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Digital Transformation and Climate ChangeAwareness: Mediated Impact on Financial Performance via Green Technology SMEs

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Abstract

This study investigates the direct and indirect effects of digital transformation and climate change awareness on SME financial performance, with green technology adoption serving as a mediating variable. Drawing from stakeholder theory and the resource-based view, this research addresses a key gap in understanding how digital and environmental initiatives interact within halal-oriented small businesses. Empirical data from 192 halal food SME owners and managers in East Java were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) across 32 indicators. Findings reveal that digital transformation significantly enhances both green technology adoption and financial performance, underscoring its strategic value in expanding market access and operational efficiency. While climate change awareness strongly encourages green technology adoption, it lacks a direct financial impact. Notably, green technology adoption shows a negative effect on financial performance, likely due to high initial costs and integration challenges. The study contributes to the literature by demonstrating the complex trade-offs between environmental innovation and profitability in emerging market SMEs. It suggests that digital strategies may serve as a bridge toward sustainability without undermining financial goals. Practical implications include the need for targeted government incentives and support mechanisms to offset green transition costs and bolster competitive resilience in halal food SMEs.

Keywords:
Digital transformation, climate change awareness, green technology, financial performance, SMEs, sustainability
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1. Introduction

In an increasingly competitive business environment, halal food SMEs in Indonesia face various challenges and opportunities. Global uncertainties and environmental issues such as climate change have created new demands for businesses to innovate and adapt (Kong et al., 2024) and (Matos et al., 2022). SMEs, with their limited resources, are particularly vulnerable to these changes, making it essential for them to explore more sustainable and efficient operational practices (Oloruntobi et al., 2023). Rising consumer awareness of environmental sustainability has encouraged halal food SMEs to adopt environmentally friendly technologies to meet market expectations. At the same time, digital transformation has emerged as a key driver of competitiveness, enabling SMEs to improve operational efficiency, expand market reach, and streamline business processes (Javaid et al., 2022). These two factors, digital transformation and climate change awareness, are crucial in influencing the financial performance of halal food SMEs.

Despite growing attention to digital transformation and environmental sustainability, the interrelationship between these factors in the context of halal food SMEs remains underexplored. Prior research presents inconsistent findings. For example, the impact of digital transformation on the adoption of green technology was found to be positive in(Elfaki & Ahmed, 2024) and(Sun et al., 2022) reported that digitalization was ineffective without proper infrastructure or tended to ignore environmental concerns. Similarly, the influence of climate change awareness on the adoption of green technologies varies: some studies show a positive impact due to regulatory pressure (Rahko & Alola, 2024), while others argue that awareness alone is insufficient to drive behavioral change (Cheng et al., 2022) and (Ahmad et al., 2021). The effect of climate change awareness on financial performance also yields mixed results, including positive (Younis et al., 2024), insignificant (Han & Niu, 2022), or even negative impacts due to cost burdens (Sari et al., 2023). The adoption of environmentally friendly technology itself does not always lead to improved financial performance, with long-term benefits noted by(Lin et al., 2024) but high initial investments highlighted by (Agrawal et al., 2024). Moreover, the mediating role of green technology adoption remains inconclusive, with some studies reporting positive mediation effects (Henry Ejiga Adama & Chukwuekem David Okeke, 2024) and (C. Wang et al., 2023), while others found no effect or even adverse outcomes (Y. Liu et al., 2023) and (Xu et al., 2024).

This study offers a holistic approach to address the inconsistency in previous findings by examining the direct and indirect effects of digital transformation and climate change awareness on financial performance through the mediating role of green technology adoption. The focus on halal food SMEs in Indonesia adds novelty to the research, considering the additional complexities such as halal certification compliance, limited resources, and growing pressures for sustainable innovation, which have not been widely addressed in similar studies.

This study aims to analyze how digital transformation and climate change awareness affect the financial performance of halal food SMEs directly and indirectly through adopting environmentally friendly technology. It also includes relevant control variables, such as firm size, geographic location, and the owner's business experience, to ensure a more accurate assessment of the proposed relationships.

With over 50,000 registered halal SMEs in 2023 and their significant contribution to the national Sharia economy(Priyono & Hidayat, 2024), a deeper understanding of how digital and sustainability strategies impact performance is crucial. The findings of this study are expected to provide theoretical contributions to the literature and practical insights for

halal food SMEs seeking to balance digital competitiveness and environmental responsibility for sustainable financial outcomes.

This study defines digital transformation as the level of adoption of digital technologies in SMEs' operations, including the use of e-commerce, digital supply chain management, and automation in food production. Digital transformation enables halal food SMEs to enhance operational efficiency, expand market reach, and streamline business processes, thereby driving competitiveness and improved performance (Bughin & Zeebroeck, 2021); (Feroz et al., 2021) and (C. L. Chen et al., 2021) found that digital transformation helps companies integrate green technologies through automation, operational efficiency, and improved access to environmental information. Digitalization also enhances a firm's capability to adopt sustainability-focused technologies. (Akbar et al., 2022)revealed that investment in digitalization facilitates the adoption of green technologies in food manufacturing firms. (Davies et al., 2023) Highlighted that digital transformation improves operational efficiency and creates value, ultimately boosting financial performance. (Abdul Basit et al., 2024) reported that SMEs adopting digital technologies experienced increased revenue and competitiveness.

Similarly,(Li et al., 2023) and (Akbar et al., 2022) demonstrated that green technologies, such as energy-efficient cooking appliances, biodegradable packaging, and waste management solutions, help firms reduce energy and material costs, improve production efficiency, and create value, contributing to enhanced financial performance. (Laranja Ribeiro et al., 2021) and (Wong et al., 2020) noted that green technology adoption promotes cost efficiency and long-term sustainability.

Climate change awareness is defined as the level of understanding and concern SME owners or managers have regarding environmental issues, such as energy efficiency, pollution, and sustainability in food production. This awareness motivates halal food SMEs to adopt environmentally friendly technologies and practices to reduce their environmental footprint while attracting sustainability-conscious customers(Nunhes et al., 2020) and (W. Wang et al., 2024) observed that rising climate change awareness drives companies to adopt green technologies as a response to market and regulatory pressures. (Haldorai et al., 2022) showed that environmentally conscious firms are more likely to implement green practices to maintain their reputation and business sustainability. (Arslan et al., 2021) and (Lee & Park, 2022) argued that climate change awareness fosters innovation, leading to cost efficiencies, improved reputation, and new market opportunities. (Q. Liu et al., 2022) found that firms prioritizing environmental concerns tend to attract more customers and investors, enhancing their financial performance.

This study also emphasizes green technology adoption as a mediating variable, which includes implementing technologies or practices that reduce environmental impact. Examples include using energy-efficient refrigeration systems, sustainable food processing techniques, and waste reduction programs. Such adoption reflects SMEs' commitment to sustainability, enhancing business reputation while supporting financial performance through cost savings and increased customer loyalty(Xie et al., 2019) and (S.-C. Chen & Lin, 2015).

Financial performance, as the dependent variable, is measured through indicators such as revenue growth, profitability, and return on investment (ROI). Digital transformation and climate change awareness are considered to have both direct and indirect effects on financial performance, with green technology adoption serving as the main mediator.

According to (Raihan et al., 2024) and (Xin et al., 2023), digital transformation facilitates the integration of green technologies, ultimately improving operational efficiency and reducing costs. (Abernethy et al., 2022) noted that digitally advanced firms are better prepared to implement green innovations, enhancing financial performance. (Darko et al., 2017) and (W. Wang et al., 2024) found that environmental awareness drives green technology adoption, which, despite its initial cost, ultimately improves cost efficiency and competitiveness. Similarly, (Zhen et al., 2024) reported that green technology adoption bridges the gap between climate change awareness and improved financial outcomes.

Additionally, control variables are incorporated to ensure analytical accuracy: SME size is measured by the number of employees or annual revenue scale, representing operational capacity. (Ribeiro-Navarrete et al., 2021) linked larger organizational size with greater resources, which can enhance financial performance. Geographical location refers to the SMEs' operational region, such as urban vs. rural areas, which influences access to technology and customers. (Hussain et al., 2022) and (Q. Liu et al., 2022) noted that strategic locations, such as trade hubs, provide broader market access and networking opportunities. SME owners' experience: Measured by years of experience in the halal food industry, reflecting the owners' ability to manage and adapt to new technologies. Greater experience allows for better decision-making, as noted by (Peteraf & Barney, 2003).

