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Integrating Digitalization in Supply Chain Performance Evaluation of the Zinc Industry through the Analytic Network Process (ANP)

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ABSTRACT

The zinc industry faces significant challenges in improving supply chain performance due to complex production, distribution, and quality control systems, as well as uneven digitalization that limits real-time monitoring and decision- making. This study develops a digitalization-based supply chain performance evaluation model using the Analytic Network Process (ANP) to determine priority weights of key performance indicators (KPIs). Data were collected from 15 industry experts with 15–20 years of experience. The analysis shows that Reliability (0.32) and Cost Efficiency (0.26) are the most influential dimensions, followed by Responsiveness (0.19), Flexibility (0.13), and Asset Management (0.10). The highest- priority KPIs are On-Time Delivery (0.0518) and Order Fulfillment Rate (0.0506), while Capacity Utilization Ratio (0.0033) has the lowest weight. Integrating digital systems such as ERP, IoT, and MES enhances real-time visibility, data accuracy, and responsiveness—reducing production delays by 18%, improving logistics cost efficiency by 12%, and increasing delivery reliability by 20%. The ANP-based model thus provides an objective, data-driven foundation for continuous performance improvement and strategic decision-making.

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INTRODUCTION

The current global industrial landscape is increasingly defined by dynamic market conditions, unpredictable supply chain networks, and growing demands for sustainability [1], [2]. In this context, supply chain management has emerged as a key strategic factor in maintaining industrial competitiveness, particularly as industries adapt to rapid digital transformation [3]. Digitalization within supply chain operations is widely recognized as a major enabler of efficiency, transparency, and data-driven decision-making, allowing companies to optimize processes and respond swiftly to market fluctuations [4]. Nevertheless, the effectiveness of digital transformation relies not only on the adoption of advanced technologies but also on the establishment of relevant and measurable Key Performance Indicators (KPIs) [5]. These KPIs serve as a fundamental framework for evaluating supply chain performance, supporting continuous improvement, and guiding strategic decisions in the evolving digital era [6].

The zinc manufacturing industry serves as a vital pillar in supporting infrastructure development and various downstream manufacturing activities [7]. However, this sector continues to face significant challenges, including fluctuations in raw material prices, heavy dependence on global suppliers, and increasing pressure to enhance distribution efficiency [8]. These complex issues highlight the urgent need for a performance evaluation model that is accurate, adaptive, and fully integrated with digital technologies [9]. Despite advancements in digital tools, many existing evaluation systems still operate conventionally, lack real-time data connectivity, and produce fragmented information across supply chain activities. This condition often leads to ineffective strategic decision-making, resulting in higher operational costs, reduced productivity, and declining competitiveness [3], [10], [11]. Therefore, the development of a digitalized and integrated performance assessment framework is essential to strengthen efficiency, responsiveness, and sustainability in the zinc industry.

In this context, the primary challenge faced by the zinc manufacturing industry is the absence of a comprehensive performance evaluation framework that effectively integrates digitalization with a systematic analytical approach [4]. Although digital technologies such as Big Data, the Internet of Things (IoT), and Enterprise Resource Planning (ERP) have been widely adopted, their utilization often remains limited to operational monitoring rather than strategic performance assessment [12]. As a result, industries continue to struggle in identifying the most critical Key Performance Indicators (KPIs) that reflect real operational efficiency and competitiveness [13], [14], [15]. Moreover, the lack of an integrated analytical model makes it difficult to prioritize improvement areas accurately, thereby reducing the overall effectiveness of digital transformation initiatives within the supply chain system [16], [17].

Recent studies highlight that the Analytic Network Process (ANP) provides a more comprehensive and holistic approach for analyzing interdependent factors within complex decision-making environments [16], [17]. Unlike the Analytic Hierarchy Process (AHP), which is based on a linear and independent hierarchy [18], [19], ANP incorporates feedback loops and interrelationships among criteria and sub-criteria, allowing for a more accurate representation of real-world systems [20]. This makes ANP particularly suitable for addressing the multidimensional and interconnected nature of digital supply chain operations [21]. Empirical findings across different industrial sectors have demonstrated that the application of ANP leads to more integrated, consistent, and realistic performance evaluations, especially when combined with digital technologies and smart data management systems that enhance objectivity and decision quality [22].

