ANALYSIS OF CRITICAL SUCCESS FACTORS FOR INDUSTRY 4.0 ADOPTION IN MANUFACTURING INDUSTRY: A SYSTEMATIC LITERATURE REVIEW USING PRISMA 2020

Aji Pamungkas, Information Systems, Sekolah Tinggi Teknologi Bina Tunggal , Bekasi, West Java , aji.pmks@gmail.com[1*]
Gustam Effendi, Information Systems, Sekolah Tinggi Teknologi Bina Tunggal , Bekasi, West Java, gustam.efendi2009@gmail.com [2]
Manase Sahat H Simarangkir, Teknologi Rekayasa Perangkat Lunak, Politeknik META Industri, Kawasan Hyundai, Jl. Inti I No.007 Blok C1, Cibatu, Cikarang Sel., Kabupaten Bekasi, Jawa Barat 17530, manase@politeknikmeta.ac.id[3]
Rita Purnamasari, Teknologi Rekayasa Perangkat Lunak, Politeknik META Industri, Kawasan Hyundai, Jl. Inti I No.007 Blok C1, Cibatu, Cikarang Sel., Kabupaten Bekasi, Jawa Barat 17530, ritapurnamasari650@gmail.com[4]
Corrsepondensi Authors : aji.pmks@gmail.com

Abstract

Background	:	Industry 4.0 adoption has become a key strategy for manufacturing industries to enhance competitiveness. However, its implementation faces various challenges.
Purpose	:	This study aims to identify and analyze the Critical Success Factors (CSFs) for Industry 4.0 adoption in the manufacturing sector using a Systematic Literature Review based on PRISMA 2020.
Methodology	:	Data were collected from 10 international and national journal articles indexed by Scopus and SINTA from 2018 to 2022.
Findings	:	The synthesis revealed 8 main CSFs: top management support, implementation strategy, technological infrastructure, competent human resources, organizational culture, collaboration, cybersecurity, and government policy. Studies by Lestari et al. (2020) and Wibowo et al. (2022) confirm that the readiness of Indonesian SMEs is a determining factor.
Implications	:	This study provides an applicable CSF framework for manufacturing managers to plan their Industry 4.0 adoption roadmap
Originality	:	The strengths of this literature review, which focuses on a critical analysis of success factors in Industry 4.0.

Keywords *: Industry 4.0; Critical Success Factors; Manufacturing; PRISMA 2020; Systematic Literature Review*

INTRODUCTION

The emergence of Industry 4.0 has fundamentally transformed the manufacturing sector through the integration of cyber-physical systems (CPS), the Internet of Things (IoT), big data analytics, cloud computing, artificial intelligence, and other advanced digital technologies into production and business processes (Buer et al., 2018). This transformation enables manufacturers to develop smart and interconnected production systems capable of improving operational efficiency, production flexibility, product quality, responsiveness, and global competitiveness. Nevertheless, the adoption of Industry 4.0 is not solely a technological challenge. Organizations must also address managerial, organizational, human-resource, infrastructural, and external environmental factors that determine whether technology implementation can deliver its expected benefits.

Despite the potential benefits, Industry 4.0 implementation continues to face a substantial risk of failure. Masood and Sonntag (2020) reported that the failure rate of Industry 4.0 implementation can reach approximately 70%, indicating that the availability of advanced technologies does not automatically guarantee successful digital transformation. One of the major challenges is the limited understanding of the factors that influence successful Industry 4.0 adoption. Organizations may invest heavily in digital technologies while overlooking organizational preparedness, employee capabilities, leadership commitment, financial resources, cybersecurity, technological infrastructure, and collaboration with external stakeholders. Consequently, identifying and understanding the factors that critically influence Industry 4.0 implementation is essential for organizations seeking to reduce implementation risks and achieve sustainable digital transformation.

