THE JOURNAL OF MANAGEMENT, DIGITAL BUSINESS, AND ENTREPENEURSHIP

The Journal of Management, Digital Business, and Entrepreneurship
Homepage: https://jurnal.glowscien.com/index.php/JMDBE
Vol. 4, Issue 1, March (2026), 31-42
DOI Issue: https://doi.org/10.58857/JMDBE.2026.v04.i01
E-ISSN 3031-9064

Strategy for Implementing New Technology to Improve Supply Chain Management Efficiency: A Systematic Literature Review

Dewa Ayu Sri Arimas Dewi
Faculty of Economics and Business, Udayana University
email: ayuarimasdewi@gmail.com

DOI Article: https://doi.org/10.58857/JMDBE.2026.v04.i01.p03

ARTICLE INFO

Article History:
Submitted: 20 February 2025
Reviewed: 05 June 2025
Revision: 11 January 2026
Accepted: 8 February 2026
Publish: 30 March 2026

Keywords: Supply Chain Management, Information Technology, Sustainability

Corresponding Author:
Dewa Ayu Sri Arimas Dewi
email:
ayuarimasdewi@gmail.com

ABSTRACT

The use of information technology in supply chains is becoming increasingly important due to several factors, such as the growing complexity of supply chains. Supply chains have become complex due to factors like globalization and market volatility, which necessitate the implementation of digitalization to enhance visibility and agility across the entire supply chain network. This research aims to explore strategies for implementing new technology to improve supply chain management efficiency through a Systematic Literature Review (SLR) approach. The transformation driven by Industry 4.0 technologies—such as artificial intelligence (AI), the Internet of Things (IoT), and blockchain—has presented significant challenges and opportunities. This study highlights the importance of sustainability in automation implementation by balancing economic efficiency, environmental sustainability, and social welfare. By synthesizing findings from various studies, this research offers policy recommendations that support sustainability and social inclusiveness, as well as strategic guidance for the industry on adopting supply chain automation in a sustainable manner.

INTRODUCTION

Information technology is currently used to improve supply chain management because information serves as a critical foundation for decision-making, particularly in supply chain management. Managers cannot make accurate decisions without information, as they would be unaware of market demand levels that need to be met—such as inventory availability and the types of products that must be produced to satisfy market demand. The use of information technology in the supply chain has become increasingly important due to several phenomena, such as the growing complexity of supply chains. These supply chains have become complex due to factors like globalization and market volatility, which demand the implementation of digitalization to enhance visibility and agility across the entire supply chain network. Digitalization offers innovative solutions to manage this complexity by improving visibility and agility.

Digital transformation over the past few decades has had a significant impact on various aspects of life, including business, the economy, education, and government. Technologies such as

Artificial Intelligence (AI), the Internet of Things (IoT), and blockchain have transformed how companies operate and how people interact socially. These technologies offer operational efficiency, enhanced security, and more personalized services, thereby supporting the rapidly accelerating growth of the digital economy (Alfiani et al., 2022). Consequently, the adoption of digital technologies has become crucial for organizations that wish to remain relevant and competitive in a dynamic global market.

In Indonesia, this transformation is receiving special attention, particularly in support of digital infrastructure development aimed at reducing economic inequality in the country. Accelerating digital development has the potential to drive sustainable economic growth, although challenges such as the digital divide and cybersecurity issues must still be addressed (Mocc et al., 2023).

In the Industry 4.0 era, automation in the supply chain is driving transformation across various industrial sectors. Technologies such as artificial intelligence (AI), the Internet of Things (IoT), and blockchain improve efficiency, accelerate decision-making, and reduce operational costs. Although automation brings many benefits, its impact on workers' well-being remains a subject of debate (Baryannis et al., 2019; Ivanov et al., 2019). On the one hand, automation can reduce physical workloads, improve safety, and create high-skill job opportunities; on the other hand, automation is often associated with a reduction in manual labor and the potential for rising unemployment, particularly in sectors that still rely heavily on human labor (Autor, 2015). Intense industrial competition demands that companies improve the efficiency and effectiveness of their production processes. Supply Chain Management (SCM) has become a key strategy for addressing these challenges, with the primary goal of optimizing production processes and achieving a competitive advantage (Christopher, 2016). Effective implementation of SCM can provide strategic advantages by improving coordination among different parts of the supply chain, reducing operational costs, and enhancing product quality. However, applying SCM principles in practice often faces various obstacles that affect the expected final results.