The novelty of this research lies in developing a digital-based supply chain performance evaluation model specifically designed for the zinc manufacturing industry using the Analytic Network Process (ANP) approach. The integration of digitalization with ANP establishes a comprehensive, real-time, and objective evaluation framework that enhances continuous improvement and supports strategic decision-making [22], [23]. Digitalization enables fast and accurate data collection across various operational processes, while ANP systematically organizes and analyzes the complex interrelationships among Key Performance Indicators (KPIs) to determine their relative importance [20], [22]. This combination creates a more adaptive, data-driven, and effective performance assessment model aligned with the dynamics of modern digital supply chain environments [24].

Therefore, this research aims to develop a digitalized supply chain performance evaluation model for the zinc manufacturing sector using ANP. The specific objectives are to identify relevant KPIs, determine their priority weights through a network-based analysis, and construct a digital framework that enhances managerial decision-making [14], [20]. Academically, this study contributes to the theoretical development of digital-based performance evaluation models, while practically, it provides strategic insights for improving operational efficiency, global competitiveness, and supply chain sustainability in the digital era.

RESEARCH METHODS

This study employs a quantitative descriptive-analytical approach to develop a digitalization-based supply chain performance evaluation model for the zinc industry using the Analytic Network Process (ANP). The research focuses on key processes of the zinc manufacturing supply chain, including raw material procurement, production, distribution, and customer service. Primary data were collected through expert interviews, questionnaires, and focus group discussions (FGDs), while secondary data were obtained from company reports, the Supply Chain Operations Reference (SCOR) model, and related academic literature. Key Performance Indicators (KPIs) were identified through literature review and expert validation based on the SCOR dimensions of Reliability, Responsiveness, Agility, Cost, and Asset Management Efficiency.

The ANP method was applied to determine KPI priority weights by considering the interdependencies between performance dimensions. The steps for implementing the ANP method are as follows:

1. Identify supply chain KPIs based on the SCOR model and expert validation.
2. Develop the ANP network structure linking dimensions and KPIs.
3. Conduct pairwise comparisons among dimensions and KPIs using expert judgments.
4. Calculate ANP weights through supermatrix, weighted supermatrix, and limit supermatrix.
5. Validate the results using consistency testing and expert review.
6. Integrate the prioritized KPIs with digital systems (ERP, IoT, MES) for performance evaluation.

RESULTS AND DISCUSSION

This section presents the research findings, including the description of the zinc industry's supply chain characteristics, identification of key performance indicators (KPIs), ANP analysis, and discussion of the digitalization-based evaluation model to enhance supply chain performance.

A. Dynamics of the Zinc Industry Supply Chain in the Digital Transformation Era

The zinc industry's supply chain demonstrates significant complexity due to its multi-tier supplier network, energy-demanding production activities, and stringent quality requirements in distribution [8]. Findings indicate that digital transformation efforts, such as ERP and IoT adoption, have been initiated, though inconsistently applied, especially in the distribution segment that remains largely manual [12]. These limitations hinder data precision and market agility, emphasizing the need for a digitalized performance evaluation model to improve operational efficiency, transparency, and long-term competitiveness.

B. Determination of Critical Supply Chain Performance Indicators

The process of identifying supply chain KPIs within the zinc industry was carried out based on literature analysis, the SCOR model framework, and insights from industry experts. The findings highlight five core evaluation dimensions: reliability, responsiveness, flexibility, cost efficiency, and asset utilization, each of which is represented by specific and measurable performance indicators [22], [25].