In this context, **Critical Success Factors (CSFs)** refer to a limited number of key areas in which satisfactory performance is essential for an organization to achieve its strategic objectives (Cohen et al., 2022). Within Industry 4.0 implementation, CSFs can function as a strategic reference for organizations in assessing their readiness, allocating resources, prioritizing implementation initiatives, and mitigating potential barriers (Pozzi et al., 2021). Previous studies have identified various CSFs associated with Industry 4.0 adoption, including top management support, technological and infrastructure readiness, financial capability, employee competence, organizational culture, strategic alignment, data management, and collaboration within the industrial ecosystem (Ghobakhloo, 2020; Sony & Naik, 2020). However, the importance and relevance of these factors may differ depending on organizational characteristics, industrial sectors, national contexts, and levels of technological maturity.

The issue is particularly relevant in Indonesia, where manufacturing plays an important role in national economic development, while the adoption of Industry 4.0 remains uneven across organizations and industrial sectors. Indonesian manufacturing small and medium-sized enterprises (SMEs), in particular, continue to face limitations in terms of technological readiness, financial resources, human-resource capabilities, and digital infrastructure. Lestari et al. (2020) reported that Indonesian manufacturing SMEs remain at a relatively low level of Industry 4.0 readiness. Furthermore, Wibowo et al. (2022) highlighted the importance of government policies, institutional support, and ecosystem collaboration in accelerating Industry 4.0 adoption in Indonesia. These findings indicate that the success of Industry 4.0 implementation in Indonesia cannot be explained solely by internal technological factors but also requires consideration of organizational and external ecosystem factors.

Although numerous studies have discussed Industry 4.0 adoption and its influencing factors, the existing literature remains fragmented across different perspectives, countries, organizational contexts, and industrial sectors. Some studies emphasize technological readiness, while others focus on organizational capabilities, human resources, management commitment, government support, or ecosystem collaboration. This fragmentation creates a challenge for practitioners and researchers in determining which factors should be considered as the most critical and how these factors are interconnected within the Industry 4.0 implementation process. Moreover, evidence from global studies needs to be contextualized with the conditions of Indonesian manufacturing, particularly considering the differences in technological maturity, organizational capabilities, and institutional environments.

Therefore, a systematic synthesis of the existing literature is required to consolidate the identified CSFs and provide a more comprehensive understanding of the factors influencing Industry 4.0 adoption in manufacturing. This study employs a **Systematic Literature Review (SLR)** following the **PRISMA 2020** framework to systematically identify, screen, evaluate, and synthesize relevant studies concerning CSFs for Industry 4.0 implementation. The review considers both international and Indonesian literature to identify common patterns, contextual differences, and factors that consistently emerge as critical to successful Industry 4.0 adoption.

Corresponding Authors : aji.pmks@gmail.com

Based on this research gap, this study aims to: **(1)** identify and categorize the Critical Success Factors influencing Industry 4.0 adoption in the manufacturing sector; **(2)** analyze the patterns and contextual differences of CSFs identified in international and Indonesian studies; and **(3)** develop a comprehensive and applicable CSF framework that can serve as a reference for manufacturing organizations in assessing priorities and improving the effectiveness of Industry 4.0 implementation. The findings are expected to contribute to the development of the Industry 4.0 adoption literature while providing practical guidance for managers, policymakers, and other stakeholders involved in manufacturing digital transformation.

LITERATURE REVIEW

2.1 Industry 4.0 Adoption in Manufacturing

Industry 4.0 represents a transformation in manufacturing characterized by the integration of digital technologies, cyber-physical systems (CPS), the Internet of Things (IoT), cloud computing, big data analytics, artificial intelligence, and other advanced technologies into manufacturing and organizational processes (Buer et al., 2018). The adoption of these technologies enables organizations to establish interconnected and intelligent production systems that support real-time monitoring, data-driven decision-making, production flexibility, process optimization, and improved operational performance.

However, Industry 4.0 adoption is a multidimensional transformation that extends beyond the implementation of individual technologies. It requires organizations to modify existing processes, develop new employee competencies, establish appropriate organizational structures, and align digital initiatives with business strategies (Ghobakhloo, 2020). Therefore, successful Industry 4.0 adoption depends on the organization's ability to simultaneously manage technological, organizational, human, and environmental dimensions.