Development Hypotheses

This study integrates the Resource-Based View (RBV) and Institutional Theory to explain how internal capabilities and external pressures shape the performance of halal food SMEs. The RBV emphasizes the strategic importance of internal resources, such as digital capabilities and green technology, in achieving superior performance (Barney, 1986). Meanwhile, Institutional Theory highlights how external expectations, such as climate change awareness and environmental norms, pressure firms, especially SMEs, to adopt sustainable practices to maintain legitimacy (Ansari et al., 2024).

Digital transformation is conceptualized in this study as a valuable internal capability aligned with RBV. It enables SMEs to improve operational efficiency, optimize decision-making, and increase responsiveness to market changes (Bharadwaj et al., 2013). These capabilities can also facilitate access to and integration of environmentally friendly technologies. Studies such as those (Elfaki & Ahmed 2024) found that digitalization enables firms to more easily implement green technologies due to improved information flow and funding access. However, other studies, including Yusof et al. (2023), noted that digital transformation might not automatically lead to green practices unless supported by adequate infrastructure and environmental orientation.

H1: Digital transformation has a positive effect on the adoption of environmentally friendly technology in halal food SMEs.

In line with Institutional Theory, climate change awareness represents external institutional pressure, both normative and regulative, that can drive SMEs to adopt sustainable innovations. (Rahko & Alola, 2024) found that climate change awareness significantly encouraged the adoption of environmentally friendly practices, particularly under pressure from consumers and regulators. However, studies by (Cheng et al., 2022) and (Ahmad et al., 2021) suggest that awareness alone is insufficient, especially when financial resources or technical knowledge are limited.

H2: Climate change awareness has a positive effect on the adoption of environmentally friendly technology in halal food SMEs.

The relationship between digital transformation and financial performance is well documented in the literature. Digital tools can enhance productivity, reduce costs, and create new market opportunities(Bughin & Zeebroeck, 2021). In the context of SMEs, (Javaid et al., 2022) found that digitalization increases business agility and revenue generation. However, in sectors like halal food, which face strict regulations and resource constraints, digital initiatives must be strategically integrated to yield financial benefits.

H3: Digital transformation positively affects the financial performance of halal food SMEs.

The impact of climate change awareness on financial performance is more mixed. Some studies found a positive link, where firms perceived as environmentally responsible gained reputational advantage and customer loyalty (Younis et al., 2024). However, others (Han & Niu, 2022) and (Sari et al., 2023) argue that environmental efforts may increase costs without immediate financial returns, particularly for resource-constrained SMEs.

H4: Climate change awareness has a positive effect on the financial performance of halal food SMEs.

Adopting environmentally friendly technology can enhance financial performance by reducing resource use, improving efficiency, and differentiating the brand (Panda et al., 2020) and (Lin et al., 2024). Nevertheless,(Agrawal et al., 2024) caution that high initial investment in green technologies may burden SMEs financially, especially without long-term strategic planning.

H5: Adopting environmentally friendly technology has a positive effect on the financial performance of halal food SMEs.

Furthermore, the adoption of green technology may act as a mediator between both digital transformation and climate change awareness and financial performance. Digital transformation may enable the integration of sustainable innovations (C. Wang et al., 2023), while awareness may create motivation or pressure to adopt them(Rahko & Alola, 2024). However, studies like(Y. Liu et al., 2023) and (Xu et al., 2024) show that mediation is not always present, particularly in firms lacking readiness or alignment between strategy and sustainability goals.

H6: Adopting environmentally friendly technology mediates the relationship between digital transformation and the financial performance of halal food SMEs.

H7: Adopting environmentally friendly technology mediates the relationship between climate change awareness and the financial performance of halal food SMEs.

To ensure an accurate estimation of the relationships above, this study also includes several control variables. Larger firms may have more capacity to invest in technology and comply with sustainability demands. Geographical location may affect access to digital infrastructure or green suppliers. The owner's experience in the halal food industry can also influence strategic decisions and innovation capacity (Vitapamoorthy et al., 2021).

Ha1: SME size has a positive effect on the financial performance of halal food SMEs.

Ha2: Geographical location has a positive effect on the financial performance of halal food SMEs.

Ha3: The owner's experience has a positive effect on the financial performance of halal food SMEs.

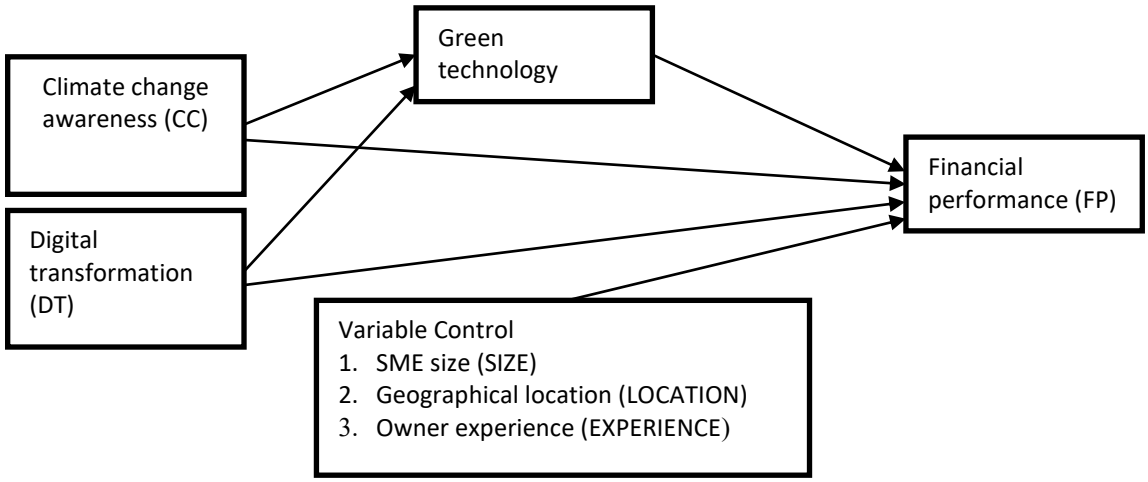

Figure1: Proposed Research Model

2. Method

2.1. Research Design

This study employs an explanatory research design to analyze the relationships among digital transformation, climate change awareness, green technology adoption, and the financial performance of halal food SMEs in Indonesia. A cross-sectional approach was adopted due to its efficiency in capturing relationships at a specific point in time. While a longitudinal design may offer deeper insights into long-term trends, the exploratory nature of this study and resource constraints make cross-sectional data collection more appropriate (Harrison et al., 2020). Future research should employ a longitudinal design for a more comprehensive understanding.

Control variables such as SME size, geographical location, and owner's experience were included to enhance internal validity and minimize potential bias when analyzing the impact of digital transformation and climate change awareness on green technology adoption and financial performance. SME size was selected as a control variable because it reflects the organisation's financial, human, and technological resource capacity. Larger SMEs typically have better access to technology and sustainability investments, which can directly affect green technology adoption and financial performance outcomes.

Geographical location is a crucial factor due to variations in digital infrastructure, regulatory support, and proximity to markets and halal resources across regions. Areas with strong internet access, halal logistics networks, or local government support for digital transformation tend to offer greater opportunities for SME development. Meanwhile, owner experience was included as a control variable because the knowledge, networks, and managerial skills of business owners play a significant role in strategic decision-making, including the adoption of new technologies and response to sustainability issues.

By controlling for these three variables, this study aims to ensure that the influence of independent variables on the mediating and dependent variables reflects the actual relationships studied rather than being affected by uncontrolled external factors.

2.2. Sampling Strategy

This study employs a cluster sampling method to ensure geographical representation and operational efficiency in reaching the diversity of halal food SMEs in East Java. This method is considered appropriate due to the wide geographic dispersion and the unavailability of a complete sampling frame for all halal food SMEs in the region. Therefore, the population was divided into five regional clusters Surabaya, Malang,Madiun, Bojonegoro, and Besukiwith an average of 39 respondents per area, resulting in a total of 192 SME owners and managers as research respondents. This approach enabled the researchers to obtain data from various economic, infrastructural, and environmental awareness backgrounds, as well as differing levels of technology adoption.