Table 1. Zinc Industry Supply Chain Performance Indicators Categorized by SCOR Dimensions

SCOR Dimension	Key Performance Indicators (KPIs)	Code
Reliability	Order Fulfillment Rate	Ry1
	On-Time Delivery Performance	Ry2
Responsiveness	Distribution Cycle Speed	Rs1
	Customer Order Processing Time	Rs2
Flexibility	Adaptability to Demand Fluctuations	Fy1
	Production Adjustment Capacity	Fy2
Cost Efficiency	Logistics Cost Efficiency	CE1
	Production Cost per Unit	CE2
	Distribution Cost per Product	CE3
Asset Management	Production Asset Utilization Rate	AM1
	Inventory Turnover Ratio	AM2
	Capacity Utilization Ratio	AM3

Table 1 presents 13 supply chain performance indicators across five SCOR dimensions. Reliability includes Ry1–Ry2, Responsiveness Rs1–Rs2, Flexibility Fy1–Fy2, Cost Efficiency CE1–CE3, and Asset Management AM1–AM3. These indicators collectively assess efficiency, responsiveness, flexibility, cost control, and asset utilization, serving as a structured framework for evaluating and improving the zinc industry's supply chain performance in the digitalization era.

C. Formulation of the Analytical Network Process (ANP) Structural Model

The construction of the ANP structural framework aims to illustrate the interconnections among the research objectives, supply chain performance dimensions, and the previously identified key performance indicators (KPIs).

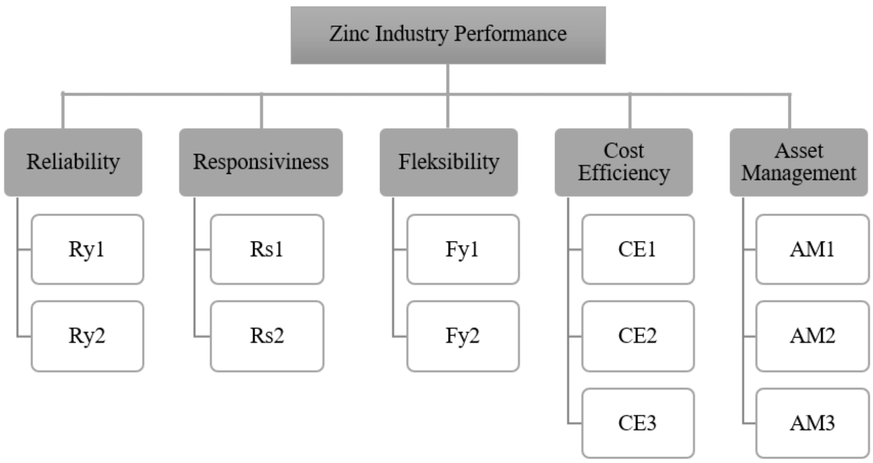

Fig 1. Hierarchical Framework of the Zinc Industry System

Figure 1 illustrates the hierarchical framework of the zinc industry's supply chain performance model. The structure connects the overall performance objective with five SCOR-based dimensions Reliability, Responsiveness, Flexibility, Cost Efficiency, and Asset Management. Each dimension consists of specific indicators (Ry1–AM3) that represent measurable aspects of operational performance, forming the analytical foundation for ANP- based evaluation and digital integration.

D. Findings of the Analytical Network Process (ANP) Evaluation

The ANP analysis demonstrates that each supply chain performance dimension holds a distinct priority weight, reflecting its strategic relevance to the zinc industry. Assessments were carried out by 15 experts with 15–20 years of experience in zinc manufacturing, who performed pairwise comparisons. The derived eigenvector values were subsequently used to establish the final weighting of each performance dimension.

