should be prioritized,
2. Impact of each technology on sustainability and manufacturing performance outcomes,
3. Which enablers act as primary drivers and which are supportive, and
4. How interdependencies between DTE affect digital transformation roadmaps [6, 7].

The extant research has frequently evaluated the digital enablers of I4.0 in silos or using conceptual frameworks, unable to address with comprehensive quantitative results encompassing sustainability and manufacturing performance dimensions [8]. Furthermore, there is inadequate empirical research focusing on the cumulative influence of DTE on the triple bottom-line sustainability framework, while also affecting the manufacturing outcomes such as quality, flexibility, productivity, and downtime reduction. In view of these gaps, the current study emphasizes the following research objectives:

1. To identify the key Digitized Transforming Enablers (DTE) that support I4.0-driven manufacturing transformation.
2. To assess the impact of DTE on environmental (planet), economic (profit), and social (people) dimensions of sustainability.
3. To assess the impact of sustainability enhancements on enhanced manufacturing performance (quality, productivity, flexibility, and downtime reduction).
4. To determine the priority weights of DTE by using expert-driven analysis.
5. To analyze the causal interrelationships within DTE and categorize them into cause-effect grouping.

The present study offers a hybrid methodology with an objective of integrating multi-dimensional, interdependent, and expert-driven facets of DTE assessment with a focus on addressing the above research objectives. The traditional evaluation methods fail to effectively demonstrate complex technical interdependencies or fully incorporate performance and sustainability factors [9]. As a result, this research employs a hybrid Multi-Criteria Decision-Making (MCDM) framework, integrating Best-Worst Method (BWM) for determining consistent priority weights [10] and Decision-Making Trial and Evaluation Laboratory (DEMATEL) to find causal linkages [11].

This hybrid framework is particularly pertinent because it:

- Systematically gathers expert information,
- Mitigates evaluation bias and inconsistency,
- Models interdependencies among digital enablers,
- Integrates sustainability and manufacturing performance factors and
- Provides actionable insights for digital transformation strategy.

The paper proposes novel work by assessing relational interdependencies among DTE, sustainability dimensions, and manufacturing performance. The expert-driven analysis utilised in the present work positively appreciates the impact of digital enablers on the economic, environmental, and social dimensions of sustainability, as well as among manufacturing performance factors. Moreover, the pressing issue of digital integration and transition is addressed by providing a framework for policymakers, industrialists, and researchers [12, 13].

2. Literature Review

The extant literature on the FIR highlights the blend of physical and digital environments, which subsequently leads to improvements in manufacturing outcomes, sustainable inclusivity, and long-term competitiveness. According to [2, 14-16], there is a potential for the set-up of an intelligent, interconnected, and data-centric manufacturing ecosystem by transitioning to the essential technologies of DTE.

2.1. Digitized Transforming Enablers (DTE)

[17] opined that the Internet of Things (IoT) makes things highly accessible, easier to explore by integrating machines, sensors, and systems into real-time data. Predictions and decision-making based on facts are possible using Big Data Analytics (BDA). Assisting accurate forecasting and efficient operations [18]. [14, 19] emphasizes the role of AI by enhancing manufacturing process planning, defect identification through real-time optimization, and pattern recognition. Cloud Computing (CC) provides scalable computing resources and decentralized accessibility of data, which enables flexible and collaborative production networks [20].

Cyber-Physical Systems (CPS) include sensing, computing, and control to create the fundamental architecture for smart manufacturing and decision-making without human aid [21]. Additive Manufacturing (AM) makes it easier to customize products, cuts down on material waste, and speeds up product development cycles, all of which make manufacturing more environmentally friendly [22]. Autonomous Robots (AR) improve accuracy, efficiency, and safety at work, especially when doing the same thing over and over again or when it is dangerous [23]. Cybersecurity protects the integrity of systems, the security of data, and the reliability of interconnected manufacturing environments, which lowers the risk of problems in the workplace [24].

2.2. Sustainability Dimensions

The utilization of smart monitoring, interconnected, and optimization systems is one of the strategies that Industry 4.0 employs to make it more convenient for manufacturing processes to make effective use of resources. The work of [25] highlights the lens of environmental sustainability. Key attributes of the environmental dimension, such as energy usage, emissions, and water reuse, are discussed in relation to the manufacturing environment. According to the findings of the study [26], economic sustainability is the most important factor for Indian organizations, followed by social and environmental sustainability. Cost-effectiveness, resource efficiency, a better return on investment, and long-term corporate competitiveness are the most important things that economic sustainability looks at first. Studies have shown that digitization makes better use of assets, cuts down on downtime, and leads to better decisions [27].

