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Research Article

Digitalization Mediates Supplier Collaboration, Technological Innovation and Supply Chain Sustainability

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ABSTRACT

Introduction: Supply chain sustainability is increasingly critical for halal food SMEs in Indonesia, driven by the growing halal industry and rising consumer demand for transparency and compliance with halal standards. However, many SMEs face challenges in incorporating sustainability into their supply chains. Factors such as supplier collaboration, technological innovation, and digitalization play key roles, but the impact of government policy as a moderating factor remains underexplored.

Objectives: This study examines the effects of supplier collaboration and technological innovation on supply chain sustainability, investigates the mediating role of digitalization, and analyzes the moderating effect of government policy.

Methods: Data from 200 halal food SME owners in Indonesia were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM).

Results: The study finds that digitalization mediates the relationship between supplier collaboration, technological innovation, and supply chain sustainability. However, government policy weakens the positive relationship between collaboration and sustainability outcomes.

Conclusions: The research highlights the importance of strengthening digital capabilities and strategic collaboration to improve supply chain sustainability in the halal food sector.

Keywords: Supply Chain Sustainability; Digitalization, Supplier Collaboration; Technological Innovation

INTRODUCTION

Supply chain sustainability has become a critical issue for small and medium enterprises (SMEs), particularly in the halal food sector in Indonesia. SMEs face increasing pressure to adopt sustainable practices amid intense market competition. The goal of supply chain sustainability is to minimize the negative environmental and societal impacts of business operations while fostering long-term economic growth and resilience (Olanrewaju et al., 2020) and (Purnamasari et al., 2024). For halal food SMEs, sustainability is especially important due to the rising global demand for halal products and the need for ethical practices (Primadasa et al., 2024).

The COVID-19 pandemic exposed vulnerabilities in global and local supply chains, including those of halal food SMEs in Indonesia. Operational disruptions, changing consumer behaviors, and resource limitations have highlighted the need for adaptive strategies. Supplier collaboration and technological innovation are key factors that can improve efficiency and support supply chain sustainability (Rejeb et al., 2021); (Bartik et al., 2020); (Rahmat et al., 2025). Collaboration optimizes resources and creates transparency, while technological innovation enhances process efficiency and responsiveness to market demand (Khedr & S, 2024); (Cheng et al., 2022).

However, there is a research gap regarding the role of digitalization as a mediator between supplier collaboration, technological innovation, and supply chain sustainability, especially in halal food SMEs in Indonesia. Previous studies (Rejeb et al., 2021); (Cheng et al., 2022); (Susitha et al., 2024) have focused on technology and collaboration without addressing how digitalization enhances these relationships. Additionally, the moderating role of government policy in reducing market uncertainty and supporting sustainability in the halal sector remains underexplored.

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This study fills this gap by proposing a conceptual model that integrates digitalization as a mediator and government policy as a moderator in the relationship between supplier collaboration, technological innovation, and supply chain sustainability in Indonesia's halal food SMEs. Digitalization is not just a technical tool but a strategic element that enhances collaboration, innovation, efficiency, transparency, and compliance with halal certification standards (Bux et al., 2022; Rejeb et al., 2021; Susitha et al., 2024; Miklian & Hoelscher, 2022).

The purpose of this study is to examine the mediating role of digitalization in the relationship between supplier collaboration and technological innovation for supply chain sustainability in halal food SMEs. Additionally, it explores the moderating role of government policy in strengthening sustainability strategies and reducing market uncertainty. This research aims to contribute to the development of supply chain management theory and provide practical implications for halal food SMEs and policymakers in fostering long-term competitiveness and sustainability

OBJECTIVES

Resource-Based View (RBV), Institutional Theory, and Dynamic Capabilities Theory

The RBV emphasizes that an organization's competitive advantage stems from internal resources that meet the VRIO criteria: Valuable, Rare, Inimitable, and Organized (Teng et al., 2022). The focus is on leveraging human capabilities, technology, and strategic partnerships. Institutional Theory explains that institutional pressures such as social norms, government regulations, and industry practices influence organizational structures and behaviors. Isomorphism occurs in response to coercive, normative, and mimetic pressures (Behl et al., 2022). Dynamic Capabilities Theory highlights an organization's ability to adapt to rapid environmental changes through innovation, learning, and agile decision-making (Teece, 2017).

Supply Chain Sustainability

Sustainability in the supply chain encompasses economic, social, and environmental dimensions. (Rizvi et al., 2020) emphasize the integration of these three aspects for long-term performance. (Bux et al., 2022) highlight the role of digitalization in product traceability and halal compliance, while (Rejeb et al., 2021) underline the importance of resilience and adaptability through technologies like blockchain and IoT.