The sample size was determined based on (Ferdinand, 2014) guideline, which recommends a minimum sample size of five to ten times the number of indicators in the model when using Partial Least Squares Structural Equation Modeling (PLS-SEM). With a total of 32 measurement indicators, a minimum of 160 to 320 respondents is required. The sample of 192 respondents used in this study is considered sufficient to ensure statistical power and the reliability of the PLS-SEM analysis.

Inclusion criteria were established to ensure the relevance and experience of respondents in relation to the research topic. These criteria include: (1) halal food SME owners or managers officially registered in the selected cluster areas; (2) aged at least 20 years old; (3) having operated their business for at least two years; (4) possessing basic understanding of digital transformation (e.g., use of digital platforms, e-commerce, or digital tools in operations); (5) having awareness of climate change and environmental sustainability issues, particularly in food production; and (6) complying with halal certification standards. Exclusion criteria included unregistered informal businesses, SMEs outside the food sector, and respondents who lack understanding of basic concepts of digital transformation and sustainability. This ensures that the responses come from relevant business actors with adequate comprehension of the studied variables.

Data collection was conducted using structured questionnaires distributed via face-to-face interviews or online forms, depending on each respondent's digital accessibility. Data collection spanned two months and was supported by trained field enumerators who were familiar with the local business context in each region.

2.3. Data Collection

Data were collected from July to September 2024 using a structured Likert-scale questionnaire covering various aspects. Digital transformation was measured based on the adoption of digital tools, process automation, and the use of e-commerce in halal food businesses (Cheng et al., 2022). Climate change awareness was measured by assessing respondents' understanding of sustainable halal food production, the use of eco-friendly packaging, and waste management practices (Zhao et al., 2022). Green technology adoption was evaluated based on the use of energy-efficient equipment, sustainable halal supply chain practices, and environmentally friendly food processing methods (Wong et al., 2020). Financial performance was assessed based on revenue growth, profitability, and return on investment (ROI), with a particular focus on the effects of halal certification and market expansion(Xin et al., 2023). A pilot test was conducted to refine the questionnaire and ensure its clarity and relevance for halal food SMEs.

2.4. Data Analysis Technique

The data analysis method used in this study is Partial Least Squares Structural Equation Modeling (PLS-SEM), which is considered most suitable for exploratory research with a complex theoretical model, numerous indicators, and a medium-sized sample (Hair et al., 2017). PLS-SEM was chosen because it can accommodate models with mediation relationships, both formative and reflective latent variables, and it does not require the assumption of normal data distribution a common challenge in SME studies in developing countries.

The analysis process consists of two main stages. The first stage is the evaluation of the measurement model, which assesses construct validity and instrument reliability. Convergent validity is determined by the Average Variance Extracted (AVE), with a value ≥ 0.5 indicating that the indicators sufficiently explain the latent variable. Construct reliability is assessed using Composite Reliability (CR) and Cronbach's Alpha, both of which must be ≥ 0.7, indicating the high internal consistency of the indicators. To ensure discriminant validity, i.e., that different constructs measure distinct concepts, Fornell-Larcker criteria (AVE must exceed inter-construct correlations) and the Heterotrait-Monotrait Ratio (HTMT, which must be below 0.85) are used.

The second stage involves testing the structural model, focusing on the relationships among latent constructs through path coefficients, evaluated using bootstrapping with 5,000 resamples. A T-statistic > 1.96 at a 5% significance level indicates a statistically significant relationship. In addition, R^2 values are used to evaluate the predictive power of the independent variables on the dependent variables, Q^2 is used to assess out-of-sample predictive relevance, and f^2 is used to determine the effect size of each relationship in the model.

With this methodological framework, the study aims to ensure that each construct is measured validly and reliably and that the tested relationships reflect actual influences that can inform policy recommendations and better managerial practices for halal food SMEs.

3. Result and Discussion

3.1. Background Socio-Demographic Statistics

Halal food SMEs in East Java, Indonesia, show strong growth potential. Most business owners are male (69.9%), with a dominant age group of 37–52 years (40.8%), followed by younger entrepreneurs (28.4%) driving innovation in halal production and digital marketing. Nearly half (47.3%) hold a bachelor's degree, supporting digital adoption and sustainable practices. Over half (59.6%) have operated for more than 10 years, reflecting sector stability. Most SMEs (76.3%) employ 10–49 workers, serving local and global halal markets. With proper support, technology access, halal certification, and government incentives—halal food SMEs can drive Indonesia's halal economy through innovation, job creation, and sustainability.

3.2. Measurement Model Assessments

The results of the measurement model testing indicate that all latent variables meet the criteria for adequate validity and reliability. Convergent validity is achieved, with Average Variance Extracted (AVE) values ≥ 0.50 for all variables, including FP (AVE = 0.718), GT (AVE = 0.695), DT (DT) (AVE = 0.646), and CC Awareness (AVE = 0.694). Reliability is also excellent, with Composite Reliability (CR) values ≥ 0.936 and Cronbach's Alpha (α) values ≥ 0.922 for all main variables, indicating high internal consistency.

Additionally, the indicators significantly contribute to their respective latent variables, with λ (loading factor) values ≥ 0.70. Control variables such as SIZE, LOCATION, and EXPERIENCE also demonstrate perfect reliability (CR = 1.000, AVE = 1.000, α = 1.000). Overall, this model is highly reliable for further analysis, as it meets all measurement criteria effectively.

3.3. Measurement Model Assessments

The discriminant validity analysis using the Fornell-Larcker criterion and Heterotrait-Monotrait Ratio (HTMT) confirms that the measurement model meets the validity criteria. The square root of the AVE values for Climate Change Awareness (0.833), Digital Transformation (0.804), Financial Performance (0.847), and Green Technology Adoption (0.833) exceed their correlations with other variables, ensuring distinct conceptual identities. Most HTMT values remain below 0.85, indicating good discriminant validity. However, strong relationships between LOCATION and GT (0.895) and LOCATION and FP (0.887) suggest significant control variable influences. Overall, the model demonstrates adequate discriminant validity, supporting further analysis of halal food SMEs in East Java.

3.4. Hypothesis Testing Results

Table 1: Hypothesis Testing

Variable	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Decision
Direct Effects						
H1: DT ->GT	0.389	0.391	0.056	6.926	0.000	Significant
H2: CC ->GT	0.433	0.433	0.058	7.414	0.000	Significant
H3: DT ->FP	0.131	0.132	0.043	3.024	0.003	Significant
H4: CC ->FP	0.032	0.034	0.043	0.752	0.452	Not Significant
H5: GT ->FP	-0.459	-0.458	0.087	5.259	0.000	Significant
Effects variable control						
Ha1: SIZE ->FP	0.301	0.294	0.208	1.448	0.148	Not Significant
Ha2: LOCATION ->FP	1.486	1.481	0.171	8.668	0.000	Significant
Ha3: EXPERIENCE ->FP	-0.618	-0.609	0.227	2.717	0.007	Significant
Ha1: SIZE ->FP	0.301	0.294	0.208	1.448	0.148	Not Significant
Indirect Effects (Mediating)						
H6: DT ->GT ->FP	-0.179	-0.179	0.042	4.233	0.000	Significant
H7: CC ->GT ->FP	-0.199	-0.198	0.046	4.273	0.000	Significant

Source: Data processed

Based on Table 1, the analysis results indicate that DT has a significant impact on GT (T-statistics = 6.926, P-value = 0.000, coefficient = 0.389), as does CC (T-statistics = 7.414, P-value = 0.000, coefficient = 0.433). DT also has a direct, significant effect on FP (T-statistics = 3.024, P-value = 0.003, coefficient = 0.131), whereas CC does not show a significant direct effect on FP (T-statistics = 0.752, P-value = 0.452, coefficient = 0.032). However, GT has a significant negative

effect on FP (T-statistics = 5.259, P-value = 0.000, coefficient = -0.459), reflecting potential high costs or initial implementation challenges.