Social sustainability includes traits that help people grow socially throughout their lives. The focus of social sustainability is on the welfare of employees, job security, equitable labor practices, and the application of technology to assist employees in advancing their careers. The implementation of DTE not only necessitates the acquisition of new skills, but it also provides opportunities for the creation of safer and more ergonomic working environments [9]. Digital technologies enhance operational efficiency while concurrently enabling reduced emissions, optimized energy and water consumption, improved employee well-being, and superior cost and resource management [4, 28].

2.3. Manufacturing Performance

Increasing productivity, lowering downtime, improving quality, and making production more flexible are a few frequent methods to measure how well a manufacturing business is performing. Studies consistently demonstrate that Industry 4.0 technologies improve performance metrics by incorporating automation, predictive analytics, and real-time control [15, 29]. According to [30-32], IoT, AI, BDA, and CPS significantly enhance the quality of production, lower the number of machine failures, speed up the process, and make it easier to quickly adapt to changing customer needs.

2.4. MCDM Methods and Industry 4.0

Multi-Criteria Decision-Making (MCDM) methodologies are extensively employed to figure out what the priorities are for digital transformation, how well they perform in terms of sustainability, and what prevents people from adopting new technologies [33]. The Best–Worst Method (BWM) provides very consistent priority weights from experts and makes comparisons easier than the Analytic Hierarchy Process [10]. A lot of the time, DEMATEL is used to make digital transformation cause-and-effect models. This helps find the driving and dependent factors [34].

2.5. Research Gap

The wings of the Fourth Industrial Revolution have reached a long way, but there is still a clear need for more studies that use a hybrid MCDM framework to connect DTE, sustainability, and manufacturing performance. In line with the research highlighted by [8, 16], the literature supports a limited framework combining manufacturing and sustainability outcomes. To close this void, there is a need to develop a systematic, unified assessment method that can take into account relational interdependencies using a trifocal approach, expert opinion, and understand the impact of going digital.

3. Research Methodology

A hybrid MCDM framework integrating Best-Worst Method (BWM) and Decision-Making Trial and Evaluation Laboratory (DEMATEL) is proposed in the present research. The methodological framework assesses the impact of DTE on sustainability dimensions and manufacturing performance. The articulated novel approach in the current research offers a structured, reliable, and data-driven plan to deal with complicated and interconnected facets of digital enablers.

3.1. Research Design

A research design encompassing the following steps was used:

a) Variables Identification: Descriptive and content analysis of I4.0 and sustainability literature identified eight Digitized Transforming Enablers and fourteen variables outlining sustainability and manufacturing performance metrics [2, 26, 35].
b) Data Collection: Experts from the fields of manufacturing, sustainability, and Industry 4.0 technologies (including industrial and academic) were responsible for data gathering.
c) Hybrid Multi-Criteria Decision-Making techniques:
a) BWM prioritizes the weights of DTE.
b) DEMATEL analyses causal linkages among DTE.
c) Further, assessing the impact of DTE on sustainability and manufacturing performance factors by using a 7-point Likert influence scale.

[10, 23] also advocated a comprehensive methodology that prioritizes intricate technological and sustainability factors.

3.2. Best-Worst Method

The BWM approach was employed to obtain consistent priority weights for DTE. In contrast to conventional pairwise comparison techniques, the Best-Worst Method (BWM) diminishes inconsistency and necessitates fewer comparisons, hence enhancing expert dependability [10]. [36] Give support to the extensive use of the BWM technique in I4.0 assessment studies due to its robustness. The steps involved for the BWM technique with respect to DTE factors are provided below:

Step 1: Define Criteria: The eight DTE factors (IoT, BDA, AI, CC, CPS, AM, AR, CYBSEC) were confirmed through literature validation.
Step 2: Identify Best and Worst Criteria: Experts provided their input about the most influential (Best) and least influential (Worst) DTE.
Step 3: Best-to-Others (BO) comparison: Experts give their opinion about how strongly the Best criterion is preferred over all others on a scale of 1 to 9.
Step 4: Others-to-Worst (OW) comparison: Experts give their opinion about how strongly all criteria are preferred over the Worst criterion on a scale of 1 to 9.
Step 5: Optimization: Weights were computed by solving the BWM nonlinear optimization model to minimize inconsistencies.