Supplier Collaboration

Supplier collaboration involves information sharing, joint planning, and process alignment (Kamble et al., 2022). In the halal industry, this is crucial for ensuring compliance and product integrity. (Shang et al., 2024) state that collaboration enables co-innovation and quality improvement, while (Matarneh et al., 2024) add that collaboration fosters digital transformation and the exchange of best practices.

Technological Innovation

Technological innovation refers to the application or improvement of technologies to add value and efficiency. (Bux et al., 2022) identify technologies such as blockchain and AI as key tools for halal product traceability. (Alma Çallı et al., 2022) emphasize innovation's role in enhancing efficiency and sustainability, while (Huang, 2023) highlight its contribution to risk management and supply chain resilience.

Digitalization

Digitalization involves integrating digital technologies to improve efficiency and competitiveness. (Rejeb et al., 2021) emphasize the use of IoT and big data for supply chain visibility. (Susitha et al., 2024) describe digitalization as a driver of sustainability and innovation, while (Liu et al., 2023) stress the transformation of business models and organizational culture to enhance flexibility and resilience.

Government Policy

Government policy plays a key role in supporting innovation and sustainability through regulation, fiscal incentives, and digital infrastructure (Gao et al., 2023). (Canh et al., 2019) show that policy can reduce market uncertainty, while

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(Tiwari et al., 2024) highlight the importance of proactive policies in strengthening public-private collaboration and supply chain transformation

Hypothesis Development

This study adopts the Resource-Based View (RBV) as the grand theory, emphasizing that competitive advantage stems from internal strategic resources. Supplier collaboration is viewed as such a resource, enabling firms to adopt digital technologies through trust-based relationships, real-time coordination, and shared innovation (Kunkel et al., 2022); (Ahmad & Karim, 2019); (Alma Çallı et al., 2022). H1: Supplier collaboration positively influences digitalization.

Technological innovation, also under RBV, is considered a key enabler of digital transformation, enhancing operational efficiency and adaptability. It forms the foundation for integrating digital systems (Radicic & Petković, 2023); (Miklian & Hoelscher, 2022); (Wu et al., 2024). H2: Technological innovation positively influences digitalization.

Supplier collaboration also supports supply chain sustainability by improving transparency, efficiency, and shared green innovation (Mani et al., 2018); (Ahmad & Karim, 2019); (Alma Çallı et al., 2022). H3: Supplier collaboration positively influences supply chain sustainability.

Technological innovation contributes to sustainability by improving operational processes, reducing environmental impacts, and increasing supply chain integration through advanced technologies like IoT and AI (Saberi et al., 2019); (Kouhizadeh et al., 2021); (Miklian & Hoelscher, 2022); (Wu et al., 2024). H4: Technological innovation positively influences supply chain sustainability.

Digitalization acts as a strategic resource that enhances supply chain sustainability via automation, transparency, and better monitoring (Yao et al., 2023); (Aditya et al., 2023); (Vázquez Meléndez et al., 2025). H5: Digitalization positively influences supply chain sustainability.

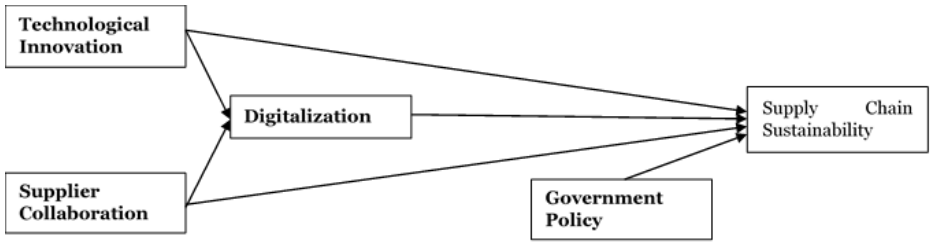
Using Institutional Theory, this study posits that supportive government policy (e.g., digital incentives, regulations, training) strengthens the link between digitalization and sustainability (Khedr & S, 2024); (Bourletidis & Triantafyllopoulos, 2014); (Latan et al., 2024). H6: Government policy strengthens the relationship between digitalization and supply chain sustainability.

Combining RBV and Dynamic Capabilities Theory, supplier collaboration enhances digital adoption, which in turn promotes sustainability through efficient, transparent processes (Kusi-Sarpong et al., 2022); (Dharmayanti et al., 2023); (Costantini et al., 2017). H7: Digitalization mediates the relationship between supplier collaboration and supply chain sustainability.