The mediation effects reveal that DT influences FP through GT with a significant effect (T-statistics = 4.233, P-value = 0.000, coefficient = -0.179). Similarly, CC affects FP through GT adoption, also with a significant effect (T-statistics = 4.273, P-value = 0.000, coefficient = -0.199). Among the control variables, company location has a highly significant effect on FP (T-statistics = 8.668, P-value = 0.000, coefficient = 1.486), while organizational size is not significant (T-statistics = 1.448, P-value = 0.148, coefficient = 0.301). Company experience also has a significant but negative effect on FP (T-statistics = 2.717, P-value = 0.007, coefficient = -0.618).

3.5. **Direct Effects**

Digital Transformation on Green Technology Adoption

The findings reveal that digital transformation exerts a positive and significant influence on the adoption of green technology among halal food SMEs (coefficient = 0.389, t = 6.926, $p < 0.001$). This indicates that as SMEs increasingly integrate digital tools into their operations, they are more inclined to implement environmentally friendly technologies. Digitalization enhances operational transparency, enables efficient resource management, and provides better access to technological innovations that support sustainability. These results are consistent with prior research by (Elfaki & Ahmed, 2024) and (Javaid et al., 2022), which highlight the role of digital systems in improving waste monitoring, automating production processes, and fostering a data-driven approach to green practices. Overall, the development of digital infrastructure plays a crucial role in accelerating the shift toward more sustainable business models within the halal food sector.

Climate Change Awareness on Green Technology Adoption

The analysis shows that climate change awareness has a positive and significant impact on green technology adoption among halal food SMEs (coefficient = 0.433, t = 7.414, $p < 0.001$). This finding reinforces the perspective of (Rahko & Alola, 2024), who emphasize the role of moral responsibility and regulatory frameworks in encouraging firms to implement environmentally sustainable practices. Despite contrasting views, such as those presented by (Ahmad et al., 2021), who argue that awareness alone is inadequate without supportive financial mechanisms, the results of this study suggest that Indonesian halal SMEs are responding to climate concerns with concrete actions. The growing demand for halal products that are also environmentally friendly appears to be a key driver, indicating a shift in consumer values and a broader societal push toward sustainability. This implies that awareness campaigns and value-driven branding may be effective strategies for promoting green innovation within the SME sector.

Digital Transformation on Financial Performance

The findings reveal that digital transformation positively and significantly influences the financial performance of halal food SMEs (coefficient = 0.131, t = 3.024, $p = 0.003$), though the effect size is modest. This suggests that digital technologies contribute to operational cost savings, expanded market access, and enhanced financial transparency, aligning with insights from (Bughin & Zeebroeck, 2021). Nonetheless, the relatively low coefficient may indicate that the full benefits of digital transformation are not yet fully realized across all SMEs. Factors such as limited digital literacy, inadequate infrastructure, or budget constraints may hinder some firms from leveraging digital tools effectively, thereby limiting the overall financial impact. This underscores the need for capacity-building initiatives and digital support systems tailored to the needs of smaller enterprises.

Climate Change Awareness on Financial Performance

The analysis shows that climate change awareness does not have a significant impact on financial performance (coefficient = 0.032, t = 0.752, p = 0.452). This finding aligns with prior research by (Cheng et al., 2022) and (Han & Niu, 2022), which suggest that being environmentally conscious does not necessarily lead to immediate financial benefits. One possible explanation is the perception among SMEs that implementing sustainable practices increases operational costs without a clear or rapid return. Additionally, in the absence of supportive financial mechanisms such as subsidies or tax incentives, many SMEs may struggle to convert their environmental awareness into profitable actions. This highlights the gap between environmental intent and financial outcome, underscoring the need for policies and support systems that can bridge this divide for small businesses.

Green Technology Adoption on Financial Performance

The analysis reveals a significant negative relationship between green technology adoption and financial performance (coefficient = -0.459, t = 5.259, p < 0.001). This unexpected outcome suggests that while green practices may offer long-term sustainability benefits, their short-term financial implications can be challenging, especially for resource-constrained halal food SMEs. High upfront investment costs, incompatibility of advanced technologies with smaller operational scales, and limited access to proper training can undermine immediate profitability. These findings resonate with (Agrawal et al., 2024), who emphasize the delayed return on investment often associated with environmentally friendly technologies. In the context of SMEs, such financial strain can be particularly acute, as expenditures on energy-efficient machinery or biodegradable packaging may erode short-term margins. This highlights the importance of strategic planning and phased implementation when integrating green innovations, along with external support, to mitigate early financial burdens.

3.6. **Indirect Effects (Mediating)**

Digital Transformation mediates the relationship between Green Technology and Financial Performance.

Green technology adoption negatively mediates the relationship between digital transformation and financial performance (coefficient = -0.179, t = 4.233, p < 0.001). While digital transformation encourages SMEs to adopt environmentally friendly technologies, the financial burden associated with such adoption can outweigh the benefits in the short term, leading to an overall negative effect on financial outcomes. This finding implies that when not paired with sound financial planning and capacity building, digital initiatives may inadvertently harm business performance. For digital transformation to yield sustainable financial benefits, SMEs need structured guidance, cost-benefit analysis tools, and affordable financing schemes. Therefore, policymakers and support agencies should intervene by offering incentives, subsidies, or low-interest loans to help SMEs embrace green technology without compromising their financial stability.

Climate Change Awareness mediates the relationship between Green Technology and Financial Performance.

This pathway reveals that climate change awareness positively drives the adoption of green technology, but due to the negative impact of that technology on financial outcomes, the overall indirect effect is negative (coefficient = -0.199, t = 4.273, p < 0.001). These results underscore the dilemma faced by SMEs in balancing environmental responsibility with profitability, echoing the concerns raised by (Xu et al., 2024). While awareness may inspire

action toward sustainability, the lack of accompanying financial incentives, technical support, or policy alignment can transform good intentions into financial strain. This highlights the need for integrated strategies such as tax relief, grants, and environmental business training to ensure that SMEs can adopt green practices without compromising their financial viability.

3.7. Effects variable control

SME Size on Financial Performance

The effect of SME size on financial performance is not significant ($p = 0.148$), suggesting that the size of the business does not directly influence profitability. This implies that factors such as operational efficiency, innovation, and the ability to adapt to market changes are more critical determinants of financial success than simply the scale of the business. Smaller SMEs can still perform well if they are agile and efficient, while larger businesses may face challenges if they lack innovation or the ability to streamline operations. This finding emphasizes the importance of focusing on capabilities and strategies rather than just size when assessing the financial performance of SMEs.

Geographical Location on Financial Performance

The effect of geographical location on financial performance is highly significant ($\beta = 1.486$, $p < 0.001$), indicating that access to infrastructure, markets, and logistics plays a crucial role in determining financial outcomes. SMEs located in strategic areas such as Surabaya benefit from better connectivity, greater market access, and more efficient supply chains, which contribute to improved profitability. This suggests that businesses in well-connected regions are better positioned to capitalize on resources and customer demand, giving them a competitive advantage. In contrast, SMEs located in more remote or less developed areas may face challenges in achieving similar financial performance due to limited access to essential infrastructure and markets.

Owner’s Experience on Financial Performance

The relationship between the owner's experience and financial performance is significantly negative ($\beta = -0.618$, $p = 0.007$), which is surprising. This may be due to resistance to change or reliance on traditional business practices that are not well aligned with the demands of digitalization and sustainability. Experienced owners may find it challenging to embrace new technologies or adjust to modern business practices, which can hinder their financial performance in the context of rapidly evolving market dynamics. This highlights the importance of providing adaptive training and support to help experienced entrepreneurs navigate digital transformation and sustainability initiatives effectively. Encouraging a mindset shift and offering the necessary tools can help overcome this resistance and improve business outcomes.

3.8. Practical Implications and Recommendations

For SMEs

SMEs should adopt green technologies gradually, starting with areas that offer the most cost-effective solutions. This allows businesses to mitigate the financial burden of initial investments while still reaping the benefits of sustainability. Additionally, SMEs must align their digitalization efforts not only with operational efficiency but also with data-driven decisions related to sustainability. By doing so, they can improve both their operational processes and environmental impact. Furthermore, engaging in training programs focused on environmental cost management is essential for SMEs to strategically utilize green technologies without compromising financial performance.