BWM outputs:

- Normalized weights for each DTE
- Consistency Ratio validating the expert reliability

3.3. DEMATEL Method

The cause-effect links and relational interdependencies among DTE were analysed by the DEMATEL technique. The technique is capable of analysing and illustrating intricate interdependencies among various factors, as opined by [37]. The steps involved for the DEMATEL technique with respect to DTE factors are provided below:

Step 1: Construct Initial Influence Matrix: Experts provided their opinion on the direct influence of each DTE on others using a 0–4 scale.

Step 2: Normalizing the Matrix: The direct influence matrix was normalized, ensuring computational stability.

Step 3: Total Influence Matrix: The total relation matrix, T, (direct + indirect effects) was computed.

Step 4: Computing Causal Indicators for each DTE:
- D (Dispatch) is the total influence exerted
- R (Receive) is the total influence received
- D + R is the prominence indicating overall importance
- D – R termed as relation (positive value indicates cause group and negative value indicates effect group variable)

3.4. Expert Panel and Data Collection

The research design followed a purposive sampling technique to identify experts, which aligns with the recommendations among MCDM studies given by [20]. Expert selection criteria included the following:
- Minimum 10 years of experience
- Involvement in the manufacturing industry (automotive, pharmaceuticals, machinery, etc.)
- Digital transformation consultant
- Academia specializing in I4.0, sustainability and manufacturing
- Involvement in smart/digital manufacturing projects.

3.5. Research Framework

The research framework assesses the impact of DTE, the independent variable, consisting of IoT, BDA, AI, CC, CPS, AM, AR, CYBSEC, on sustainability dimensions, a mediator, consisting of environmental, economic, and social factors, as well as on the dependent variable, manufacturing performance, having attributes of quality, productivity, flexibility, downtime reduction. According to [38], hybrid MCDM integration assures a thorough assessment of DTE across several dimensions.

4. Results

This section delineates the results from the hybrid MCDM framework that amalgamates BWM and DEMATEL to assess the impact of Digitized Transforming Enablers (DTE) on sustainability outcomes and manufacturing performance. A total of 22 experts from the domains of manufacturing, sustainability, and I4.0 technologies (including industrial and academic) provided their response, in accordance with [27, 33]. The results are organized chronologically to illustrate the contribution of each approach and the interpretation of DTE.

4.1. BWM Results: Priority Weights of DTE

The Best-Worst Method (BWM) was used to determine the importance (weights) of the decision criteria for eight DTE factors and to rank the alternatives by identifying the worst and best criteria based on expert assessments. BWM developed a remarkably constant array of weights, corroborating the dependability of expert assessments, in accordance with [10].

Cyber-Physical Systems (CPS) was among the most important digital enablers, according to the data-driven outcome of BWM and Cybersecurity (CYBSEC), as the least important. Table 1 highlights the weight-based BWM ranking among eight DTEs, with a consistency index of 0.232 and an input-based Consistency Ratio of 0.232.

Table 1. Ranking of the final normalized weights

DTE	Rank	Weights
Cyber-Physical Systems (CPS)	1	0.301
Cloud Computing (CC)	2	0.187
Artificial Intelligence (AI)	3	0.125
Big Data Analytics (BDA)	4	0.093
Internet of Things (IoT)	5	0.093
Additive Manufacturing (AM)	6	0.093
Autonomous Robots (AR)	7	0.075
Cybersecurity (CYBSEC)	8	0.028

4.1.1. Key Findings

- Cyber-Physical Systems (CPS) obtained the highest importance, representing their pivotal function in smart manufacturing, in alignment with previous research identifying CPS as the foundation of I4.0 [39, 40].
- The Internet of Things (IoT) and Big Data Analytics (BDA) obtained substantial scores, highlighting their role in real-time monitoring and data-driven insights [18]. Cybersecurity (CYBSEC) gained lower priority, but was acknowledged as an ancillary technology.

4.1.2. Interpretation

The conclusion from the BWM technique indicates that advanced sensing, integration, and analytics technologies (CPS, AI, IoT, BDA) serve as essential facilitators for digital transformation, corroborating the findings of [25]. These weight values were used as driving input for subsequent DEMATEL analyses.