2.2 Critical Success Factors for Industry 4.0 Adoption

Critical Success Factors (CSFs) refer to the limited number of areas in which satisfactory performance is essential for an organization to achieve its strategic objectives (Cohen et al., 2022). In the context of Industry 4.0, CSFs represent the organizational, technological, human, financial, and environmental conditions that must be adequately addressed to ensure successful implementation.

Previous studies have identified several factors that influence Industry 4.0 adoption. Top management support is considered one of the most important factors because management commitment determines strategic direction, resource allocation, organizational priorities, and employee support for digital transformation (Sony & Naik, 2020). Without strong managerial commitment, Industry 4.0 initiatives may face difficulties in obtaining sufficient financial resources and organizational acceptance.

Technological and infrastructure readiness is another important factor. Industry 4.0 requires reliable digital infrastructure, connectivity, data management systems, cybersecurity, and interoperability between machines and information systems (Ghobakhloo, 2020). Organizations with inadequate technological infrastructure may experience difficulties integrating new technologies into existing production systems.

Human-resource competence is also critical because Industry 4.0 changes the skills required in manufacturing organizations. Employees increasingly need competencies related to digital technologies, data analysis, automation, problem-solving, and interdisciplinary collaboration. Consequently, training, employee development, and organizational learning become important mechanisms for supporting Industry 4.0 transformation (Sony & Naik, 2020).

Corresponding Authors : aji.pmks@gmail.com

2.3 Organizational and Environmental Factors

In addition to technological and internal organizational factors, Industry 4.0 adoption is influenced by the external business environment. Government policies, financial incentives, industry standards, technology providers, educational institutions, and collaboration among supply-chain partners can facilitate or constrain digital transformation.

For developing economies such as Indonesia, these external factors become particularly important because manufacturing organizations may face limitations in technological investment, skilled human resources, digital infrastructure, and access to advanced technologies. Government support and ecosystem collaboration can therefore play an important role in reducing adoption barriers and accelerating Industry 4.0 implementation (Wibowo et al., 2022).

Organizational culture is another factor that can influence Industry 4.0 adoption. A culture that encourages innovation, learning, collaboration, and openness to technological change can facilitate employee acceptance of digital transformation. Conversely, resistance to change and a lack of organizational readiness may hinder the implementation of Industry 4.0 technologies. Thus, successful adoption requires not only technological investment but also organizational transformation.

2.4 Industry 4.0 Readiness in Indonesian Manufacturing

The adoption of Industry 4.0 in Indonesia presents specific challenges because manufacturing organizations differ considerably in terms of technological maturity, organizational capabilities, financial resources, and human-resource competencies. These challenges are particularly evident among small and medium-sized manufacturing enterprises (SMEs), which may have limited resources for investing in advanced digital technologies.

Lestari et al. (2020) reported that Indonesian manufacturing SMEs remain at a relatively low level of Industry 4.0 readiness. This condition suggests that technological availability alone is insufficient to ensure successful adoption. Organizations must also develop managerial capabilities, employee competencies, organizational readiness, and supporting infrastructure. Furthermore, government policies and collaboration within the industrial ecosystem are important in creating an environment that supports digital transformation (Wibowo et al., 2022).

The Indonesian context therefore provides an important research setting for identifying and evaluating CSFs because factors identified in developed countries may not have the same level of importance in developing economies. Differences in infrastructure availability, investment capacity, workforce skills, institutional support, and technological maturity may influence the relative importance of individual CSFs.

2.5 Research Gap

Based on the review of the selected literature, three major research gaps can be identified.

1. Contextual Gap

A substantial proportion of Industry 4.0 studies have been conducted in developed industrial economies, where technological infrastructure, human-resource capabilities, and digital maturity are relatively advanced. In contrast, empirical evidence concerning the CSFs of Industry 4.0 adoption in Indonesian manufacturing remains comparatively limited. This creates a need to contextualize internationally identified CSFs with the characteristics and challenges of Indonesian manufacturing organizations (Lestari et al., 2020).