Technological innovation leads to digital transformation, enabling real-time monitoring and efficient sustainability practices. Digitalization serves as a key mechanism linking innovation to sustainability outcomes (Yao et al., 2023); (Costantini et al., 2017); (Karimi et al., 2023). H8: Digitalization mediates the relationship between technological innovation and supply chain sustainability.

The conceptual framework illustrating these hypotheses is presented in Figure 1.

Figure 1. Conceptual Framework



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METHODS

This study employs an explanatory approach with a cross-sectional design to analyze the relationships between supplier collaboration, technological innovation, and digitalization on supply chain sustainability, with government policy as a moderating variable. This approach is chosen for its efficiency in capturing current conditions (Harrison et al., 2020), although it has limitations in illustrating long-term dynamics (Gomm, 2008). In the context of halal food SMEs in Indonesia, supplier collaboration fosters synergy through information sharing and resource integration (Kunkel et al., 2022); (Ahmad & Karim, 2019), while technological innovation enhances operational efficiency through product traceability, waste reduction, and data management (Radicic & Petković, 2023); (Wu et al., 2024). Digitalization acts as a mediating variable that strengthens the impact of collaboration and innovation on sustainability through increased efficiency, transparency, and adaptive decision-making (Alma Çallı et al., 2022). Meanwhile, government policy reinforces the relationship between digitalization and sustainability by providing infrastructure support, fiscal incentives, and regulations that promote the adoption of technologies aligned with halal standards (Bourletidis & Triantafyllopoulos, 2014).

The sample was purposively drawn from 200 owners or decision-makers in halal food SMEs in Indonesia, with inclusion criteria being a minimum age of 18 years and a business age of at least two years. The total number of indicators in this study is 25, making the sample size of 200 appropriate based on the recommended ratio of 5–10 times the number of indicators (Hair & Hair, 2010). The focus on the halal food sector enables an in-depth analysis of variable relationships within a specific context. Future studies may expand the scope to other sectors or regions to enhance the generalizability of the findings.

Data collection was conducted using a Likert-scale questionnaire between August and November 2024, which was pre-tested beforehand (Gomm, 2008). Key factors examined include supplier collaboration (Connor et al., 2020), technological innovation (Oliveira Saraiva et al., 2024); (Al Dhaheri et al., 2024), and digitalization (Alma Çallı et al., 2022); (Zhao & Zhou, 2024). Respondents were given flexible completion times to accommodate time constraints.

Data analysis was performed using Partial Least Squares Structural Equation Modeling (PLS-SEM), which is suitable for complex models and non-normal data distributions (Sarstedt et al., 2020). The measurement model was evaluated through convergent validity (AVE > 0.5), discriminant validity (Fornell-Larcker criterion and HTMT < 0.85), and instrument reliability (Composite Reliability and Cronbach's Alpha > 0.7) (Dijkstra & Henseler, 2015). The structural model was assessed using path coefficients, bootstrapping (5,000 resamples, T > 1.96), predictive power (R^2 and Q^2), and effect size (f^2) (Hair et al., 2014).

RESULTS

The analysis of 200 respondents from halal food SMEs in Indonesia reveals that the majority of respondents are women (62.4%) and fall within the 18–34 age group (42.9%). In terms of education, most hold a bachelor's degree (38.5%), although there are also respondents with basic or non-formal education backgrounds. Business experience is relatively balanced, with 47.7% having operated for 2–10 years and 52.3% for more than 10 years. Most of the businesses are classified as micro-enterprises (61.4%), reflecting the dominance of women and younger generations in this sector, as well as highlighting its significant potential for sustainability and innovation.

The measurement model testing indicates that all key variables—supplier collaboration, technological innovation, digitalization, government policy, and supply chain sustainability—demonstrate strong convergent validity and reliability. All indicators have loading values above 0.70, while both Composite Reliability and Cronbach's Alpha exceed the threshold of 0.70. The Average Variance Extracted (AVE) values are also above 0.50, indicating strong contributions of the indicators to their respective constructs.

Discriminant validity, assessed using the Fornell-Larcker criterion and the HTMT ratio, shows that each construct is clearly distinguishable from the others. The square roots of the AVE values are higher than the correlations between constructs, and all HTMT values fall below the 0.90 threshold. These results indicate no multicollinearity or overlap between variables, making the model suitable for further analysis.