For Policymakers

Policymakers should provide fiscal incentives, such as subsidies or easy access to green capital, to assist SMEs in adopting eco-friendly technologies. This financial support can ease the initial investment costs and make green technology more accessible. Additionally, developing sustainable business support centers that help SMEs balance sustainability with profitability is crucial. These centers can offer guidance, resources, and networks that help SMEs navigate the complexities of sustainable business practices. Lastly, focusing on the development of digital and halal distribution infrastructure in remote regions will help reduce geographic inequalities, ensuring that SMEs in less developed areas have the same opportunities to thrive in the digital and sustainable economy.

4. Conclusion

This study highlights how digital transformation and climate change awareness shape sustainability and financial outcomes in halal food SMEs, mediated by green technology adoption. While digital tools contribute to improved operational performance and market responsiveness, the adoption of environmentally friendly technologies presents cost-related challenges that may hinder short-term profitability.

Theoretically, the study extends the application of Resource-Based View and Institutional Theory by demonstrating how intangible capabilities such as digital readiness and environmental awareness interact with external pressures to influence firm performance through sustainability-oriented innovation. Practically, the findings emphasize the critical need for financial and policy support to help SMEs transition toward green practices without compromising their economic viability.

For SME owners, gradual investment in scalable green technologies, combined with digital upskilling, can foster both compliance and competitiveness. For regulators, the provision of targeted financial incentivesuch as green subsidies, tax relief, or low-interest loans will be essential to reduce adoption barriers. Furthermore, improving infrastructure in non-urban halal markets and delivering tailored training programs can support broader and more inclusive sustainable transformation.

Future research should expand to larger and more diverse SME populations, employ longitudinal approaches to capture dynamic performance impacts, and investigate the role of government support mechanisms and consumer demand in accelerating green innovation across halal food value chains.

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References

Abdul Basit, S., Gharleghi, B., Batool, K., Hassan, S. S., Jahanshahi, A. A., & Kliem, M. E. (2024). Review of enablers and barriers of sustainable business practices in SMEs. *Journal of Economy and Technology*, *2*(March), 79–94. https://doi.org/10.1016/j.ject.2024.03.005

Abernethy, A., Adams, L., Barrett, M., Bechtel, C., Brennan, P., Butte, A., Faulkner, J.,

Fontaine, E., Friedhoff, S., Halamka, J., Howell, M., Johnson, K., Long, P., McGraw, D., Miller, R., Lee, P., Perlin, J., Rucker, D., Sandy, L., … Valdes, K. (2022). The Promise of Digital Health: Then, Now, and the Future. *NAM Perspectives*, *6*(22). https://doi.org/10.31478/202206e

Agrawal, R., Agrawal, S., Samadhiya, A., Kumar, A., Luthra, S., & Jain, V. (2024). Adoption of green finance and green innovation for achieving circularity: An exploratory review and future directions. *Geoscience Frontiers*, *15*(4), 101669. https://doi.org/10.1016/j.gsf.2023.101669

Ahmad, A., Sohail, A., & Hussain, A. (2021). Emergence of financial technology in Islamic banking industry and its influence on bank performance in covid-19 scenario: A case of developing economy. *Gomal University Journal of Research*, *37*(1), 97–109.

Akbar, A., Hussain, A., Shahzad, A., Mohelska, H., & Hassan, R. (2022). Environmental and technological factor diffusion with innovation and firm performance: Empirical evidence from manufacturing SMEs. *Frontiers in Environmental Science*, *10*(July), 1–16. https://doi.org/10.3389/fenvs.2022.960095

Ansari, M. A. A., Sajid, M., Khan, S. N., Antohi, V. M., Fortea, C., & Zlati, M. L. (2024). Unveiling the effect of renewable energy and financial inclusion towards sustainable environment: Does interaction of digital finance and institutional quality matter? *Sustainable Futures*, *7*(March), 100196. https://doi.org/10.1016/j.sftr.2024.100196

Arslan, A., Haapanen, L., Hurmelinna-Laukkanen, P., Tarba, S. Y., & Alon, I. (2021). Climate change, consumer lifestyles and legitimation strategies of sustainability-oriented firms. *European Management Journal*, *39*(6), 720–730. https://doi.org/10.1016/j.emj.2021.03.005

Barney, J. B. (1986). Strategic factor markets BARNEY. In *Management science* (Vol. 32, Issue 10, pp. 1231–1241).

Bharadwaj, A., El Sawy, O. A., Pavlou, P. A., & Venkatraman, N. (2013). Digital business strategy: Toward a next generation of insights. *MIS Quarterly: Management Information Systems*, *37*(2), 471–482. https://doi.org/10.25300/MISQ/2013/37:2.3

Bughin, J., & Zeebroeck, N. Van. (2021). *The Entrepreneurial Returns to Incumbents' Digital Transformation*. https://dipot.ulb.ac.be/dspace/bitstream/2013/327345/3/WP2021-048-BUGHIN_VANZEEBROECK-the.pdf

Chen, C. L., Lin, Y. C., Chen, W. H., Chao, C. F., & Pandia, H. (2021). Role of government to enhance digital transformation in small service business. *Sustainability (Switzerland)*, *13*(3), 1–26. https://doi.org/10.3390/su13031028

Chen, S.-C., & Lin, C.-P. (2015). The impact of customer experience and perceived value on sustainable social relationship in blogs: An empirical study. *Technological Forecasting and Social Change*, *96*, 40–50.

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

Darko, A., Chan, A. P. C., Gyamfi, S., Olanipekun, A. O., He, B. J., & Yu, Y. (2017). Driving forces for green building technologies adoption in the construction industry: Ghanaian perspective. *Building and Environment*, *125*, 206–215. https://doi.org/10.1016/j.buildenv.2017.08.053

Davies, P., Bustinza, O. F., Parry, G., & Jovanovic, M. (2023). Unpacking the relationship

between digital capabilities, services capabilities, and firm financial performance: A moderated mediation model. *Industrial Marketing Management*, *115*(September), 1–10. https://doi.org/10.1016/j.indmarman.2023.09.005

Elfaki, K. E., & Ahmed, E. M. (2024). Digital technology adoption and globalization innovation implications on Asian Pacific green sustainable economic growth. *Journal of Open Innovation: Technology, Market, and Complexity*, *10*(1), 100221. https://doi.org/10.1016/j.joitmc.2024.100221

Ferdinand, A. (2014). *Metode penelitian manajemen: Pedoman penelitian untuk penulisan skripsi tesis dan desrtasi ilmu manajemen*.

Feroz, A. K., Zo, H., & Chiravuri, A. (2021). Digital transformation and environmental sustainability: A review and research agenda. *Sustainability (Switzerland)*, *13*(3), 1–20. https://doi.org/10.3390/su13031530

Hair, J. F., Hult, G. T. M., Ringle, C. M., Sarstedt, M., & Thiele, K. O. (2017). Mirror, mirror on the wall: a comparative evaluation of composite-based structural equation modeling methods. *Journal of the Academy of Marketing Science*, *45*(5), 616–632. https://doi.org/10.1007/s11747-017-0517-x

Haldorai, K., Kim, W. G., & Garcia, R. L. F. (2022). Top management green commitment and green intellectual capital as enablers of hotel environmental performance: The mediating role of green human resource management. *Tourism Management*, *88*(January 2021), 104431. https://doi.org/10.1016/j.tourman.2021.104431

Han, Y., & Niu, Q. (2022). Enhancing green radical product innovation through sustainable entrepreneurship orientation and sustainable market orientation for sustainable performance: managerial implications from sports goods manufacturing enterprises of China. *Economic Research-Ekonomska Istrazivanja* , *0*(0), 1–20. https://doi.org/10.1080/1331677X.2022.2164325

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

Henry Ejiga Adama, & Chukwuekem David Okeke. (2024). Digital transformation as a catalyst for business model innovation: A critical review of impact and implementation strategies. *Magna Scientia Advanced Research and Reviews*, *10*(2), 256–264. https://doi.org/10.30574/msarr.2024.10.2.0066