4.2. DEMATEL Results: Cause-Effect Linkage

DEMATEL revealed the interaction and causal linkages among the eight DTE. Like other research on digital transformation given by [34, 41], the comprehensive relation matrix demonstrated the direction and strength of each DTE effect on the others. The average raw matrix of DEMATEL response is shown in Table 2.

4.2.1. Key Findings

- CPS, AI, and IoT suggest favoring (D – R) values, classifying them as causative group technologies as reflected in Table 3, and with prominence values, relation values shown in Figure 1. These assistive devices speed up the progress and impact the whole system integration process.
- AM, AR, and CYBSEC exhibit negative (D – R) values, categorizing them inside the effect group, indicating their reliance on foundational technologies for optimal efficacy.
- BDA and CC occupy intermediary roles, serving as both influencers and enablers within the digital ecosystem.

4.2.2. Interpretation

The causal framework corresponds with the hierarchical perspective of I4.0 documented in the literature, wherein Cyber-Physical Systems and Artificial Intelligence serve as principal catalysts of digitalization, with literature support of [7, 30]. Extant literature on technological preparedness agrees with the idea that AM and AR are dependent technologies for their operations, decision-making, and adaptability.

4.3. Integrated Interpretation

By combining the results from hybrid MCDM and influence Likert scale, the following observations were captured:

- CPS, AI, IoT, and BDA represent the essential enablers of sustainability and manufacturing factors.
- These enablers support:
  - Energy savings
  - Emissions reduction
  - Predictive maintenance
  - Quality improvements
  - Real-time decision-making
- AR and CYBSEC remain dependent on the core digital ecosystem.

Table 2. Average raw matrix of DEMATEL response

	IOT	BDA	AI	CC	CPS	AM	AR	CYBSEC
IOT	0	3	3	2	3	2	2	3
BDA	3	0	2	3	2	2	2	2
AI	2	3	0	2	3	3	3	3
CC	2	3	2	0	2	2	2	2
CPS	3	3	4	3	0	4	3	4
AM	2	2	2	2	2	0	2	2
AR	1	1	1	1	1	2	0	2
CYBSEC	1	1	1	1	2	1	1	0

Table 3. Prominence and relation values

DTE	D+R (Prominence)	D–R (Cause/Effect)
CPS	4.326	0.902 (Cause)
AI	3.816	0.414 (Cause)
IoT	3.660	0.452 (Cause)
BDA	3.634	0.034 (Cause)
AM	3.420	-0.196 (Effect)
CC	3.325	0.117 (Cause)
CYBSEC	3.008	-1.042 (Effect)
AR	2.726	-0.682 (Effect)

Further, interpretation among DTE can be divided across four segments;

a) Fundamental Motivators: Cyber-Physical Systems, AI, and IoT provide the basic technical framework for the transition of I4.0. They have a high impact on sustainability by energy management optimization, waste minimization, and improving process control [4].

b) Analytical and Supportive Facilitators: BDA and CC make it easier to process, store, and analyze data in real time, which encourages data-driven decision making.

c) Implementation-Level Technologies: Customization, adaptability, and worker safety are all improved by Additive Manufacturing (AM) and Autonomous Robots (AR). However, CPS, AI, and the Internet of Things are still needed for full integration.

d) Security Framework: Despite being ranked lowest, cybersecurity offers crucial protection for cyber-physical systems. Literature stresses how important it is to protect systems that are connected to each other [42], indicating that its ranking shows dependence rather than lack of importance.