In the context of the supply chain, sustainable industry requires a balance between economic efficiency, environmental conservation, and social well-being, including the protection of workers' rights. It is important to understand the impact of automation on workers' well-being from economic, social, and psychological perspectives (Rozak et al., 2024). Furthermore, the discussion extends to economic and non-economic variables—such as workers' well-being and environmental impacts—that influence the performance of a sustainable supply chain. This article also explores relevant models and indicators for assessing sustainability in small-scale industries (Abuzawida et al., 2023), providing a framework for understanding how sustainability can be integrated into the supply chain through a data-driven approach.

The vulnerability of global supply chains due to trade restrictions, the COVID-19 pandemic, and geopolitical conflicts underscores the importance of resilient and flexible supply chains. In this context, autonomous supply chains (ASC) have emerged as a solution with predictive capabilities and autonomous decision-making, although they still face research limitations (Aguiar et al., 2019; Mughal et al., 2023; Mukhsin & Suryanto, 2022; Van Capelleveen et al., 2021). This study explores the challenges of integrating information technology (IT) and operational technology (OT) in manufacturing, where the implementation of IIoT, MES, and MOM is key to building Industry 4.0-based smart factories. A case study in Denmark identified seven key implementation themes, although obstacles such as leveraging data from legacy equipment remain a challenge (Mantravadi et al., 2023). On the other hand, Big Data Analytics (BDA) in India's manufacturing supply chain revealed 12 major barriers, including a lack of managerial and financial support (Raut et al., 2021). By integrating ASC, IoT, and BDA, this article provides strategic guidance for strengthening a resilient, efficient, and integrated global supply chain.

Some literature states that sustainability in the supply chain is driven by two foundational concepts: environmental theory and stakeholder theory. The creation of added value inherently has side effects on the environment; therefore, companies should consider environmental criteria

in their operations. Similarly, regarding social issues, economic activities within the supply chain involve human resources, both directly and indirectly. Those directly involved are commonly referred to as workers, while those not directly involved include the government, communities, local civil society organizations, and others. A sustainable supply chain strategy is one that positions a business to survive and win in a competitive market. This requires a measurement or assessment system to evaluate sustainability performance across all aspects, including economic, social, and environmental performance.

Previous research has provided insights into sustainability aspects in supply chain performance assessment, the methodologies used, criteria for an ideal model, and indicators of sustainable supply chain performance. This study specifically discusses the application of such models in small-scale industries, providing practical guidance for industry stakeholders in developing inclusive and sustainable supply chain systems (Amrullah & Yasmi, 2023).

To identify strategies for implementing new technologies to improve supply chain efficiency while enhancing worker well-being, this study employs a Systematic Literature Review (SLR) approach. The findings of this review are expected to support the development of automation policies and practices that not only focus on economic efficiency but also prioritize sustainability and social inclusivity.

RESEARCH METHODOLOGY

The systematic literature review (SLR) methodology adopted in this study follows the guidelines proposed by Kitchenham (2013), which provide a structured and transparent process for identifying, evaluating, and synthesizing existing research evidence. The methodology consists of three major phases: Planning, Implementation (Conducting the Review), and Reporting, each comprising several systematic activities.

1. Planning Phase

The planning phase aims to establish a solid foundation for conducting the systematic literature review by ensuring that the review is necessary, well-defined, and methodologically rigorous. This phase includes several activities.