Hypothesis Testing Results

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Table 1 Hypothesis Testing

Variable	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Decision
Direct Effects						
H1: SC -> DZ	0.241	0.244	0.052	4.624	0.000	Significant
H2: TI -> DZ	0.659	0.657	0.049	13.384	0.000	Significant
H3: SC -> SS	0.516	0.513	0.097	5.314	0.000	Significant
H4: TI -> SS	0.058	0.065	0.172	0.339	0.735	Not Significant
H5: DZ -> SS	0.445	0.438	0.086	5.171	0.000	Significant
H6: GP -> SS	0.092	0.093	0.089	1.042	0.297	Not Significant
Indirect Effects (Mediating)						
H7: SC -> DZ -> SS	0.107	0.107	0.031	3.426	0.001	Significant
H8: TI -> DZ -> SS	0.293	0.288	0.061	4.820	0.000	Significant
Effects Moderating						
Moderating GP & DZ -> SS	-0.042	-0.046	0.053	0.795	0.426	Not Significant
Moderating GP & SC -> SS	-0.259	-0.257	0.097	2.657	0.008	Significant
Moderating GP & TI -> SS	0.062	0.061	0.102	0.609	0.542	Not Significant

Source: Data processed

Based on Table 1, the results of the hypothesis testing show that SC significantly influences DZ, with a coefficient of 0.241, T-statistic of 4.624, and P-value of 0.000. TI also has a significant effect on DZ, with a coefficient of 0.659, T-statistic of 13.384, and P-value of 0.000, indicating that TI has a greater impact compared to SC. Additionally, SC has a significant direct impact on SS, with a coefficient of 0.516, T-statistic of 5.314, and P-value of 0.000. However, TI does not have a significant direct effect on SS (coefficient 0.058, T-statistic 0.339, P-value 0.735). On the other hand, DZ significantly improves SS, with a coefficient of 0.445, T-statistic of 5.171, and P-value of 0.000.

Mediating effects are also significant, where DZ mediates the relationship between SC and SS with a coefficient of 0.107, T-statistic of 3.426, and P-value of 0.001, as well as the relationship between TI and SS with a coefficient of 0.293, T-statistic of 4.820, and P-value of 0.000.

In terms of moderating effects, GP does not show a significant influence on the relationship between DZ and SS (coefficient -0.042, T-statistic 0.795, P-value 0.426), nor on the relationship between TI and SS (coefficient 0.062, T-statistic 0.609, P-value 0.542). However, GP demonstrates a significant moderating effect that weakens the relationship between SC and SS, with a coefficient of -0.259, T-statistic of 2.657, and P-value of 0.008. These results highlight the important role of DZ in enhancing SS and suggest that GP still plays a limited role in strengthening these relationships

DISCUSSION

Direct Effects

The findings of this study indicate that supplier collaboration and technological innovation have a significant influence on digitalization in the context of halal food SMEs in Indonesia. Supplier collaboration also directly enhances supply chain sustainability, as does digitalization, which has a positive impact on sustainability. Conversely, technological innovation does not show a direct influence on supply chain sustainability, and government policy also does not have a significant effect. These findings suggest that digitalization plays an important mediating role, strengthening the impact of both collaboration and innovation on sustainability.

This aligns with the findings of (Mondejar et al., 2021), who stated that partnerships in the supply chain promote information exchange and the adoption of digital technologies, which ultimately strengthen competitiveness and sustainability. Additionally, (Mani et al., 2018) emphasized that technology alone will not have a significant impact

without effective integration with digital systems. The finding that technological innovation does not directly affect sustainability also supports the argument of (Bag et al., 2020), who explained that digitalization is a critical catalyst in translating innovation into tangible outcomes for environmental and social performance within the supply chain.

In practice, many halal SMEs still face barriers in directly accessing technology due to limitations in infrastructure, costs, and human resources, making technological innovation's contribution less than optimal. The insignificance of government policy influence indicates a gap between macro-level policies and the operational realities of SMEs. This was also found by (Zimon et al., 2022), who noted that government policies are often not effectively implemented in the informal sector. This finding contrasts with studies such as (Kim et al., 2024), which concluded that public policy plays a key role in promoting sustainability in developing countries—possibly due to differences in policy context and digital readiness between countries.

The implications of these findings highlight the importance of promoting collaboration and digitalization as key strategies to achieve sustainable supply chains for halal SMEs. The government needs to adapt its policy approaches to be more responsive to on-the-ground needs and provide practical and accessible technological support. Moreover, this study opens avenues for future research to further explore the mediating role of digitalization as well as the contextual effectiveness of policy in supporting sustainable supply chain transformation in the halal sector.

Indirect Effects (Mediating)

This study finds that digitalization significantly mediates the relationship between supplier collaboration (SC) and technological innovation (TI) on supply chain sustainability (SS) among halal food SMEs in Indonesia. This means that collaboration and innovation are not fully effective in promoting sustainability unless supported by digital technologies. Digitalization serves as a critical pathway that connects collaborative and innovative strategies to tangible sustainability outcomes.