2. Fragmentation Gap

Corresponding Authors : aji.pmks@gmail.com

Existing studies have identified numerous CSFs, including top management support, technological readiness, infrastructure, financial resources, human-resource competence, organizational culture, government support, cybersecurity, and ecosystem collaboration. However, these factors are often examined independently or within specific organizational and technological contexts. As a result, there is still limited synthesis regarding how these factors can be systematically categorized into a comprehensive framework for Industry 4.0 adoption.

3. Integrative Gap

Previous research tends to emphasize specific dimensions of Industry 4.0 adoption, such as technological readiness, organizational capabilities, human resources, or external environmental factors. A comprehensive framework integrating these dimensions and distinguishing between common global factors and factors that are particularly relevant to the Indonesian manufacturing context remains limited. Furthermore, the existing literature provides insufficient synthesis of the relationships and relative importance of CSFs across different manufacturing contexts.

4 Contribution of the Study

This Systematic Literature Review addresses these gaps by systematically identifying, categorizing, and synthesizing Critical Success Factors associated with Industry 4.0 adoption in the manufacturing sector. By applying the PRISMA 2020 framework, this study integrates evidence from international and Indonesian literature to identify recurring CSFs, contextual differences, and emerging implementation patterns.

The resulting framework is expected to provide an integrated perspective encompassing **technological, organizational, human-resource, managerial, financial, and environmental factors**. The framework can subsequently serve as a conceptual reference for manufacturing organizations in identifying implementation priorities, assessing organizational readiness, and developing strategies to reduce the risks associated with Industry 4.0 adoption. In addition, the study contributes to the literature by positioning the Indonesian manufacturing context within the broader global discussion of Industry 4.0 implementation success.

METHODOLOGY

This study employed a **Systematic Literature Review (SLR)** following the **PRISMA 2020** protocol to systematically identify, evaluate, and synthesize existing evidence regarding Critical Success Factors (CSFs) influencing Industry 4.0 adoption in the manufacturing sector. The SLR approach was selected because it provides a structured and transparent procedure for identifying relevant studies, assessing their eligibility, and synthesizing findings while minimizing potential selection and interpretation bias.

3.1 Inclusion and Exclusion Criteria

To ensure the relevance and consistency of the selected studies, predefined inclusion and exclusion criteria were established before the literature search. The inclusion criteria were as follows:

1. Articles published in international or national peer-reviewed journals indexed by **Scopus or SINTA**.
2. Articles published between **2018 and 2022**.
3. Articles written in **English or Indonesian**.
4. Studies focusing on **Critical Success Factors (CSFs), success factors, readiness factors, or adoption factors related to Industry 4.0**.

Corresponding Authors : aji.pmks@gmail.com

5. Studies conducted within the **manufacturing sector**.

The exclusion criteria were:

1. Opinion articles, editorials, conference abstracts, review articles, and other non-empirical publications.
2. Articles for which the **full text was unavailable**.
3. Studies that did not specifically address Industry 4.0 adoption or its influencing factors.
4. Studies focusing on sectors outside manufacturing.
5. Studies that discussed Industry 4.0 technologies without examining factors related to their adoption or implementation.

These criteria were applied consistently throughout the screening and eligibility assessment processes to ensure that the final studies were directly aligned with the research objectives.

3.2 Search Strategy

The literature search was conducted using three academic databases: **Scopus, ScienceDirect, and Google Scholar**. These databases were selected to provide broad coverage of international and national publications related to Industry 4.0, manufacturing, and critical success factors.

The search strategy employed the following Boolean search string:

"Industry 4.0" AND "Critical Success Factors" AND "manufacturing"

The search was conducted within the specified publication period of 2018–2022. The initial search identified **120 potentially relevant articles** across the selected databases. The retrieved records were subsequently exported, organized, and screened according to the predefined eligibility criteria.

3.3 Article Selection Based on PRISMA 2020

The article selection process followed the four main stages of the **PRISMA 2020** framework: identification, screening, eligibility, and inclusion.