Hussain, J., Lee, C. C., & Chen, Y. (2022). Optimal green technology investment and emission reduction in emissions generating companies under the support of green bond and subsidy. *Technological Forecasting and Social Change*, *183*, 0–42. https://doi.org/10.1016/j.techfore.2022.121952

Javaid, M., Haleem, A., Singh, R. P., Suman, R., & Gonzalez, E. S. (2022). Understanding the adoption of Industry 4.0 technologies in improving environmental sustainability. *Sustainable Operations and Computers*, *3*(January), 203–217. https://doi.org/10.1016/j.susoc.2022.01.008

Kong, X., Yan, C., & Ho, K. C. (2024). The impact of climate change on credit cycles: Evidence from China's bond market. *Technological Forecasting and Social Change*, *206*(May), 123490. https://doi.org/10.1016/j.techfore.2024.123490

Laranja Ribeiro, M. P., Tommasetti, R., Gomes, M. Z., Castro, A., & Ismail, A. (2021). Adoption phases of Green Information Technology in enhanced sustainability: A bibliometric study. *Cleaner Engineering and Technology*, *3*(April).

https://doi.org/10.1016/j.clet.2021.100095

Lee, B., & Park, S. K. (2022). A Study on the Competitiveness for the Diffusion of Smart Technology of Construction Industry in the Era of 4th Industrial Revolution. *Sustainability (Switzerland)*, *14*(14). https://doi.org/10.3390/su14148348

Li, S., Yang, Z., & Tian, Y. (2023). Digital transformation and corporate performance: evidence from China. *China Economic Journal*, *16*(3), 312–334. https://doi.org/10.1080/17538963.2023.2254138

Lin, C. Y., Chau, K. Y., & Moslehpour, M. (2024). Bridging the gap: The nexus of sustainability innovation, knowledge sharing, and green volunteerism for manufacturing entrepreneurial triumph. *Journal of Innovation and Knowledge*, *9*(4). https://doi.org/10.1016/j.jik.2024.100570

Liu, Q., Qu, X., Wang, D., Abbas, J., & Mubeen, R. (2022). Product Market Competition and Firm Performance: Business Survival Through Innovation and Entrepreneurial Orientation Amid COVID-19 Financial Crisis. *Frontiers in Psychology*, *12*(March), 1–12. https://doi.org/10.3389/fpsyg.2021.790923

Liu, Y., Zhang, X., Liu, L., & Lai, K. (2023). Does voice matter? Investigating patient satisfaction on mobile health consultation. *Inf. Process. Manage.*, *60*(4). https://doi.org/10.1016/j.ipm.2023.103362

Matos, S., Viardot, E., Sovacool, B. K., Geels, F. W., & Xiong, Y. (2022). Innovation and climate change: A review and introduction to the special issue. *Technovation*, *117*(July), 102612. https://doi.org/10.1016/j.technovation.2022.102612

Nunhes, T. V., Bernardo, M., & José de Oliveira, O. (2020). Rethinking the way of doing business: A reframe of management structures for developing corporate sustainability. *Sustainability (Switzerland)*, *12*(3). https://doi.org/10.3390/su12031177

Oloruntobi, O., Mokhtar, K., Mohd Rozar, N., Gohari, A., Asif, S., & Chuah, L. F. (2023). Effective technologies and practices for reducing pollution in warehouses - A review. *Cleaner Engineering and Technology*, *13*(February), 100622. https://doi.org/10.1016/j.clet.2023.100622

Panda, T. K., Kumar, A., Jakhar, S., Luthra, S., Garza-Reyes, J. A., Kazancoglu, I., & Nayak, S. S. (2020). Social and environmental sustainability model on consumers' altruism, green purchase intention, green brand loyalty and evangelism. *Journal of Cleaner Production*, *243*. https://doi.org/10.1016/j.jclepro.2019.118575

Peteraf, M. A., & Barney, J. B. (2003). Unraveling the resource-based tangle. *Managerial and Decision Economics*, *24*(4), 309–323. https://doi.org/10.1002/mde.1126

Priyono, A., & Hidayat, A. (2024). Fostering innovation through learning from digital business ecosystem: A dynamic capability perspective. *Journal of Open Innovation: Technology, Market, and Complexity*, *10*(1), 100196. https://doi.org/10.1016/j.joitmc.2023.100196

Rahko, J., & Alola, A. A. (2024). Examining green productivity amidst climate change technological development and spillovers in the Nordic economies. *Journal of Cleaner Production*, *434*(September 2022), 140028. https://doi.org/10.1016/j.jclepro.2023.140028

Raihan, A., Ridwan, M., & Rahman, S. (2024). Climate Smart Agriculture An exploration of the latest developments , obstacles , and potential future pathways for climate-smart agriculture. *Climate Smart Agriculture*, *1*(2), 100020. https://doi.org/10.1016/j.csag.2024.100020

Ribeiro-Navarrete, S., Botella-Carrubi, D., Palacios-Marqués, D., & Orero-Blat, M. (2021). The

effect of digitalization on business performance: An applied study of KIBS. *Journal of Business Research*, *126*(December 2020), 319–326. https://doi.org/10.1016/j.jbusres.2020.12.065

Sari, R. P., Azzahrha, F. K., Nuravianti, A., Achka, F. F., & Santoso, D. T. (2023). *Evaluation of the Effect of Financial Technology Through Business Sustainability Practices on the Performance of MSMEs in Karawang Regency*. *1*, 669–677. https://doi.org/10.46254/ap04.20230180

Sun, T., Zhang, W. W., Dinca, M. S., & Raza, M. (2022). Determining the impact of Covid-19 on the business norms and performance of SMEs in China. *Economic Research-Ekonomska Istrazivanja* , *35*(1), 2234–2253. https://doi.org/10.1080/1331677X.2021.1937261

Vitapamoorthy, R., Mahmood, R., & Md Som, H. (2021). The Role of Self-Efficacy and Innovative Work Behaviour in Civil Servants' Work Performance: A Conceptual Paper. *International Journal of Academic Research in Business and Social Sciences*, *11*(3), 749–761. https://doi.org/10.6007/ijarbss/v11-i3/8592

Wang, C., Ahmad, S. F., Bani Ahmad Ayassrah, A. Y. A., Awwad, E. M., Irshad, M., Ali, Y. A., Al-Razgan, M., Khan, Y., & Han, H. (2023). An empirical evaluation of technology acceptance model for Artificial Intelligence in E-commerce. *Heliyon*, *9*(8), e18349. https://doi.org/10.1016/j.heliyon.2023.e18349

Wang, W., Huang, Z., Fu, Z., Jia, L., Li, Q., & Song, J. (2024). Impact of digital technology adoption on technological innovation in grain production. *Journal of Innovation and Knowledge*, *9*(3), 100520. https://doi.org/10.1016/j.jik.2024.100520

Wong, L. W., Leong, L. Y., Hew, J. J., Tan, G. W. H., & Ooi, K. B. (2020). Time to seize the digital evolution: Adoption of blockchain in operations and supply chain management among Malaysian SMEs. *International Journal of Information Management*, *52*(June), 101997. https://doi.org/10.1016/j.ijinfomgt.2019.08.005

Xie, X., Huo, J., & Zou, H. (2019). Green process innovation, green product innovation, and corporate financial performance: A content analysis method. *Journal of Business Research*, *101*(June 2018), 697–706. https://doi.org/10.1016/j.jbusres.2019.01.010

Xin, Y., Ullah, R., Dagar, V., & Qian, F. (2023). Do international resources configure SMEs ' sustainable performance in the digital era ? Evidence from Pakistan. *Resources Policy*, *80*(September 2022), 103169. https://doi.org/10.1016/j.resourpol.2022.103169

Xu, H., Ahmad, M., Luqman Aziz, A., Uddin, I., Aljuaid, M., & Gu, X. (2024). The linkages between energy efficiency, renewable electricity, human capital and inclusive growth: The role of technological development. *Energy Strategy Reviews*, *53*(November 2023), 101414. https://doi.org/10.1016/j.esr.2024.101414