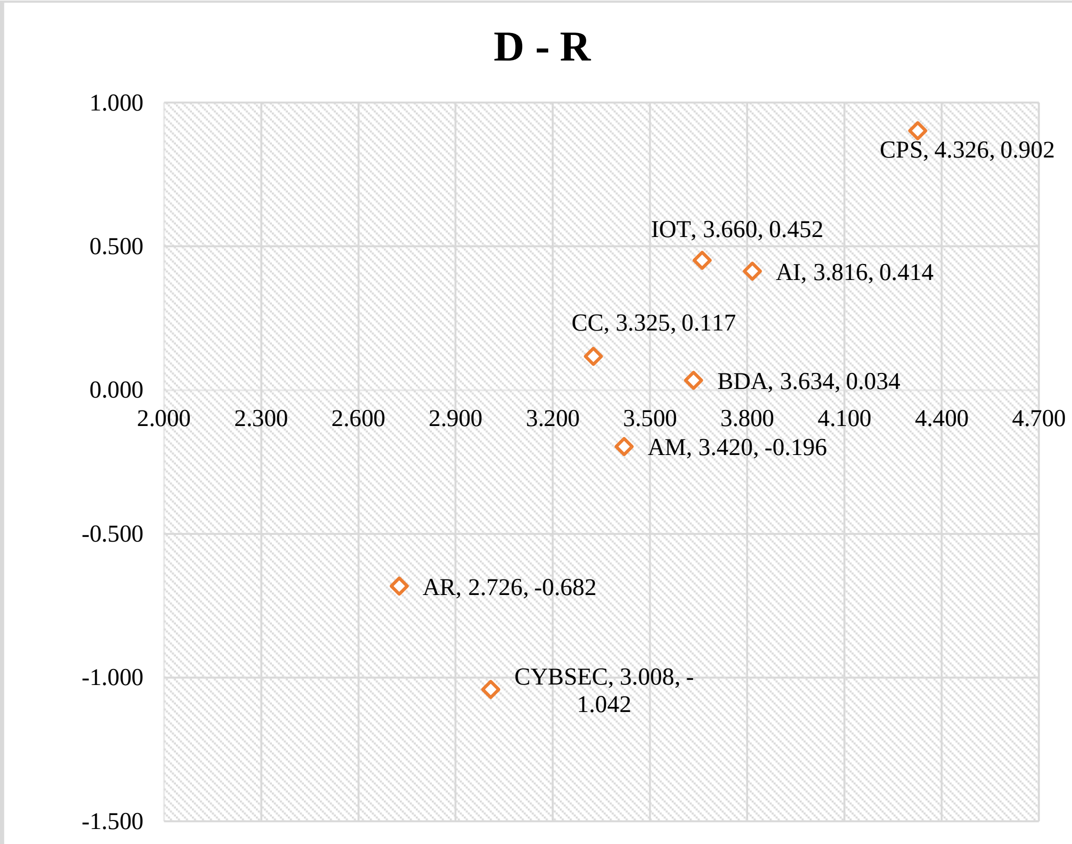

Fig. 1 DTE causal mapping (with prominence & relation values)

4.4. Summary of Findings

There is an evident hierarchy across DTE in the hybrid MCDM method, indicating that CPS, AI, IoT, and BDA are among the most significant factors for sustainability and industrial performance.

Sustainability helps progress by making energy use more efficient, reducing waste, providing the best use of resources, and making employees more satisfied within the working environment. The combined BWM–DEMATEL framework is a complete and useful way to look at the many effects of Industry 4.0 technologies. This supports earlier calls for hybrid models in studies of digital transformation [9].

5. Discussion

BWM acknowledged CPS as the foremost I4.0 technology. This supports the conclusions of [7, 43], arguing that CPS is the 'central nervous system' of digital factories, enabling intelligent sensing, real-time feedback, and self-directed decision-making loops. Artificial Intelligence and Big Data Analytics received high rankings as well, confirming their importance in predictive intelligence, quality forecasting based on machine learning, and optimization based on data, as shown in [44]. Cybersecurity came in last, showing that it is more of an enabler than a driver of performance.

5.1. DEMATEL Identified Two Significant Patterns

CPS, IoT, and AI act as Causative Enablers. These technologies of the Fourth Industrial Revolution act as drivers in the digital ecosystem, conforming to the conceptual progression in I4.0 frameworks. Digital enablers bring attributes such as: AI drives prudent decision-making, IoT brings interconnectedness and accessibility, and CPS brings system amalgamation and automates processes. Cybersecurity, Autonomous Robots, and Additive Manufacturing act as Effect Enablers. It depends greatly on the core digital foundation and underscores the necessity for a stratified digital transformation approach. Autonomous robots need AI and IoT inputs, while AM relies on superior digital models, viz., CPS and AI. Cybersecurity becomes critical only when multiple systems are interconnected.