1. Identification

At the identification stage, a total of **120 records** were retrieved from Scopus, ScienceDirect, and Google Scholar using the predefined search strategy. All identified records were collected for subsequent screening.

2. Screening

The retrieved records were initially screened to identify and remove duplicate publications. Following duplicate removal, the titles and abstracts of the remaining articles were evaluated based on the inclusion and exclusion criteria. After this screening process, **90 articles** were considered potentially relevant and proceeded to the eligibility assessment.

3. Eligibility

The full texts of the 90 potentially relevant articles were assessed to determine their substantive relevance to the research objectives. Articles were excluded when they did not provide a specific discussion of Critical Success Factors or Industry 4.0 adoption factors within the manufacturing context, did not provide sufficient empirical evidence, or failed to meet the predefined eligibility criteria. Following the full-text assessment, **20 articles** remained eligible for further evaluation.

4. Included

The remaining 20 articles were subjected to a final assessment of their methodological relevance, research focus, and contribution to the identification of CSFs for Industry 4.0 adoption. Based on this assessment, **10 articles** were selected for the final qualitative synthesis. The final sample consisted of **8 international studies and 2 Indonesian studies**, including studies by Lestari et al. (2020) and Wibowo et al. (2022).

Corresponding Authors : aji.pmks@gmail.com

The complete article selection process is presented using a **PRISMA 2020 flow diagram**, illustrating the number of records identified, screened, assessed for eligibility, excluded, and ultimately included in the qualitative synthesis.

3.4 Data Extraction and Synthesis

For each selected article, relevant information was extracted systematically, including **author and publication year, country or research context, manufacturing sector, research objectives, research method, Industry 4.0 adoption context, identified Critical Success Factors, and key findings**. The extracted information was then compared across studies to identify recurring factors and differences in the factors reported across international and Indonesian manufacturing contexts.

The identified CSFs were subsequently grouped into broader dimensions, including **technological, organizational, human-resource, managerial, financial, and environmental factors**. This categorization was used to develop an integrated framework of Critical Success Factors for Industry 4.0 adoption in manufacturing.

The synthesis focused on identifying the factors that consistently appeared across the selected studies, examining contextual differences between international and Indonesian research, and determining how the identified factors can be integrated into an applicable framework for Industry 4.0 implementation.

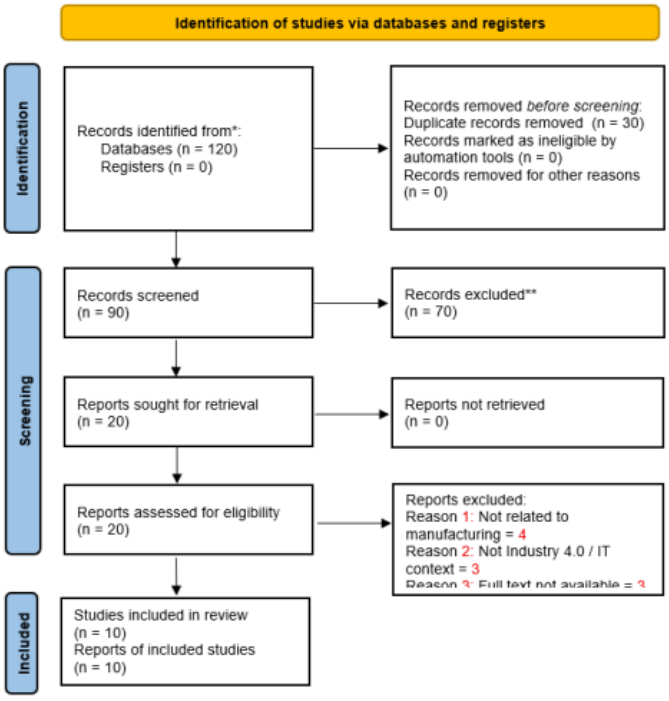


Figure 1. Prisma Flow Diagram

RESULT AND DISCUSSION

4.1 Article Selection Results

The literature selection process following the PRISMA 2020 framework resulted in **10 articles** that met all predefined inclusion and exclusion criteria. From the initial **120 records** identified through Scopus, ScienceDirect, and Google Scholar, the screening and full-text assessment processes resulted in 20

Corresponding Authors : aji.pmks@gmail.com

eligible articles. Following the final assessment of relevance and methodological suitability, 10 articles were selected for qualitative synthesis.