Younis, J. A., Al-Shammari, H., Hejase, H. J., Massoud, M., & Hejase, A. J. (2024). E-satisfaction as a mediator between consumer loyalty and E-CRM: The context of Lebanese e commerce. *International Journal of Innovative Research and Scientific Studies*, *7*(3), 978–996. https://doi.org/10.53894/ijirss.v7i3.2987

Zhao, Q., Yu, P., Mahendran, R., Huang, W., Gao, Y., Yang, Z., Ye, T., Wen, B., Wu, Y., Li, S., & Guo, Y. (2022). Global climate change and human health: Pathways and possible solutions. *Eco-Environment and Health*, *1*(2), 53–62. https://doi.org/10.1016/j.eehl.2022.04.004

Zhen, J., Wang, L., & Ouyang, J. (2024). Enterprise innovation willingness, government policy preference and park support orientation in the high-quality development of industrial

parks: A three-party evolutionary game analysis. *Heliyon*, *10*(18), e36618. https://doi.org/10.1016/j.heliyon.2024.e36618

Abdul Basit, S., Gharleghi, B., Batool, K., Hassan, S. S., Jahanshahi, A. A., & Kliem, M. E. (2024). Review of enablers and barriers of sustainable business practices in SMEs. *Journal of Economy and Technology*, *2*(March), 79–94. https://doi.org/10.1016/j.ject.2024.03.005

Abernethy, A., Adams, L., Barrett, M., Bechtel, C., Brennan, P., Butte, A., Faulkner, J., Fontaine, E., Friedhoff, S., Halamka, J., Howell, M., Johnson, K., Long, P., McGraw, D., Miller, R., Lee, P., Perlin, J., Rucker, D., Sandy, L., … Valdes, K. (2022). The Promise of Digital Health: Then, Now, and the Future. *NAM Perspectives*, *6*(22). https://doi.org/10.31478/202206e

Agrawal, R., Agrawal, S., Samadhiya, A., Kumar, A., Luthra, S., & Jain, V. (2024). Adoption of green finance and green innovation for achieving circularity: An exploratory review and future directions. *Geoscience Frontiers*, *15*(4), 101669. https://doi.org/10.1016/j.gsf.2023.101669

Ahmad, A., Sohail, A., & Hussain, A. (2021). Emergence of financial technology in Islamic banking industry and its influence on bank performance in covid-19 scenario: A case of developing economy. *Gomal University Journal of Research*, *37*(1), 97–109.

Akbar, A., Hussain, A., Shahzad, A., Mohelska, H., & Hassan, R. (2022). Environmental and technological factor diffusion with innovation and firm performance: Empirical evidence from manufacturing SMEs. *Frontiers in Environmental Science*, *10*(July), 1–16. https://doi.org/10.3389/fenvs.2022.960095

Ansari, M. A. A., Sajid, M., Khan, S. N., Antohi, V. M., Fortea, C., & Zlati, M. L. (2024). Unveiling the effect of renewable energy and financial inclusion towards sustainable environment: Does interaction of digital finance and institutional quality matter? *Sustainable Futures*, *7*(March), 100196. https://doi.org/10.1016/j.sftr.2024.100196

Arslan, A., Haapanen, L., Hurmelinna-Laukkanen, P., Tarba, S. Y., & Alon, I. (2021). Climate change, consumer lifestyles and legitimation strategies of sustainability-oriented firms. *European Management Journal*, *39*(6), 720–730. https://doi.org/10.1016/j.emj.2021.03.005

Barney, J. B. (1986). Strategic factor markets BARNEY. In *Management science* (Vol. 32, Issue 10, pp. 1231–1241).

Bharadwaj, A., El Sawy, O. A., Pavlou, P. A., & Venkatraman, N. (2013). Digital business strategy: Toward a next generation of insights. *MIS Quarterly: Management Information Systems*, *37*(2), 471–482. https://doi.org/10.25300/MISQ/2013/37:2.3

Bughin, J., & Zeebroeck, N. Van. (2021). *The Entrepreneurial Returns to Incumbents' Digital Transformation*. https://dipot.ulb.ac.be/dspace/bitstream/2013/327345/3/WP2021-048-BUGHIN_VANZEEBROECK-the.pdf

Chen, C. L., Lin, Y. C., Chen, W. H., Chao, C. F., & Pandia, H. (2021). Role of government to enhance digital transformation in small service business. *Sustainability (Switzerland)*, *13*(3), 1–26. https://doi.org/10.3390/su13031028

Chen, S.-C., & Lin, C.-P. (2015). The impact of customer experience and perceived value on sustainable social relationship in blogs: An empirical study. *Technological Forecasting and Social Change*, *96*, 40–50.

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

Darko, A., Chan, A. P. C., Gyamfi, S., Olanipekun, A. O., He, B. J., & Yu, Y. (2017). Driving forces for green building technologies adoption in the construction industry: Ghanaian perspective. *Building and Environment*, *125*, 206–215. https://doi.org/10.1016/j.buildenv.2017.08.053

Davies, P., Bustinza, O. F., Parry, G., & Jovanovic, M. (2023). Unpacking the relationship between digital capabilities, services capabilities, and firm financial performance: A moderated mediation model. *Industrial Marketing Management*, *115*(September), 1–10. https://doi.org/10.1016/j.indmarman.2023.09.005

Elfaki, K. E., & Ahmed, E. M. (2024). Digital technology adoption and globalization innovation implications on Asian Pacific green sustainable economic growth. *Journal of Open Innovation: Technology, Market, and Complexity*, *10*(1), 100221. https://doi.org/10.1016/j.joitmc.2024.100221

Ferdinand, A. (2014). *Metode penelitian manajemen: Pedoman penelitian untuk penulisan skripsi tesis dan desrtasi ilmu manajemen*.

Feroz, A. K., Zo, H., & Chiravuri, A. (2021). Digital transformation and environmental sustainability: A review and research agenda. *Sustainability (Switzerland)*, *13*(3), 1–20. https://doi.org/10.3390/su13031530

Hair, J. F., Hult, G. T. M., Ringle, C. M., Sarstedt, M., & Thiele, K. O. (2017). Mirror, mirror on the wall: a comparative evaluation of composite-based structural equation modeling methods. *Journal of the Academy of Marketing Science*, *45*(5), 616–632. https://doi.org/10.1007/s11747-017-0517-x

Haldorai, K., Kim, W. G., & Garcia, R. L. F. (2022). Top management green commitment and green intellectual capital as enablers of hotel environmental performance: The mediating role of green human resource management. *Tourism Management*, *88*(January 2021), 104431. https://doi.org/10.1016/j.tourman.2021.104431

Han, Y., & Niu, Q. (2022). Enhancing green radical product innovation through sustainable entrepreneurship orientation and sustainable market orientation for sustainable performance: managerial implications from sports goods manufacturing enterprises of China. *Economic Research-Ekonomska Istrazivanja* , *0*(0), 1–20. https://doi.org/10.1080/1331677X.2022.2164325

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

Henry Ejiga Adama, & Chukwuekem David Okeke. (2024). Digital transformation as a catalyst for business model innovation: A critical review of impact and implementation strategies. *Magna Scientia Advanced Research and Reviews*, *10*(2), 256–264. https://doi.org/10.30574/msarr.2024.10.2.0066

Hussain, J., Lee, C. C., & Chen, Y. (2022). Optimal green technology investment and emission reduction in emissions generating companies under the support of green bond and subsidy. *Technological Forecasting and Social Change*, *183*, 0–42. https://doi.org/10.1016/j.techfore.2022.121952

Javaid, M., Haleem, A., Singh, R. P., Suman, R., & Gonzalez, E. S. (2022). Understanding the adoption of Industry 4.0 technologies in improving environmental sustainability. *Sustainable Operations and Computers*, *3*(January), 203–217.

https://doi.org/10.1016/j.susoc.2022.01.008

Kong, X., Yan, C., & Ho, K. C. (2024). The impact of climate change on credit cycles: Evidence from China's bond market. *Technological Forecasting and Social Change*, *206*(May), 123490. https://doi.org/10.1016/j.techfore.2024.123490