This finding aligns with (Bag et al., 2020), who emphasized that digitalization in supply chains enhances the integration of collaborative and innovative efforts to build more sustainable systems. Similarly, (Mondejar et al., 2021) highlighted that digital integration strengthens relationships among supply chain actors, improves transparency, and boosts responsiveness to business changes.

Theoretically, these results are in line with Dynamic Capability Theory, which stresses the importance of firms adapting, reconfiguring, and leveraging technology to respond to environmental challenges. In practice, many halal SMEs have begun adopting systems such as halal raw material tracking apps, e-certification platforms, and digital logistics solutions to enhance transparency and efficiency.

Moreover, (Behl et al., 2022) argue that digital technologies play a strategic role in converting operational strategies into sustainability performance. Conversely, (Radicic & Petković, 2023) highlight the stronger role of institutional pressures than internal digitalization, indicating that contextual factors may influence these relationships.

Moderating Effects

This study also reveals that government policy (GP) significantly weakens the positive relationship between supplier collaboration and supply chain sustainability. This suggests that top-down policies may be misaligned with the practical, flexible nature of collaborations in halal SMEs, which often rely on informal networks.

(Durrani et al., 2024) and (Khan et al., 2022) note that rigid, non-contextual policy interventions may hinder collaborative synergy within the SME sector. This is also consistent with Institutional Theory (Dimaggio & Powell, 2021), which argues that regulatory pressures are not always effective when misaligned with organizational practices.

On the other hand, government policy does not significantly moderate the relationship between technological innovation or digitalization and sustainability. This supports Teece (2010), who emphasized that the adoption of technology depends more on internal organizational readiness than external policy pressure.

These findings imply that government policy must be more flexible and responsive to the real needs of halal SMEs. Meanwhile, SMEs should continue building robust internal digital and innovation capacities to achieve sustainable supply chains independently of policy interventions.

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REFRENCES

[1] Aditya, N., Ramadani, I., Nabillah, W., & Nasution, A. R. (2023). Penggunaan Media Software PowerPoint Dalam Meningkatkan Motivasi Belajar. *Jurnal Informatika Dan Teknologi Pendidikan*, *3*(1), 14–20. https://doi.org/10.25008/jitp.v3i1.42

[2] Ahmad, F., & Karim, M. (2019). Impacts of knowledge sharing: a review and directions for future research. *Journal of Workplace Learning*, *31*(3), 207–230. https://doi.org/10.1108/JWL-07-2018-0096

[3] Al Dhaheri, M. H., Ahmad, S. Z., & Papastathopoulos, A. (2024). Do environmental turbulence, dynamic capabilities, and artificial intelligence force SMEs to be innovative? *Journal of Innovation and Knowledge*, *9*(3), 100528. https://doi.org/10.1016/j.jik.2024.100528

[4] Alma Çallı, B., Özşahin, M., Coşkun, E., & Rıfat Arık, A. (2022). Do Generative Leadership and Digital Literacy of Executive Management Help Flourishing Micro and Small Business Digital Maturity? *International Journal of Organizational Leadership*, *11*(3), 307–332. https://doi.org/10.33844/ijol.2022.60332

[5] Bag, S., Gupta, S., & Luo, Z. (2020). Examining the role of logistics 4.0 enabled dynamic capabilities on firm performance. *International Journal of Logistics Management*, *31*(3), 607–628. https://doi.org/10.1108/IJLM-11-2019-0311

[6] Bartik, A., Cullen, Z., Bertrand, M., Glaeser, E. L., Luca, M., & Stanton, C. (2020). How Are Small Businesses Adjusting to COVID-19? Early Evidence From a Survey. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3570896

[7] Behl, A., Gaur, J., Pereira, V., Yadav, R., & Laker, B. (2022). Role of big data analytics capabilities to improve sustainable competitive advantage of MSME service firms during COVID-19 – A multi-theoretical approach. *Journal of Business Research*, *148*, 378–389. https://doi.org/10.1016/j.jbusres.2022.05.009

[8] Bourletidis, K., & Triantafyllopoulos, Y. (2014). SMEs Survival in Time of Crisis: Strategies, Tactics and Commercial Success Stories. *Procedia - Social and Behavioral Sciences*, *148*, 639–644. https://doi.org/10.1016/j.sbspro.2014.07.092

[9] Bux, C., Varese, E., Amicarelli, V., & Lombardi, M. (2022). Halal Food Sustainability between Certification and Blockchain: A Review. *Sustainability (Switzerland)*, *14*(4), 1–18. https://doi.org/10.3390/su14042152