5.2. Linking DTE → Sustainability → Manufacturing Performance

The research investigation identifies that digital transformation fosters sustainability and further enhances industrial performance, with the help of data-driven expert opinions evaluated using the Likert influence rating, as described. Environmental Sustainability dimensions can be improved via digital enablers, viz., IoT and CPS, which mitigate energy waste via real-time surveillance, cloud computing facilitates digital twins, hence diminishing emissions, and AI enhances process efficiency to minimize scrap and waste. Economic Sustainability dimensions can be improved via digital enablers, viz., BDA lowers material usage, AI-driven predictive maintenance decreases downtime expenses, and CPS optimizes machine use, hence augmenting return on investment. Dimensions of Social Sustainability are positively enhanced by digital enablers: AI enhances ergonomics and mitigates hazardous workloads, the Internet of Things enhances working conditions via remote monitoring, and digitalization facilitates reskilling and upskilling initiatives.

All sustainability gains ultimately enhance manufacturing performance factors.

- Product quality
- Productivity
- Operational flexibility
- Downtime reduction

6. Conclusion

This research assessed the impact of eight critical I4.0 Digitized Transforming Enablers (DTE)—namely, IoT, BDA, AI, CC, CPS, AM, AR and Cybersecurity on sustainability dimensions (encompassing environmental, economic and social dimensions) as well as on manufacturing performance (specifically, quality, productivity, downtime reduction and flexibility), presenting a novel trifocal consideration of factors. A Hybrid Multi-Criteria Decision-Making (MCDM) framework was employed in the research, integrating Best-Worst Method (BWM) and Decision-Making Trial and Evaluation Laboratory (DEMATEL), systematically and empirically assessing the impact of digital enablers on manufacturing performance factors, aligning with recent scholarly work that supports integrated MCDM frameworks for assessing I4.0 [10, 23]. The results demonstrate the pivotal function of Cyber-Physical Systems (CPS) as a causal enabler, thereby emphasizing their essential contribution to real-time sensing, autonomous decision-making, and cyber-physical integration within smart factories, as reported by [3, 39]. AI, IoT, and BDA also remain key enablers, as research highlights their importance for predictive analytics, smart optimization, and data-driven manufacturing [31, 45].

Further, a key finding is the identification of the sustainability dimension as a mediating factor, which strengthens the connection: linking DTE → Sustainability (environmental, economic, social) → Manufacturing Performance. The results from the Likert influence rating demonstrate the influential impact of DTE on sustainability dimensions as well as the further impact of sustainability dimensions on manufacturing performance factors, thus highlighting the mediating nature of sustainability factors. The findings of the research would help policymakers, industrial practitioners, and academicians in bolstering digital transformation progress.

6.1. Managerial Implications

The study offers a unique contribution by providing a decision-support framework focusing on the impact of digital enablers on industrial outputs, aligned with sustainability factors.

6.1.1. Digital Transformation Roadmap

The following 3-stage roadmap is recommended, based on the research findings:

Stage 1: Establish the digital infrastructure, encompassing IoT, CPS, and Cloud Computing.

Stage 2: Integrate an intelligence layer, incorporating AI and Big Data Analytics.

Stage 3: Achieve automation and security through Autonomous Robots, Additive Manufacturing, and Cybersecurity measures.

6.1.2. Enhancing Sustainability Through Digitalization

Digital enablers are instrumental towards sustainability objectives through energy efficiency using IoT and CPS; cost optimization using BDA and AI; employee well-being & job safety through IoT, AI, and Autonomous Robots, also opined by [3, 4, 25]. Managers are motivated to embrace digital initiatives in the ecosystem, considering the sustainability dimension, and in doing so, they would benefit the organization and society.

6.1.3. Strengthening Cybersecurity Infrastructure

Even though it received the lowest score, cybersecurity is still a fundamental element in enabling secure digital transformation. Cybersecurity is widely recognized in academic literature as a crucial element for protecting cyber-physical production systems [42].

As industries are integrating digital technologies, investment in cybersecurity tools should also be considered. This becomes essential for ensuring system resilience and protecting data integrity.

6.2. Limitations and Future Scope

The study only included experts from a single country context, and as a result, variations from different regions may influence the findings. For the purposes of the analysis, reliance was placed on expert judgment rather than on real-time case-based operational data. The exclusion of the Emerging Sector Technologies, which are classified under 4.0 and 5.0, such as cyber-production physical systems, cobots, and digital-twins, is a possibility that could have an impact on evaluations in the future. Future research directions for subsequent investigations may also incorporate Fuzzy Multi-Criteria Decision-Making frameworks to address uncertainty [33]. Sensitivity analysis, comparative study, and sector-specific impact assessment may be carried out by future researchers. Also, other Multi-Criteria Decision-Making techniques could be considered for future research work.

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