First, the need for the review is identified by examining whether sufficient evidence already exists and determining the research gap that justifies conducting a systematic review. The purpose is to avoid duplication of previous reviews while addressing unresolved issues or emerging topics in the literature.

Second, the review process is initiated by defining the scope and objectives of the study. At this stage, the researchers determine the research domain, identify the target population or context, specify the technologies or concepts to be investigated, and define the expected outcomes of the review.

Third, clear and focused Research Questions (RQs) are formulated. These questions serve as the primary guide throughout the review process by directing the literature search, determining the inclusion and exclusion criteria, and guiding the synthesis of findings. The research questions are generally developed using frameworks such as PICOC (Population, Intervention, Comparison, Outcome, and Context) to ensure clarity and comprehensiveness.

Finally, a detailed review protocol is developed before the literature search begins. The protocol specifies the search strategy, electronic databases to be used, search strings, eligibility criteria, quality assessment procedures, data extraction forms, and data synthesis methods. Establishing a review protocol in advance minimizes researcher bias and enhances the transparency and reproducibility of the review process.

2. Implementation Phase

The implementation phase, also referred to as the conducting phase, involves the systematic execution of the review protocol. This phase consists of five sequential steps.

a. Study Identification

The first step involves conducting a comprehensive and systematic search for relevant literature. Multiple scientific databases, such as Scopus, Web of Science, ScienceDirect, IEEE Xplore, SpringerLink, or other reputable digital libraries, are searched using predefined keywords, Boolean operators (AND, OR, NOT), and search strings derived from the research questions.

The objective of this stage is to identify all potentially relevant studies while minimizing publication bias and ensuring comprehensive coverage of the research topic.

b. Selection of Primary Studies

After all potentially relevant articles have been identified, a screening process is conducted to determine which studies should be included in the review.

The screening typically consists of several levels:

- removal of duplicate records;
- title screening;
- abstract screening;
- full-text eligibility assessment.

Each study is evaluated against predefined inclusion and exclusion criteria, such as publication year, language, publication type, research methodology, relevance to the research questions, and availability of full-text articles.

The selection process is commonly documented using the PRISMA flow diagram, which illustrates the number of studies identified, screened, excluded, and ultimately included in the final review.

c. Study Quality Assessment

Once the primary studies have been selected, each article undergoes a quality assessment to determine its methodological rigor and overall reliability.

Quality assessment typically involves evaluating several aspects, including:

- clarity of research objectives;
- appropriateness of research design;
- adequacy of data collection methods;
- validity and reliability of measurements;
- robustness of data analysis;
- credibility of conclusions;
- consistency between findings and research objectives.

Each criterion may be scored using a predefined checklist or quality assessment instrument. Studies with insufficient methodological quality may be excluded or assigned lower weight during the synthesis process.

This step ensures that the conclusions of the systematic review are based on high-quality evidence.

d. Data Extraction and Monitoring

Following quality assessment, relevant information is systematically extracted from each selected study using standardized data extraction forms.

The extracted information generally includes:

- bibliographic information (author, publication year, journal);
- country or research setting;
- research objectives;
- theoretical framework;
- research methodology;
- sample characteristics;

- variables investigated;
- analytical methods;
- key findings;
- limitations;
- future research recommendations.

Throughout this stage, the extracted data are continuously monitored and verified to ensure completeness, consistency, and accuracy before proceeding to synthesis.

e. Data Synthesis

The final step of the implementation phase is data synthesis, in which the extracted evidence is integrated to answer the research questions.

Depending on the characteristics of the collected studies, synthesis may be conducted using:

- narrative synthesis;
- thematic analysis;
- content analysis;
- descriptive analysis;
- quantitative meta-analysis (when statistical pooling is feasible).

The synthesis process aims to identify recurring themes, research trends, similarities, differences, research gaps, methodological patterns, and future research opportunities.

Rather than simply summarizing previous studies, data synthesis generates new insights by integrating evidence from multiple sources into a coherent body of knowledge.

3. Reporting Phase

The reporting phase focuses on communicating the results of the systematic literature review in a transparent, comprehensive, and reproducible manner.