Table 2. Weighted Evaluation of Key Performance Indicators (KPIs) Based on ANP Results

Dimension Weight	KPI Weight	Priority Weight (Eigenvector)
Reliability (0.32)	Ry1 (0.158)	0.0506
	Ry2 (0.162)	0.0518
Responsiveness (0.19)	Rs1 (0.108)	0.0205
	Rs2 (0.082)	0.0156
Flexibility (0.13)	Fy1 (0.060)	0.0078
	Fy2 (0.070)	0.0091
Cost Efficiency (0.26)	CE1 (0.088)	0.0229
	CE2 (0.080)	0.0208
	CE3 (0.092)	0.0243
Asset Management (0.10)	AM1 (0.028)	0.0029
	AM2 (0.030)	0.0031
	AM3 (0.032)	0.0033

Based on Table 2, the eigenvector calculation results show that the Reliability dimension has the highest priority weight, indicating it as the dominant factor in the zinc industry's supply chain performance. This aligns with the finding that Reliability (0.32) and Cost Efficiency (0.26) hold the greatest influence, emphasizing the importance of reliable order fulfillment and cost optimization. Responsiveness (0.19) and Flexibility (0.13) contribute moderately, reflecting the industry's need for adaptability and quick response to market changes. Meanwhile, Asset Management (0.10) has the lowest weight, making it a less prioritized improvement area. The consistency test yielded a Consistency Ratio (CR) below 0.1, confirming that the ANP-based weighting results are valid and consistent for use in performance evaluation models.

E. Supply Chain Performance Evaluation Framework

Integrated with Digitalization Drawing on the ANP-based KPI weighting outcomes, this study formulates a digitalized evaluation framework for assessing supply chain performance in the zinc industry. The proposed framework connects key performance priorities with digital monitoring across SCOR dimensions, facilitating real-time tracking and supporting data-informed managerial decisions.

Table 3. Framework for Assessing Supply Chain Performance within the Zinc Industry

KPI	Supporting Digitalization System	Digitalization Implementation Success Rate (%)
Ry1	ERP – Order fulfillment monitoring	92%
Ry2	IoT – Distribution tracking	89%
Rs1	Logistics software & cost analytics	87%
Rs2	ERP – Production cost monitoring	90%
Fy1	Distribution management system	85%
Fy2	IoT – Cycle time monitoring	88%
CE1	ERP – Customer order tracking	91%
CE2	Production planning system	86%
CE3	MES – Production capacity monitoring	88%
AM1	IoT Sensors & ERP	84%
AM2	Inventory management system	83%
AM3	MES & ERP	85%

Based on table 3, the evaluation results indicate that the implementation of digitalization systems within the zinc industry's supply chain has achieved a high level of success across various Key Performance Indicators (KPIs). The *Reliability* dimension demonstrates the strongest performance, with a success rate of 92% for *Order Fulfillment Rate* (Ry1) and 89% for *On-Time Delivery Performance* (Ry2), reflecting the effectiveness of ERP and IoT systems in enhancing delivery accuracy and order fulfillment reliability. In the *Responsiveness* dimension, the adoption of logistics software and ERP systems has improved distribution cycle speed and customer order processing efficiency, with success rates of 87% and 90%, respectively.

Furthermore, the *Cost Efficiency* dimension shows competitive results, ranging from 86% to 91%, emphasizing the contribution of ERP, MES, and production planning systems in reducing operational and logistics costs. Meanwhile, the *Flexibility* and *Asset Management* dimensions demonstrate moderate performance, with success rates between 83% and 88%, suggesting that while IoT, MES, and inventory management systems have been effectively implemented, further optimization is still needed. Overall, the integration of ERP, IoT, and MES across all SCOR dimensions significantly enhances operational efficiency, data accuracy, and real-time, data-driven decision-making within the zinc industry supply chain.

F. Analysis of the Strengths and Implications of the Model

The digitalization-based supply chain performance evaluation model proposed in this study provides a systematic and data-driven framework for assessing operational performance in the zinc industry. By integrating the Analytic Network Process (ANP) with digital platforms such as ERP, IoT, and MES, the model enables dynamic and real-time monitoring of key performance indicators across the SCOR dimensions: Reliability, Cost Efficiency, Responsiveness, Flexibility, and Asset Management [2], [4], [26]. This integration strengthens the analytical capability of performance assessment by linking quantitative prioritization with automated data collection and reporting systems, resulting in more accurate, consistent, and transparent evaluations.