The final sample consisted of **8 international journal articles indexed by Scopus and 2 Indonesian national journal articles indexed by SINTA**. The Indonesian studies included research conducted by Lestari et al. (2020) and Wibowo et al. (2022). This composition indicates that the existing literature on Critical Success Factors (CSFs) for Industry 4.0 adoption is predominantly represented by international research, while studies specifically examining the Indonesian manufacturing context remain relatively limited.

The dominance of international publications provides a broader perspective on the factors influencing Industry 4.0 adoption across different industrial and national contexts. However, the relatively small number of Indonesian studies also highlights the contextual research gap identified in this study. Factors considered critical in developed manufacturing economies may not necessarily have the same level of importance in Indonesia due to differences in technological infrastructure, workforce competencies, investment capabilities, organizational maturity, and government support.

Therefore, the inclusion of both international and Indonesian studies is important for developing a more comprehensive understanding of Industry 4.0 adoption. The international studies provide evidence regarding commonly reported CSFs, while the Indonesian studies contribute contextual insights regarding the specific challenges and supporting factors encountered by manufacturing organizations in Indonesia. The distribution of the selected articles is summarized in Table 1.

Table 1. Distribution of the selected articles

No	Author & Year	Country	Sector	Method	Main CSFs Discussed
1	Buer, S.-V., Strandhagen, J. O., & Chan, F. T. S. (2018)	Norway	Manufacturing	Review	The link between Industry 4.0 and lean
2	Cohen, Y., Nasceraldin, H., Chaudhuri, A., & Pilati, F. (2022)	Israel	Manufacturing	Roadmap	Assembly systems in Industry 4.0
3	Ghobakhloo, M. (2020)	Malaysia	Manufacturing	Conceptual	Industry 4.0, digitization, and opportunities for sustainability
4	Javaid, M., Haleem, A., Rab, S., Singh, R. P., Suman, R., & Mohan, S. (2022)	India	Manufacturing	Review	Progressive schema of 5G for Industry 4.0
5	Javaid, M., Haleem, A., Rab, S., Singh, R. P., Suman, R., & Mohan, S. (2021)	India	Manufacturing	Review	Sensors for daily life: IoT + Sensor manufacturing cerdas
6	Lestari, F., Lestari, Y. D., Hidayatno, A., & Herdiansyah, H. (2020)	Indonesia	Manufacturing	Survey	Model kesiapan Industri 4.0
7	Masood, T., & Sonntag, P. (2020)	Germany	Manufacturing	SLR	Adopsi Tantangan & Keuntungan UKM
8	Pozzi, R., Rossi, T., & Secchi, R. (2021)	Italy	Manufacturing	Case Study	CSFs implementasi dan peningkatan Teknologi Industri 4.0

Corresponding Authors : aji.pmks@gmail.com

No	Author & Year	Country	Sector	Method	Main CSFs Discussed
9	Sony, M., & Naik, S. (2020)	India	Manufacturing	Conceptual	Arsitektur CPS + Lean Six Sigma
10	Wibowo, M. A., Mustofa, A., & Nurhidayat, N. (2022)	Indonesia	Manufacturing	Survey	CSFs I 4.0 adopsi di Indonesia

4.2 Critical Success Factors for Industry 4.0 Adoption

The thematic synthesis of the 10 selected articles identified **eight major Critical Success Factors (CSFs)** that influence the successful adoption of Industry 4.0 in the manufacturing sector. These factors represent interconnected technological, organizational, human, managerial, and external dimensions that determine an organization's ability to initiate, implement, and sustain Industry 4.0 transformation. The eight identified CSFs are **(1) top management support, (2) strategy and implementation roadmap, (3) technology infrastructure and connectivity, (4) competent human resources, (5) organizational culture, (6) ecosystem collaboration, (7) cybersecurity, and (8) government policy and support**.