This phase includes presenting the review methodology, search strategy, study selection process, quality assessment results, synthesized findings, discussion, limitations, practical implications, theoretical contributions, and recommendations for future research.

To improve transparency, researchers generally report:

- the complete search strategy;
- the PRISMA flow diagram;
- characteristics of included studies;
- quality assessment results;
- summary tables of extracted data;
- synthesized evidence addressing each research question.

The reporting should enable readers to understand how the review was conducted, evaluate the reliability of its findings, and replicate the review if necessary. A well-structured reporting process enhances the credibility of the systematic literature review and provides valuable evidence for researchers, practitioners, policymakers, and other stakeholders.

RESULTS AND DISCUSSION

A) Formulating Research Questions

Research questions are the most important aspect to identify and address in a systematic literature review (SLR). Throughout the review, various efforts were made to identify and address research questions based on Kitchenham's framework (Kitchenham & Brereton, 2013). PICOC is an acronym for Population, Intervention, Comparison, Outcome, and Context. The PICOC framework for this study is as follows:

PICOC (Population, Intervention, Comparison, Outcome, Context) can be outlined as follows:

P (Population): Companies that implement Industry 4.0 in CSCM

I (Intervention): The implementation of Industry 4.0 technologies in CSCM

C (Comparison): Comparison between companies that implement Industry 4.0 and those that do not
O (Outcome): Sustainability (social, environmental, and economic aspects)
C (Context): Specific industries, developing countries, and the social dimension of sustainability.

Based on PICOC, the resulting research questions are:
RQ1: How does the implementation of Industry 4.0 technology in sustainable supply chain management (CSCM) affect a company's social, environmental, and economic aspects?
RQ2: How does sustainability (social, environmental, and economic aspects) differ between companies that implement Industry 4.0 technology in CSCM and those that do not in a specific industrial sector?
RQ3: How is the social dimension of sustainability influenced by the implementation of Industry 4.0 technology in CSCM?

B) Search String

Before the research begins, a search strategy must be established and validated to address the research questions. This includes selecting keywords, terminology, databases, and relevant sources. This strategy is tailored to the research needs and then used to conduct a broad literature search across three major academic databases to identify relevant primary studies. Once the appropriate databases are identified, the next step is to compile a list of synonyms, acronyms, and alternative spellings based on the PICOC framework, the research questions, and relevant terms from the titles and abstracts. This aims to facilitate the selection of appropriate keywords. This study used keywords such as "industry," "CSCM," and "supply chain," which were further refined using operators such as AND and OR as follows: "sustainability" AND ("Industry 4.0" OR "CSCM" OR "Supply Chain Management").

Table 1. Data Sources

Search Target Database	**Scopus**	**ScienceDirect**	**IEEE Xplore**
Search expression	"sustainability" AND ("Industry 4.0" OR "CSCM" OR "Supply Chain Management")	"sustainability" ("Industry AND 4.0" OR "CSCM" OR "Supply Chain Management")	"sustainability" ("Industry AND 4.0" OR "CSCM" OR "Supply Chain Management")
Search field	Topic, Title, Keywords, and Abstract	Topic, Title, Keywords, and Abstract	Topic, Title, Keywords, and Abstract
First search results	10,060	31,519	939
Document types (research articles only)	5,865	3,329	167
Search period (last ten years)	2014 to 2024	2014 to 2024	2014 to 2024
Refined search results	19	16	30

C) Study Selection Criteria

The reviewed articles were selected based on criteria established before the process began and aligned with the research questions. Inclusion criteria included articles published between 2014 and 2024; studies that applied Industry 4.0 in CSCM; studies that addressed sustainability (social,

environmental, and economic aspects); studies conducted in specific industries or developing countries; and studies that examined the social dimension of sustainability. Exclusion criteria included non-English articles; studies that did not apply Industry 4.0 in CSCM; studies that did not address sustainability (social, environmental, and economic aspects); and studies not conducted in specific industries, developing countries, or addressing the social dimensions of sustainability. The article selection process was time-consuming because it required sifting through hundreds of relevant works. After applying the inclusion and exclusion criteria, 42,518 articles were identified from various databases. Additional searches were conducted manually using the snowballing technique, ultimately resulting in 65 articles selected for quality assessment.