[10] Canh, N. T., Liem, N. T., Thu, P. A., & Khuong, N. V. (2019). The impact of innovation on the firm performance and corporate social responsibility of Vietnamese manufacturing firms. *Sustainability (Switzerland)*, *11*(13). https://doi.org/10.3390/su11133666

[11] Cheng, D., Liu, K., Qian, Z., Chen, Z., & Mao, H. (2022). Study on Survival and Sustainable Development of Small- and Medium-Sized Tourism and Hospitality Enterprises in Macao Based on Regional Soft Environment and Competitive Advantage. *Frontiers in Psychology*, *12*(January), 1–15. https://doi.org/10.3389/fpsyg.2021.817695

[12] Connor, N. O., Lowry, P. B., & Treiblmaier, H. (2020). Interorganizational cooperation and supplier performance in high-technology supply chains. *Heliyon*, *6*(3), e03434. https://doi.org/10.1016/j.heliyon.2020.e03434

[13] Costantini, V., Crespi, F., Marin, G., & Paglialunga, E. (2017). Eco-innovation, sustainable supply chains and environmental performance in European industries. *Journal of Cleaner Production*, *155*, 141–154.

[14] Dharmayanti, N., Ismail, T., Hanifah, I. A., & Taqi, M. (2023). Exploring sustainability management control system and eco-innovation matter sustainable financial performance: The role of supply chain management and digital adaptability in indonesian context. *Journal of Open Innovation: Technology, Market, and Complexity*, *9*(3), 100119. https://doi.org/10.1016/j.joitmc.2023.100119

[15] Dijkstra, T. K., & Henseler, J. (2015). Consistent Partial Least Squares. *MIS Quarterly*, *39*(1), 1–44. http://misq.org/consistent-partial-least-squares-path-modeling.html

[16] Dimaggio, P. J., & Powell, W. W. (2021). the Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields. *The New Economic Sociology: A Reader*, *January 1983*, 111–134. https://doi.org/10.2307/2095101

[17] Durrani, N., Raziq, A., Mahmood, T., & Khan, M. R. (2024). Barriers to adaptation of environmental sustainability in SMEs: A qualitative study. *PLoS ONE*, *19*(5 May), 1–22. https://doi.org/10.1371/journal.pone.0298580

[18] Gao, J. L., Chen, Y., & Zhang, X. Q. (2023). Digital Technology Driving Exploratory Innovation in the Enterprise: A Mediated Model with Moderation. *Systems*, *11*(3). https://doi.org/10.3390/systems11030118

[19] Gomm, R. (2008). Social Research Methodology. *Social Research Methodology*. https://doi.org/10.1007/978-0-230-22911-2

[20] Hair, J. F., & Hair, J. F. (2010). *Multivariate Data Analysis*. Prentice Hall. https://books.google.co.id/books?id=JlRaAAAAYAAJ

[21] Hair, J. F., Sarstedt, M., Hopkins, L., & Kuppelwieser, V. G. (2014). Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research. *European Business Review*, *26*(2), 106–121.