1. Top Management Support

Top management support is one of the most important organizational factors influencing Industry 4.0 adoption. Management commitment is required to establish a clear strategic direction, allocate financial and technological resources, facilitate organizational change, and ensure that Industry 4.0 initiatives remain aligned with long-term business objectives (Buer et al., 2018; Masood & Sonntag, 2020). Industry 4.0 implementation generally requires substantial organizational changes and investments; therefore, without strong leadership commitment, digital transformation initiatives may encounter resistance, insufficient resources, or a lack of organizational coordination. Top management also plays an important role in establishing a culture that encourages innovation and acceptance of new technologies.

2. Strategy and Implementation Roadmap

A clear strategy and implementation roadmap are essential for translating Industry 4.0 objectives into structured implementation activities. Organizations need to determine their technological priorities, implementation stages, performance indicators, resource requirements, and potential risks before introducing advanced digital technologies (Cohen et al., 2022; Pozzi et al., 2021). A roadmap enables organizations to evaluate their current technological maturity and establish realistic transformation targets. It also helps management prioritize investments and avoid fragmented technology implementation. Therefore, Industry 4.0 adoption should be viewed as a gradual strategic transformation rather than a one-time technology investment.

3. Technology Infrastructure and Connectivity

Technology infrastructure constitutes the fundamental technical foundation of Industry 4.0 implementation. Technologies such as the Internet of Things (IoT), cloud computing, big data analytics, cyber-physical systems, and advanced communication networks require reliable connectivity, data infrastructure, interoperability, and system integration (Ghobakhloo, 2020; Sony & Naik, 2020). Organizations with outdated legacy systems or inadequate connectivity may experience difficulties integrating new Industry 4.0 technologies into existing production environments. In the Indonesian manufacturing context, infrastructure readiness remains an important challenge, particularly for organizations with limited technological resources and capabilities (Lestari et al., 2020).

Corresponding Authors : aji.pmks@gmail.com

4. Competent Human Resources

Human-resource competence is another critical factor because Industry 4.0 changes the knowledge and skills required in manufacturing organizations. Employees increasingly need competencies in areas such as data analytics, digital technologies, automation, cybersecurity, information systems, and cyber-physical systems. The successful implementation of Industry 4.0 therefore requires continuous employee training, reskilling, and upskilling. In the Indonesian context, the development of competent human resources is particularly important because limitations in digital skills can constrain the effective utilization of advanced technologies (Wibowo et al., 2022). Human-resource development should consequently be integrated into the organization's Industry 4.0 implementation strategy rather than treated as a separate training activity.

5. Organizational Culture

Organizational culture influences how employees respond to technological and organizational changes associated with Industry 4.0. A culture that promotes innovation, collaboration, continuous learning, knowledge sharing, and openness to change can facilitate technology adoption (Sony & Naik, 2020). Conversely, employee resistance, fear of technological replacement, limited communication, and unwillingness to change established work practices can become significant barriers. Therefore, organizations need to develop a supportive change-management environment in which employees understand the benefits and objectives of Industry 4.0 transformation. Organizational culture is closely connected with top management support because leadership commitment can influence employee acceptance and organizational readiness for change.

6. Ecosystem Collaboration

Industry 4.0 adoption does not occur exclusively within organizational boundaries. Collaboration with suppliers, technology providers, universities, research institutions, industry associations, and government agencies can facilitate knowledge exchange, technology transfer, innovation, and access to external expertise (Pozzi et al., 2021; Wibowo et al., 2022). Such collaboration is particularly relevant for manufacturing organizations that lack sufficient internal technological capabilities. Through ecosystem collaboration, organizations can obtain access to specialized knowledge, technological solutions, research capabilities, and implementation support. Consequently, Industry 4.0 adoption should be considered as an ecosystem-level transformation involving multiple stakeholders rather than solely an internal organizational initiative.