D) Quality Assessment

One of the key elements in a systematic literature review (SLR) is quality assessment. This involves evaluating the primary studies included in the review strategy. The purpose of quality assessment is to ensure the accuracy and reliability of the SLR's conclusions. This can be done by presenting a list of questions in the form of a survey. This aligns with the following recommendations:

1) Content Relevance: Is this study directly related to the impact of supply chain automation strategies on worker well-being in the sustainable industrial sector?
2) Clarity of Research Objectives: Are the main research objectives clearly and specifically described in the paper?
3) Methodology Used: Does this study employ a valid and appropriate methodology for examining supply chain automation strategies?
4) Quality of Data Used: Does the data used in the study come from reliable sources and meet quality standards?
5) Analysis Conducted: Are the analytical methods used robust enough to answer the research questions posed?
6) Timeliness: Was this study conducted within a timeframe relevant to analyzing current trends in automation and the supply chain?
7) Inclusion of Sustainability Aspects: Does this study consider sustainability elements in its analysis of automation strategies?
8) Overall Validity of Findings: Are the findings of this study supported by sufficient evidence and logical arguments?
9) Balance of Perspectives: Does this study present a balanced view of the benefits of automation and its potential impact on worker well-being?
10) Contribution to the Literature: Does this study make a significant contribution to the understanding or advancement of knowledge regarding supply chain automation and worker well-being?

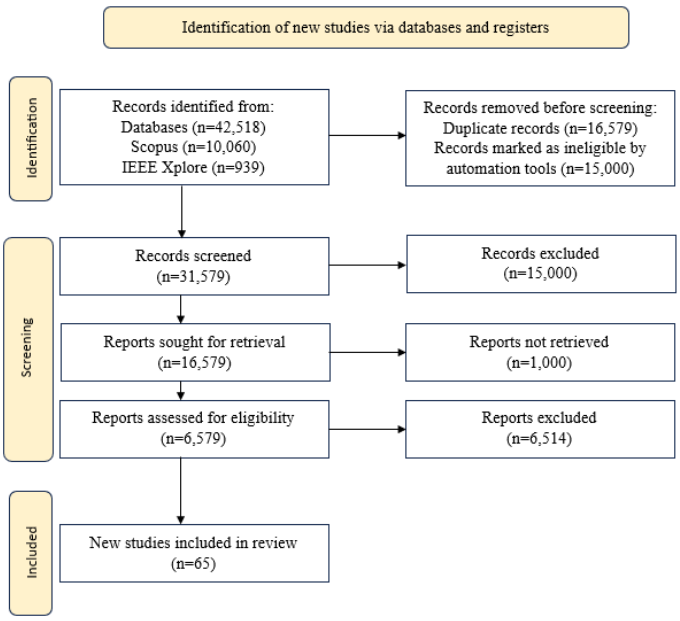

Figure 1. PRISMA flowchart of the article selection process

E) Designing the Data Extraction Form

During the data extraction phase, valuable information was documented in selected journals based on the descriptions established during the planning phase. This data was then used to answer research questions. The data was documented in tabular format, which allows for further analysis.