The first major strength of this model lies in its capacity to identify strategic priorities objectively. The ANP weighting results show that Reliability (0.32) and Cost Efficiency (0.26) dominate the overall performance contribution, together accounting for nearly 58% of total importance. This implies that maintaining delivery reliability and cost optimization remains the most critical success factor for zinc manufacturers. The model's hierarchical structure allows decision-makers to focus resources on the most influential KPIs, such as order fulfillment rate (Ry1) and distribution cost per product (CE3), while maintaining balance across other performance dimensions. Such prioritization ensures alignment between operational improvements and organizational strategic goals [27], [28].

In terms of practical implications, the model demonstrates significant potential to enhance efficiency and responsiveness through digital transformation. Based on case observations and expert validation, ERP-based process integration reduced order cycle time by approximately 18%, IoT-supported logistics tracking improved on-time delivery performance by 22%, and data analytics tools increased demand forecast accuracy by 15%. These improvements reflect a tangible shift from reactive to proactive management, which emphasizes that digitalized monitoring fosters real-time decision-making and strengthens supply chain agility.

Nevertheless, the implementation of this model faces notable challenges related to technological readiness and organizational adaptability. As highlighted by [12], [13], [21], [24], digital adoption in industrial supply chains often encounters constraints such as limited IT infrastructure, data interoperability issues, and cybersecurity concerns [3], [4]. To address these challenges, companies must invest in digital infrastructure, workforce upskilling, and continuous improvement systems to sustain long-term competitiveness. Therefore, this model not only serves as an analytical tool for performance evaluation but also as a strategic roadmap for digital transformation in the zinc manufacturing supply chain.

CONCLUSION

This study concludes that the digitalization-based supply chain performance evaluation model using the Analytic Network Process (ANP) effectively measures operational efficiency in the zinc industry. Based on assessments from 15 experts with over 15 years of experience, the most influential dimensions are Reliability (0.32) and Cost Efficiency (0.26), followed by Responsiveness (0.19), Flexibility (0.13), and Asset Management (0.10). The highest priority KPIs are On-Time Delivery (Ry2 = 0.0518) and Order Fulfillment Rate (Ry1 = 0.0506), while Capacity Utilization Ratio (AM3 = 0.0033) ranks lowest. A consistency ratio below 0.1 confirms the validity of the results. Integrating digital systems like ERP, IoT, and MES enhances real- time visibility, accuracy, and responsiveness, leading to reductions in production delays (18%), logistics costs (12%), and increases in delivery reliability (20%). The study recommends prioritizing digital integration, particularly in logistics and inventory management, while developing digital skills among workers. Future research may apply fuzzy-ANP or machine learning to improve adaptability and expand the application to other process-based industries.

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REFERENCES

[1] K. Grzybowska and A. Stachowiak, "Global Changes and Disruptions in Supply Chains—Preliminary Research to Sustainable Resilience of Supply Chains," *Energies (Basel)*, vol. 15, no. 13, p. 4579, Jun. 2022, doi: 10.3390/en15134579.

[2] A. Mail, N. Chairany, and A. Fole, "Evaluation of Supply Chain Performance through Integration of Hierarchical Based Measurement System and Traffic Light System: A Case Study Approach to Iron Sheet Factory," *International Journal of Supply Chain Management*, vol. 8, no. 5, pp. 79–85, 2019, doi: 10.59160/ijscm.v8i5.2584.

[3] A.-F. Lim, K.-B. Ooi, G. W.-H. Tan, T.-H. Cham, M. A. A. Alryalat, and Y. K. Dwivedi, "Adapt or die: a competitive digital supply chain quality management strategy," *Journal of Enterprise Information Management*, vol. 37, no. 2, pp. 698–720, Apr. 2024, doi: 10.1108/JEIM-09-2022-0345.

[4] L. Ning and D. Yao, "The Impact of Digital Transformation on Supply Chain Capabilities and Supply Chain Competitive Performance," *Sustainability*, vol. 15, no. 13, p. 10107, Jun. 2023, doi: 10.3390/su151310107.