7. Cybersecurity

The increasing interconnection of machines, production systems, information systems, and external networks creates additional cybersecurity risks. Industry 4.0 environments generate and exchange large volumes of operational and organizational data, making manufacturing systems potentially vulnerable to unauthorized access, data breaches, system disruption, and other cyber threats. Consequently, cybersecurity must be incorporated into Industry 4.0 implementation from the early planning stage rather than being treated as an additional technical requirement after implementation (Masood & Sonntag, 2020). Adequate cybersecurity mechanisms, data protection, access control, and employee awareness are necessary to maintain the reliability and continuity of digital manufacturing systems.

8. Government Policy and Support

Corresponding Authors : aji.pmks@gmail.com

Government policy and institutional support represent important external factors, particularly in developing manufacturing economies. Government programs, regulations, financial incentives, infrastructure development, standards, education policies, and technology-support initiatives can reduce barriers to Industry 4.0 adoption and encourage organizations to invest in digital transformation. This factor is particularly relevant in Indonesia, where differences in technological maturity and organizational capabilities create a need for external support mechanisms (Wibowo et al., 2022). Government support can also strengthen collaboration between industry, universities, technology providers, and other stakeholders, thereby contributing to the development of a more supportive Industry 4.0 ecosystem.

Overall, the thematic synthesis indicates that Industry 4.0 adoption cannot be explained by technological readiness alone. The eight identified CSFs demonstrate that successful implementation requires the simultaneous alignment of **managerial commitment, strategic planning, technological infrastructure, human-resource capabilities, organizational culture, ecosystem collaboration, cybersecurity, and government support**. These factors are interrelated rather than independent. For example, top management support influences resource allocation and organizational culture, while human-resource competence determines the organization's ability to utilize technological infrastructure effectively. Similarly, government support and ecosystem collaboration can strengthen technological and human-resource capabilities. Therefore, the successful adoption of Industry 4.0 requires an integrated approach that considers both internal organizational capabilities and external environmental conditions.

Discussion

These findings confirm that Industry 4.0 adoption is a multidimensional process shaped by technical, managerial, and organizational factors. The identification of eight critical success factors, or CSFs, indicates that successful implementation cannot be achieved solely through technological investment. Instead, technological readiness must be supported by strong managerial commitment, adequate human resources, organizational capabilities, and an environment that facilitates digital transformation.

The Indonesian context presents additional challenges, particularly in terms of infrastructure readiness and human resource capabilities. Compared with developed countries, Indonesian manufacturing organizations may face wider gaps in digital infrastructure, technological competencies, and employee readiness (Lestari et al., 2020). These contextual conditions suggest that the CSFs identified in previous studies cannot be adopted directly without considering local organizational and industrial characteristics.

The proposed eight-CSF framework therefore provides a contextual reference for manufacturing organizations in Indonesia to assess their readiness and establish implementation priorities. Manufacturing managers can use this framework to identify critical organizational gaps and allocate resources according to the most pressing needs. This approach may help reduce implementation risks, strengthen organizational readiness, and support the long-term sustainability of Industry 4.0 initiatives.

CONCLUSION

The Systematic Literature Review PRISMA 2020 on 10 articles published 2018-2022 concludes that Industry 4.0 adoption in manufacturing is influenced by 8 Critical Success Factors: Top Management Support, Strategy and Roadmap, Technology Infrastructure, Competent Human Resources, Organizational Culture, Ecosystem Collaboration, Cybersecurity, as well as Government

Corresponding Authors : aji.pmks@gmail.com

Policy and Support. The findings of Lestari et al. and Wibowo et al. confirm that the Indonesian manufacturing context has specific challenges regarding infrastructure gaps and HR readiness compared to developed countries (Buer et al., 2018; Masood & Sonntag, 2020).

AUTHOR'S CONTRIBUTION

Aji Pamungkas: Conceptualization, methodology, literature review, data analysis, and manuscript preparation. Gustam Effendi: Data analysis, validation, and manuscript review. Manase Sahat H Simarangkir: Supervision, validation, interpretation of findings, and manuscript review. All authors contributed to the final manuscript and approved the submitted version.

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DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Corresponding Authors : aji.pmks@gmail.com