Table 2. Data Documentation

No	Data Element	Description
1	Article Title	Full title of the research article
2	Author	Name of the author or team that published the article
3	Year of Publication	The year the article was published
4	Research Objectives	Description of the main research objective
5	Methodology	Research approach/methods used
6	Main Findings	Key findings or results of the study
7	Industry Context	The industrial sector that is the focus of the study
8	Study Location	Country or region where the study was conducted
9	Sustainability Aspects	Dimensions of sustainability discussed
10	Technological Interventions	Industry 4.0 technologies used
11	Comparison	Comparison between companies that use automation and those that do not
12	Social Impact	Impact on Workers' Well-Being
13	Economic Impact	Impact on efficiency, productivity, or economic growth
14	Environmental Impact	Impact on environmental sustainability
15	Recommendations	Strategic suggestions or guidelines provided by the researcher
16	Article Quality	Assessment of article quality based on a list of quality assessment questions

F) Selection results for the articles

The following data are the results of a selection of several relevant articles identified in this study regarding strategies for implementing new technologies (AI, IoT, Blockchain) to improve the efficiency of supply chain management. This table includes 10 articles that have undergone a screening process to ensure the relevance and quality of the information. These articles were selected based on specific criteria, such as theoretical contribution, best practices described, and the recency of the data used.

Table 3. Selected Articles

Author	Year	Article Title	Key Findings
Christopher, M.	2016	Logistics and Supply Chain Management	Explains the basic concepts of Supply Chain Management and their application in supply chain management
Baryannis, G., Dani, S., Antoniou, G.	2019	Predicting Supply Chain Risk Using Machine Learning: The Trade-off Between Performance and Interpretability	Examining a framework for predicting supply chain risk using data-driven AI techniques
Aguiar, G.T., Oliveira, G.A., Tan, K.H., Kazantsev, N., Setti, D.	2019	Success Factors for the Sustainable Implementation of AGVs in Supply Chain Management in Brazilian Industry	Examining the implementation of AGVs and methods for determining critical factors, as well as identifying the relationship between ISFs and the supply chain through Structural Equation Modeling (SEM)
Raut, R.D., Yadav, V.S., Cheikhrouhou, N., Narwane, V.S., Narkhede, B.E.	2021	Big Data Analytics: Implementation Challenges in the Indian Manufacturing Supply Chain	Examining the concept of the reciprocal interaction of Big Data Analytics in the manufacturing supply chain
Capelleveen, G.V., Wieren, J.V., Amrit, C., Yazan, D.M., Zijm, H.	2021	Exploring Recommendations for Circular Supply Chain Management Through Interactive Visualization	Discussing simple methods for identifying opportunities in sustainable supply chain activities through data exploration
Mukhsin, M., Suryanto, T.	2022	The Effect of Sustainable Supply Chain Management on Company Performance Mediated by Competitive Advantage	Examining the effect of sustainable supply chain management on company performance
Amrullah, E., Yasmi, M. R.	2023	A Performance Measurement Model for Sustainable Supply Chains in Small-Scale Industries: A Systematic Literature Review	Providing insights into a new model used to assess sustainable supply chain performance, particularly in small-scale industries
Apriani, D., Azizah, N.N., Ramadhona, N.,	2023	Optimizing Data Transparency in the Supply Chain through Blockchain Technology Integration	Highlighting the approaches used in supply chain projects that adopt blockchain for transparency

Kusumawardhani, D.A.R.			
Mantravadi, S., Srai, J.S., Moller, C.	2023	Application of MES/MOM for Industry 4.0 Supply Chains: A Cross-Case Analysis	Explaining the design of MES/MOM manufacturing systems in IoT to enhance manufacturing flexibility through reconfiguration
Jamal, R., Ikhval, A.A., Nisa, N.A., Qulbi, S.H., Arifin, M.U.	2024	The Use of Information Technology in Optimizing Supply Chain Management	Highlights the effective integration of digital technologies to improve efficiency

DISCUSSION

1) The Impact of Industry 4.0 Technology Implementation in Circular Supply Chain Management (CSCM) on Social, Environmental, and Economic Aspects

The implementation of Industry 4.0 technology in circular supply chain management (CSCM) has a significant impact on the three dimensions of sustainability: social, environmental, and economic. From a social perspective, automation improves work efficiency and reduces the risk of workplace accidents through the use of IoT- and AI-based technologies. However, the adoption of these technologies also presents challenges in the form of the need for workers to adapt their skills, which can exacerbate social inequality if not addressed through inclusive training programs. The environmental benefits achieved through Industry 4.0 technologies are evident in reduced carbon emissions and improved resource efficiency. Blockchain technology, for example, can improve supply chain transparency in tracking environmentally friendly products. From an economic perspective, this implementation accelerates production processes, lowers operational costs, and enhances corporate competitiveness.