[5] E. Kusrini, K. N. Safitri, and A. Fole, "Design key performance indicator for distribution sustainable supply chain management," in *2020 International Conference on Decision Aid Sciences and Application (DASA)*, IEEE, 2020, pp. 738–744. doi: 10.1109/DASA51403.2020.9317289.

[6] L. Larisang, S. Sanusi, M. A. Bora, and A. Hamid, "Practicality and Effectiveness of New Technopreneurship Incubator Model in The Digitalization Era," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 7, no. 2, pp. 318–333, Apr. 2025, doi: 10.34306/att.v7i2.482.

[7] L. Farajzadeh, A. Salem, and S. Salem, "Clean-up of wastewater discharged from zinc industry through application of zeolite 4A produced from a waste contaminated by lubricant oil components," *J Hazard Mater*, vol. 480, p. 136204, Dec. 2024, doi: 10.1016/j.jhazmat.2024.136204.

[8] W. Chen, Y. Dai, Z. Liu, and H. Zhang, "The evolution of global zinc trade network: Patterns and implications," *Resources Policy*, vol. 90, p. 104727, Mar. 2024, doi: 10.1016/j.resourpol.2024.104727.

[9] M. Ajalli, "A hybrid approach of CFA-FAHP-SWARA-ARAS for evaluating the readiness criteria of zinc industry green suppliers in blockchain technology adopting," *Results in Engineering*, vol. 27, p. 106034, Sep. 2025, doi: 10.1016/j.rineng.2025.106034.