https://doi.org/10.1108/EBR-10-2013-0128
[22] Harrison, R. L., Reilly, T. M., & Creswell, J. W. (2020). Methodological Rigor in Mixed Methods: An Application in Management Studies. *Journal of Mixed Methods Research*, *14*(4), 473–495. https://doi.org/10.1177/1558689819900585
[23] Huang, X. (2023). The roles of competition on innovation efficiency and firm performance: Evidence from the Chinese manufacturing industry. *European Research on Management and Business Economics*, *29*(1). https://doi.org/10.1016/j.iedeen.2022.100201
[24] Kamble, S. S., Gunasekaran, A., Parekh, H., Mani, V., Belhadi, A., & Sharma, R. (2022). Digital twin for sustainable manufacturing supply chains: Current trends, future perspectives, and an implementation framework. *Technological Forecasting and Social Change*, *176*(December 2021), 121448. https://doi.org/10.1016/j.techfore.2021.121448
[25] Karimi, S., Ahmadi Malek, F., Yaghoubi Farani, A., & Liobikienė, G. (2023). The Role of Transformational Leadership in Developing Innovative Work Behaviors: The Mediating Role of Employees' Psychological Capital. *Sustainability (Switzerland)* , *15*(2). https://doi.org/10.3390/su15021267
[26] Khan, A. J., Ul Hameed, W., Iqbal, J., Shah, A. A., Tariq, M. A. U. R., & Ahmed, S. (2022). Adoption of Sustainability Innovations and Environmental Opinion Leadership: A Way to Foster Environmental Sustainability through Diffusion of Innovation Theory. *Sustainability (Switzerland)*, *14*(21). https://doi.org/10.3390/su142114547
[27] Khedr, A. M., & S, S. R. (2024). Enhancing supply chain management with deep learning and machine learning techniques: A review. *Journal of Open Innovation: Technology, Market, and Complexity*, *10*(4), 100379. https://doi.org/10.1016/j.joitmc.2024.100379
[28] Kim, D., Na, J., & Ha, H. K. (2024). Exploring the impact of green logistics practices and relevant government policy on the financial efficiency of logistics companies. *Heliyon*, *10*(10), e30916. https://doi.org/10.1016/j.heliyon.2024.e30916
[29] Kouhizadeh, M., Saberi, S., & Sarkis, J. (2021). Blockchain technology and the sustainable supply chain: Theoretically exploring adoption barriers. *International Journal of Production Economics*, *231*, 107831. https://doi.org/10.1016/j.ijpe.2020.107831
[30] Kunkel, S., Matthess, M., Xue, B., & Beier, G. (2022). Industry 4.0 in sustainable supply chain collaboration: Insights from an interview study with international buying firms and Chinese suppliers in the electronics industry. *Resources, Conservation and Recycling*, *182*(May 2021), 106274. https://doi.org/10.1016/j.resconrec.2022.106274
[31] Kusi-Sarpong, S., Mubarik, M. S., Khan, S. A., Brown, S., & Mubarak, M. F. (2022). Intellectual capital, blockchain-driven supply chain and sustainable production: Role of supply chain mapping. *Technological Forecasting and Social Change*, *175*. https://doi.org/10.1016/j.techfore.2021.121331
[32] Latan, H., Lopes de Sousa Jabbour, A. B., Sarkis, J., Chiappetta Jabbour, C. J., & Ali, M. (2024). The nexus of supply chain performance and blockchain technology in the digitalization era: Insights from a fast-growing economy. *Journal of Business Research*, *172*. https://doi.org/10.1016/j.jbusres.2023.114398
[33] Liu, J., Wu, Y., & Liu, L. (2023). Impact of Environmental Uncertainties and Strategic Flexibility in Innovation Activities on NEV Battery Recycling Firms in China. *International Journal of Environmental Research and Public Health*, *20*(4). https://doi.org/10.3390/ijerph20043497
[34] Mani, V., Gunasekaran, A., & Delgado, C. (2018). Enhancing supply chain performance through supplier social sustainability: An emerging economy perspective. *International Journal of Production Economics*, *195*(October 2017), 259–272. https://doi.org/10.1016/j.ijpe.2017.10.025
[35] Matarneh, S., Piprani, A. Z., Ellahi, R. M., Nguyen, D. N., Mai Le, T., & Nazir, S. (2024). Industry 4.0 technologies and circular economy synergies: Enhancing corporate sustainability through sustainable supply chain integration and flexibility. *Environmental Technology and Innovation*, *35*(June), 103723. https://doi.org/10.1016/j.eti.2024.103723
[36] Miklian, J., & Hoelscher, K. (2022). SMEs and exogenous shocks: A conceptual literature review and forward research agenda. *International Small Business Journal: Researching Entrepreneurship*, *40*(2), 178–204. https://doi.org/10.1177/02662426211050796
[37] Mondejar, M. E., Avtar, R., Diaz, H. L. B., Dubey, R. K., Esteban, J., Gómez-Morales, A., Hallam, B., Mbungu, N. T., Okolo, C. C., Prasad, K. A., She, Q., & Garcia-Segura, S. (2021). Digitalization to achieve sustainable development goals: Steps towards a Smart Green Planet. *Science of the Total Environment*, *794*(June). https://doi.org/10.1016/j.scitotenv.2021.148539
[38] Olanrewaju, A. S. T., Hossain, M. A., Whiteside, N., & Mercieca, P. (2020). Social media and entrepreneurship research: A literature review. *International Journal of Information Management*, *50*(May 2019), 90–110. https://doi.org/10.1016/j.ijinfomgt.2019.05.011
[39] Oliveira Saraiva, G., Ferreira, J. J., & Alves, M. C. (2024). Turnaround, Decline, and Strategic Posture of SME:

Empirical Evidence. In *Journal of the Knowledge Economy* (Issue 0123456789). https://doi.org/10.1007/s13132-024-01734-1

[40] Primadasa, R., Tauhida, D., Christata, B. R., Rozaq, I. A., Alfarisi, S., & Masudin, I. (2024). An investigation of the interrelationship among circular supply chain management indicators in small and medium enterprises. *Supply Chain Analytics*, *7*(May), 100068. https://doi.org/10.1016/j.sca.2024.100068