2) Differences in Sustainability Between Companies That Do and Do Not Implement Industry 4.0 Technology in CSCM

Companies that adopt Industry 4.0 technology in CSCM are significantly more advanced in terms of sustainability compared to those that do not. Companies with Industry 4.0 technology demonstrate productivity gains of up to 25% and a 30% reduction in waste, thanks to data-driven supply chain management efficiency. In the social dimension, these companies tend to be more proactive in providing training for their workers, thereby increasing job satisfaction and workforce skills. Conversely, companies that have not yet adopted this technology are more vulnerable to operational inefficiencies and social disparities due to their limited ability to adapt to global technological changes. Additionally, companies without Industry 4.0 technology struggle to meet environmental sustainability standards, such as waste management and carbon footprint reduction.

3) The Social Dimension of Sustainability in the Implementation of Industry 4.0 Technology in CSCM

The social dimension of sustainability is significantly influenced by the implementation of Industry 4.0 technology through three main mechanisms: enhancing worker skills, creating technology-based jobs, and reducing occupational health risks. Studies show that companies implementing this technology are able to create a more inclusive work ecosystem by supporting the development of workers' digital skills. However, there is a risk of worker displacement that requires mitigation strategies, such as collaboration with educational institutions for reskilling and upskilling programs. Additionally, the social dimension of sustainability requires policies that

support a balance between the benefits of technology and its social impacts, including protections for workers affected by automation.

CONCLUSION

This study reveals that the application of Industry 4.0 technologies in Circular Supply Chain Management (CSCM) has a significant impact on the social, environmental, and economic aspects of companies, particularly in developing countries. Technologies such as artificial intelligence (AI), the Internet of Things (IoT), and blockchain offer opportunities to improve operational efficiency, transparency, and sustainability. From a social perspective, automation contributes to improving workers' well-being by reducing physical workloads and enhancing workplace safety. However, challenges such as the reduction of manual labor and the need for retraining remain issues that need to be addressed. On the environmental front, these technologies help companies reduce waste, improve energy efficiency, and cut carbon emissions. Meanwhile, economically, the implementation of Industry 4.0 technologies supports increased productivity and competitiveness, although high initial investment remains a barrier. Companies that have adopted Industry 4.0 technologies demonstrate better sustainability performance compared to those that have not yet implemented them. The social dimension of sustainability is influenced by worker reskilling, improved workplace safety, and the reduction of social inequality. However, there is a risk of increased stress due to the pressure to adapt to new technologies.

RECOMMENDATIONS AND DIRECTIONS FOR FUTURE RESEARCH

1) Development of Reskilling and Upskilling Policies: Governments and companies need to develop affordable training programs to support workers in coping with technological changes, thereby minimizing social inequality.
2) Investment in Technology Infrastructure: Companies need to consider long-term investments in Industry 4.0 technologies to improve operational efficiency and sustainability, with government support through fiscal incentives or subsidies.
3) Further Research: Additional studies are needed to explore the application of Industry 4.0 technologies across various specific industrial sectors in developing countries, to better understand the factors contributing to success and the obstacles encountered.
4) Strengthening Social and Environmental Sustainability: Companies in developing countries must ensure that technology implementation focuses not only on economic efficiency but also on reducing negative impacts on workers and the environment.
5) Multistakeholder Collaboration: Collaboration between the government, the private sector, and academia is needed to create a strategic framework that supports the inclusive and sustainable adoption of Industry 4.0 technologies. Overall, the adoption of Industry 4.0 technologies is expected to serve as a catalyst for more equitable and sustainable economic development, provided that existing challenges can be strategically addressed.

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