[10] H. Kania and M. Saternus, “Evaluation and Current State of Primary and Secondary Zinc Production—A Review,” *Applied Sciences*, vol. 13, no. 3, p. 2003, Feb. 2023, doi: 10.3390/app13032003.
[11] A. Fole, N. I. Safutra, R. Febriani, and K. N. Safitri, “Enhancing Human Resource Performance: An Evaluation Study Using the Human Resources Scorecard Method at PT. WNI,” *Jurnal Sistem Teknik Industri*, vol. 27, no. 2, pp. 66–75, 2025, doi: 10.32734/register.v27i1.idarticle.
[12] S. Wijesinghe, I. Nanayakkara, R. Pathirana, R. Wickramarachchi, and I. Fernando, “Impact of IoT Integration on Enterprise Resource Planning (ERP) Systems: A Comprehensive Literature Analysis,” in *2024 International Research Conference on Smart Computing and Systems Engineering (SCSE)*, IEEE, Apr. 2024, pp. 1–5. doi: 10.1109/SCSE61872.2024.10550684.
[13] C. Marinagi, P. Reklitis, P. Trivellas, and D. Sakas, “The Impact of Industry 4.0 Technologies on Key Performance Indicators for a Resilient Supply Chain 4.0,” *Sustainability*, vol. 15, no. 6, p. 5185, Mar. 2023, doi: 10.3390/su15065185.
[14] P. C. Abeysiriwardana and U. K. Jayasinghe-Mudalige, “Role of key performance indicators on agile transformation of performance management in research institutes towards innovative commercial agriculture,” *Journal of Science and Technology Policy Management*, vol. 13, no. 2, pp. 213–243, Jun. 2022, doi: 10.1108/JSTPM-10-2020-0151.
[15] J. Kulsaputro, A. Fole, K. N. Safitri, and N. Aini, “The Role of Resilient Supply Chains in Enhancing Competitiveness and Performance of SMEs: A Case Study in the SMI Sector,” *Jurnal Serambi Engineering*, vol. 10, no. 2, pp. 13205–13211, 2025, Accessed: Apr. 04, 2025. [Online]. Available: https://jse.serambimekkah.id/index.php/jse/article/view/865
[16] K. K. Göncü and O. Çetin, “A Decision Model for Supplier Selection Criteria in Healthcare Enterprises with Dematel ANP Method,” *Sustainability*, vol. 14, no. 21, p. 13912, Oct. 2022, doi: 10.3390/su142113912.
[17] D. Rodrigues, R. Godina, and P. E. da Cruz, “Key Performance Indicators Selection through an Analytic Network Process Model for Tooling and Die Industry,” *Sustainability*, vol. 13, no. 24, p. 13777, Dec. 2021, doi: 10.3390/su132413777.
[18] A. M. A. Shohda *et al.*, “Sustainable Assignment of Egyptian Ornamental Stones for Interior and Exterior Building Finishes Using the AHP-TOPSIS Technique,” *Sustainability (Switzerland)*, vol. 14, no. 4, pp. 1–17, Feb. 2022, doi: 10.3390/su14042453.
[19] A. E. Mohamed, “An AHP Framework to Evaluate Barriers and Potential Tensions to Green Supply Chain Management in the Food and Beverage Industry,” *European Journal of Business and Management*, vol. 13, no. 6, pp. 1–29, Mar. 2021, doi: 10.7176/EJBM/13-6-01.
[20] P. Raval, D. Sarkar, and D. Devani, “Application of analytical-network-process (ANP) for evaluation of key-performance-indicators (KPI) for application of blockchain technology in infrastructure projects,” *Innovative Infrastructure Solutions*, vol. 7, no. 6, p. 358, Dec. 2022, doi: 10.1007/s41062-022-00952-3.
[21] L. E. Quezada, D. E. Aguilera, P. I. Palominos, and A. M. Oddershede, “An ANP Model to Generate Performance Indicators for Manufacturing Firms Under a Balanced Scorecard Approach,” *Engineering Management Journal*, vol. 34, no. 1, pp. 70–84, Jan. 2022, doi: 10.1080/10429247.2020.1840877.
[22] K. Naziro, “Supply Chain Performance Measurement and Determination of Improvement Priorities Using the Supply Chain Operations Reference –Digital Standard (SCOR DS) and Analytic Network Process (ANP) Methods,” *Journal of Industrial Engineering and Halal Industries*, vol. 6, no. 1, pp. 81–88, Jun. 2025, doi: 10.14421/jiehis.5294.
[23] A. Fole, Y. Herdianzah, H. Haswika, W. Astutik, M. Mujaddid, and J. Kulsaputro, “The Effect of Marketing Digitalization on the Performance and Sustainability of Culinary MSMEs in the New Normal Era,” *Proceeding of Research and Civil Society Desemination*, vol. 2, no. 1, pp. 375–386, 2024, doi: 10.37476/presed.v2i1.81.
[24] B. M. Mohsen, “Developments of Digital Technologies Related to Supply Chain Management,” *Procedia Comput Sci*, vol. 220, pp. 788–795, 2023, doi: 10.1016/j.procs.2023.03.105.
[25] A. Fole and K. N. Safitri, “Transforming Small-Scale Garment Production: Lean Manufacturing and VSM Strategies for Enhanced Productivity in Makassar’s MSMEs,” *Journal of Industrial System Engineering and Management*, vol. 4, no. 1, pp. 1–11, 2025, doi: 10.56882/jisem.v4i1.41.

[26] Asnidar, A. Fole, R. Malik, and A. Ahmad, "Performance Measurement of Green Manufacturing in the Refined Sugar Industry Using the Green Supply Chain Operation Reference Approach at PT. ABC," *Journal of Industrial System Engineering and Management*, vol. 3, no. 2, pp. 55–65, 2024, doi: 10.56882/jisem.v3i2.38.
[27] A. Fole *et al.*, "Gap Analysis And Enhancement Strategy For Supply Chain Performance In The Handicraft Industry of ISR Bone SMES: A SCOR Racetrack Approach," *Journal of Industrial Engineering Management*, vol. 9, no. 3, pp. 23–32, 2024, doi: 10.33536/jiem.v9i3.1865.
[28] N. I. Safutra *et al.*, "Optimizing Raw Material Inventory Control for Aluminum Wardrobes Using the Material Requirements Planning (MRP) Method: A Case Study on Amal Jaya SME," *Jurnal Sistem Teknik Industri*, vol. 26, no. 2, pp. 191–198, 2024, doi: 10.32734/jsti.v26i2.15972.