Laranja Ribeiro, M. P., Tommasetti, R., Gomes, M. Z., Castro, A., & Ismail, A. (2021). Adoption phases of Green Information Technology in enhanced sustainability: A bibliometric study. *Cleaner Engineering and Technology*, *3*(April). https://doi.org/10.1016/j.clet.2021.100095

Lee, B., & Park, S. K. (2022). A Study on the Competitiveness for the Diffusion of Smart Technology of Construction Industry in the Era of 4th Industrial Revolution. *Sustainability (Switzerland)*, *14*(14). https://doi.org/10.3390/su14148348

Li, S., Yang, Z., & Tian, Y. (2023). Digital transformation and corporate performance: evidence from China. *China Economic Journal*, *16*(3), 312–334. https://doi.org/10.1080/17538963.2023.2254138

Lin, C. Y., Chau, K. Y., & Moslehpour, M. (2024). Bridging the gap: The nexus of sustainability innovation, knowledge sharing, and green volunteerism for manufacturing entrepreneurial triumph. *Journal of Innovation and Knowledge*, *9*(4). https://doi.org/10.1016/j.jik.2024.100570

Liu, Q., Qu, X., Wang, D., Abbas, J., & Mubeen, R. (2022). Product Market Competition and Firm Performance: Business Survival Through Innovation and Entrepreneurial Orientation Amid COVID-19 Financial Crisis. *Frontiers in Psychology*, *12*(March), 1–12. https://doi.org/10.3389/fpsyg.2021.790923

Liu, Y., Zhang, X., Liu, L., & Lai, K. (2023). Does voice matter? Investigating patient satisfaction on mobile health consultation. *Inf. Process. Manage.*, *60*(4). https://doi.org/10.1016/j.ipm.2023.103362

Matos, S., Viardot, E., Sovacool, B. K., Geels, F. W., & Xiong, Y. (2022). Innovation and climate change: A review and introduction to the special issue. *Technovation*, *117*(July), 102612. https://doi.org/10.1016/j.technovation.2022.102612

Nunhes, T. V., Bernardo, M., & José de Oliveira, O. (2020). Rethinking the way of doing business: A reframe of management structures for developing corporate sustainability. *Sustainability (Switzerland)*, *12*(3). https://doi.org/10.3390/su12031177

Oloruntobi, O., Mokhtar, K., Mohd Rozar, N., Gohari, A., Asif, S., & Chuah, L. F. (2023). Effective technologies and practices for reducing pollution in warehouses - A review. *Cleaner Engineering and Technology*, *13*(February), 100622. https://doi.org/10.1016/j.clet.2023.100622

Panda, T. K., Kumar, A., Jakhar, S., Luthra, S., Garza-Reyes, J. A., Kazancoglu, I., & Nayak, S. S. (2020). Social and environmental sustainability model on consumers' altruism, green purchase intention, green brand loyalty and evangelism. *Journal of Cleaner Production*, *243*. https://doi.org/10.1016/j.jclepro.2019.118575

Peteraf, M. A., & Barney, J. B. (2003). Unraveling the resource-based tangle. *Managerial and Decision Economics*, *24*(4), 309–323. https://doi.org/10.1002/mde.1126

Priyono, A., & Hidayat, A. (2024). Fostering innovation through learning from digital business ecosystem: A dynamic capability perspective. *Journal of Open Innovation: Technology, Market, and Complexity*, *10*(1), 100196. https://doi.org/10.1016/j.joitmc.2023.100196

Rahko, J., & Alola, A. A. (2024). Examining green productivity amidst climate change technological development and spillovers in the Nordic economies. *Journal of Cleaner*

Production, *434*(September 2022), 140028. https://doi.org/10.1016/j.jclepro.2023.140028

Raihan, A., Ridwan, M., & Rahman, S. (2024). Climate Smart Agriculture An exploration of the latest developments , obstacles , and potential future pathways for climate-smart agriculture. *Climate Smart Agriculture*, *1*(2), 100020. https://doi.org/10.1016/j.csag.2024.100020

Ribeiro-Navarrete, S., Botella-Carrubi, D., Palacios-Marqués, D., & Orero-Blat, M. (2021). The effect of digitalization on business performance: An applied study of KIBS. *Journal of Business Research*, *126*(December 2020), 319–326. https://doi.org/10.1016/j.jbusres.2020.12.065

Sari, R. P., Azzahrha, F. K., Nuravianti, A., Achka, F. F., & Santoso, D. T. (2023). *Evaluation of the Effect of Financial Technology Through Business Sustainability Practices on the Performance of MSMEs in Karawang Regency*. *1*, 669–677. https://doi.org/10.46254/ap04.20230180

Sun, T., Zhang, W. W., Dinca, M. S., & Raza, M. (2022). Determining the impact of Covid-19 on the business norms and performance of SMEs in China. *Economic Research-Ekonomska Istrazivanja* , *35*(1), 2234–2253. https://doi.org/10.1080/1331677X.2021.1937261

Vitapamoorthy, R., Mahmood, R., & Md Som, H. (2021). The Role of Self-Efficacy and Innovative Work Behaviour in Civil Servants' Work Performance: A Conceptual Paper. *International Journal of Academic Research in Business and Social Sciences*, *11*(3), 749–761. https://doi.org/10.6007/ijarbss/v11-i3/8592

Wang, C., Ahmad, S. F., Bani Ahmad Ayassrah, A. Y. A., Awwad, E. M., Irshad, M., Ali, Y. A., Al-Razgan, M., Khan, Y., & Han, H. (2023). An empirical evaluation of technology acceptance model for Artificial Intelligence in E-commerce. *Heliyon*, *9*(8), e18349. https://doi.org/10.1016/j.heliyon.2023.e18349

Wang, W., Huang, Z., Fu, Z., Jia, L., Li, Q., & Song, J. (2024). Impact of digital technology adoption on technological innovation in grain production. *Journal of Innovation and Knowledge*, *9*(3), 100520. https://doi.org/10.1016/j.jik.2024.100520

Wong, L. W., Leong, L. Y., Hew, J. J., Tan, G. W. H., & Ooi, K. B. (2020). Time to seize the digital evolution: Adoption of blockchain in operations and supply chain management among Malaysian SMEs. *International Journal of Information Management*, *52*(June), 101997. https://doi.org/10.1016/j.ijinfomgt.2019.08.005

Xie, X., Huo, J., & Zou, H. (2019). Green process innovation, green product innovation, and corporate financial performance: A content analysis method. *Journal of Business Research*, *101*(June 2018), 697–706. https://doi.org/10.1016/j.jbusres.2019.01.010

Xin, Y., Ullah, R., Dagar, V., & Qian, F. (2023). Do international resources configure SMEs ' sustainable performance in the digital era ? Evidence from Pakistan. *Resources Policy*, *80*(September 2022), 103169. https://doi.org/10.1016/j.resourpol.2022.103169

Xu, H., Ahmad, M., Luqman Aziz, A., Uddin, I., Aljuaid, M., & Gu, X. (2024). The linkages between energy efficiency, renewable electricity, human capital and inclusive growth: The role of technological development. *Energy Strategy Reviews*, *53*(November 2023), 101414. https://doi.org/10.1016/j.esr.2024.101414

Younis, J. A., Al-Shammari, H., Hejase, H. J., Massoud, M., & Hejase, A. J. (2024). E-satisfaction as a mediator between consumer loyalty and E-CRM: The context of Lebanese e commerce. *International Journal of Innovative Research and Scientific*

Studies, *7*(3), 978–996. https://doi.org/10.53894/ijirss.v7i3.2987

Zhao, Q., Yu, P., Mahendran, R., Huang, W., Gao, Y., Yang, Z., Ye, T., Wen, B., Wu, Y., Li, S., & Guo, Y. (2022). Global climate change and human health: Pathways and possible solutions. *Eco-Environment and Health*, *1*(2), 53–62. https://doi.org/10.1016/j.eehl.2022.04.004

Zhen, J., Wang, L., & Ouyang, J. (2024). Enterprise innovation willingness, government policy preference and park support orientation in the high-quality development of industrial parks: A three-party evolutionary game analysis. *Heliyon*, *10*(18), e36618. https://doi.org/10.1016/j.heliyon.2024.e36618