[41] Purnamasari, R., Hasanudin, A. I., Zulfikar, R., & Yazid, H. (2024). Optimizing sustainable growth: Data, policies, and supply chains in Indonesia's public sector. *Social Sciences and Humanities Open*, *10*(August), 101104. https://doi.org/10.1016/j.ssaho.2024.101104

[42] Radicic, D., & Petković, S. (2023). Impact of digitalization on technological innovations in small and medium-sized enterprises (SMEs). *Technological Forecasting and Social Change*, *191*(March). https://doi.org/10.1016/j.techfore.2023.122474

[43] Rahmat, T., Ahman, E., & Apriliani, D. (2025). *Strategies to Improve Sustainable Competitive Advantage in The Halal Industry Through Knowledge Sharing : HR Perspective*. *12*(December 2024), 116–130. https://doi.org/10.33019/equity.v

[44] Rejeb, A., Rejeb, K., Zailani, S., Treiblmaier, H., & Hand, K. J. (2021). Integrating the Internet of Things in the halal food supply chain: A systematic literature review and research agenda. *Internet of Things (Netherlands)*, *13*(2021), 100361. https://doi.org/10.1016/j.iot.2021.100361

[45] Rizvi, S. A. R., Narayan, P. K., Sakti, A., & Syarifuddin, F. (2020). Role of Islamic banks in Indonesian banking industry: an empirical exploration. *Pacific-Basin Finance Journal*, *62*, 101117.

[46] Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2019). Blockchain technology and its relationships to sustainable supply chain management. *International Journal of Production Research*, *57*(7), 2117–2135. https://doi.org/10.1080/00207543.2018.1533261

[47] Sarstedt, M., Ringle, C. M., & Hair, J. F. (2020). Handbook of Market Research. In *Handbook of Market Research* (Issue July). https://doi.org/10.1007/978-3-319-05542-8

[48] Shang, K. C., Kuo, S. Y., Hsu, S. W., Lai, P. L., & Ye, K. D. (2024). Leader-member exchange, team-member exchange, employee satisfaction, and service-oriented organizational citizenship behavior in the international logistics industry: The moderating effect of the service climate. *Research in Transportation Business and Management*, *52*(May 2023), 101072. https://doi.org/10.1016/j.rtbm.2023.101072

[49] Susitha, E., Jayarathna, A., & Herath, H. M. R. P. (2024). Supply chain competitiveness through agility and digital technology: A bibliometric analysis. *Supply Chain Analytics*, *7*(June), 100073. https://doi.org/10.1016/j.sca.2024.100073

[50] Teece, D. J. (2017). Dynamic capabilities and (digital) platform lifecycles. In *Entrepreneurship, innovation, and platforms* (Vol. 37, pp. 211–225). Emerald Publishing Limited.

[51] Teng, X., Wu, Z., & Yang, F. (2022). Research on the Relationship between Digital Transformation and Performance of SMEs. *Sustainability (Switzerland)*, *14*(10), 1–17. https://doi.org/10.3390/su14106012

[52] Tiwari, S., Sharma, P., & Jha, A. K. (2024). Digitalization & Covid-19: An institutional-contingency theoretic analysis of supply chain digitalization. *International Journal of Production Economics*, *267*(August 2023), 109063. https://doi.org/10.1016/j.ijpe.2023.109063

[53] Vázquez Meléndez, E. I., Smith, B., & Bergey, P. (2025). Food provenance assurance and willingness to pay for blockchain data security: A case of Australian consumers. *Journal of Retailing and Consumer Services*, *82*(March 2024). https://doi.org/10.1016/j.jretconser.2024.104080

[54] Wu, D., Lin, X., Gupta, S., & Kar, A. K. (2024). Big Data Analytics Capability, Dynamic Capability, and Firm Performance: The Moderating Effect of IT-Business Strategic Alignment. *IEEE Transactions on Engineering Management*, *71*(January), 11638–11651. https://doi.org/10.1109/TEM.2024.3429648

[55] Yao, G., Zhao, H., Hu, Y., & Zheng, X. (2023). *Journal of Innovation*. *8*. https://doi.org/10.1016/j.jik.2023.100447

[56] Zhao, B., & Zhou, J. (2024). Research hotspots and trends in digitalization in higher education: A bibliometric analysis. *Heliyon*, *10*(21), e39806. https://doi.org/10.1016/j.heliyon.2024.e39806

[57] Zimon, G., Arianpoor, A., & Salehi, M. (2022). Sustainability Reporting and Corporate Reputation: The Moderating Effect of CEO Opportunistic Behavior. *Sustainability (Switzerland)*, *14*(3), 1–28. https://doi.org/10.3390/su14031257