Journal of Islamic Economics Lariba
(P-ISSN 2477-4839 E-ISSN 2528-3758)
2025, Vol. 11, No. 2, 1967-2000
https://doi.org/10.20885/jielariba.vol11.iss2.art26

Artificial Intelligence adoption in micro, small, and medium enterprises: Evidence, barriers, and Islamic ethical reflections for Muslim entrepreneurs in Yogyakarta

Edy Suandi Hamid[1] & Bhenu Artha[2]

[1]Program Studi Ilmu Ekonomi (S3), Universitas Islam Indonesia, Kab. Sleman, Indonesia
[2]Program Studi Kewirausahaan (S1), Universitas Widya Mataram, Kota Yogyakarta, Indonesia

ABSTRACT

Introduction

Artificial intelligence is increasingly recognized as a strategic driver of competitiveness and innovation in micro, small, and medium enterprises. Yet the benefits of artificial intelligence adoption are uneven across contexts and often depend on organizational readiness, infrastructure, and ethical governance. This issue is particularly relevant for micro, small, and medium enterprises in Yogyakarta, Indonesia, where many businesses operate with limited digital capability and constrained access to capital. For Muslim entrepreneurs, adoption decisions are further shaped by Islamic business ethics that emphasize trust, transparency, fairness, halal integrity, and social responsibility.

Objectives

This study examines the importance of artificial intelligence adoption for micro, small, and medium enterprises by synthesizing global evidence and developing a context-sensitive reflection for Muslim entrepreneurs in Yogyakarta, Indonesia. It aims to clarify key benefits, identify persistent barriers, and propose an ethically grounded rationale for responsible adoption.

Method

This study uses an argumentative review approach to analyze peer-reviewed literature on artificial intelligence adoption in micro, small, and medium enterprises. The synthesis is organized into five analytical themes: (1) global evidence on performance impacts, (2) drivers and barriers of adoption, (3) characteristics of micro, small, and medium enterprises in Indonesia and Yogyakarta, (4) opportunities and constraints for implementation in Yogyakarta, and (5) ethical reflections based on Islamic business ethics.

JEL Classification:
L26, L86, O33, O35, Z12, Z13

KAUJIE Classification:
H55, H62, I14, P0, T0

ARTICLE HISTORY:

Submitted: June 30, 2025
Revised: September 13, 2025
Accepted: September 14, 2025
Published: October 30, 2025

KEYWORDS:

Artificial Intelligence adoption; digital transformation; Islamic business ethics; micro, small, and medium enterprises; Muslim entrepreneurs; technology readiness; Yogyakarta

Contact: Edy Suandi Hamid ✉ edysuandi@uii.ac.id

Results
The review indicates that artificial intelligence adoption can improve productivity, cost efficiency, and decision-making quality in micro, small, and medium enterprises, while also supporting innovation and market competitiveness when integrated with complementary digital capabilities. However, adoption is frequently constrained by limited financial resources, skills gaps, inadequate infrastructure, weak data governance, and uncertainty about return on investment. In Yogyakarta, these constraints are reinforced by informal business structures and uneven digital readiness, suggesting that adoption pathways must be incremental, affordable, and supported by capability development.

Implications
This study highlights that artificial intelligence adoption for micro, small, and medium enterprises in Yogyakarta should be approached as a socio-technical and ethical decision, not merely a technical investment. Practical implications include the need for targeted training, affordable artificial intelligence services, and governance practices that strengthen consumer trust.

Originality/Novelty
This study contributes a contextual and ethically grounded synthesis by linking global artificial intelligence adoption evidence with the realities of micro, small, and medium enterprises in Yogyakarta and the normative considerations of Muslim entrepreneurship in Indonesia.

CITATION: R Hamid, E. S. & Artha, B. (2025). Artificial Intelligence adoption in micro, small, and medium enterprises: Evidence, barriers, and Islamic ethical reflections for Muslim entrepreneurs in Yogyakarta. *Journal of Islamic Economics Lariba, 11*(2), 1967-2000. https://doi.org/10.20885/jielariba.vol11.iss2.art26

INTRODUCTION

Artificial intelligence (AI) is increasingly positioned as a transformative force in contemporary business, reshaping how firms create value, allocate resources, and compete in data-intensive markets. For micro, small, and medium enterprises (MSMEs), AI is not merely a technological upgrade but a potential pathway to overcome scale disadvantages through automation, analytics, and enhanced decision-making. Recent empirical studies show that AI adoption can improve operational performance by optimizing processes and reducing costs (Badghish & Soomro, 2024; Pamungkas et al., 2023; Schwaeke et al., 2025), while enabling more effective resource allocation through data-driven decision-making (Dey et al., 2024; Mahi, 2024). Evidence also suggests that AI-supported automation can reduce errors in inventory and supply-chain routines, improving efficiency in daily operations (Al-Amin et al., 2024; Wulandari & Diko, 2024). However, the magnitude of these gains remains uneven across contexts (Schönberger, 2023; Wong & Yap, 2024), indicating the need for careful, locally grounded inquiry.

The academic literature further indicates that AI adoption can strengthen MSME competitiveness by enhancing market responsiveness and expanding revenue opportunities. Studies focusing on European SMEs suggest that AI, when integrated with complementary digital capabilities such as Big Data Analytics and the Internet of Things (IoT), can contribute to substantial revenue growth and improved customer insight (Ardito et al., 2024; Barton et al., 2022). AI-based accounting and financial analysis tools have also been associated with improved pricing strategies and sales performance (Odonkor et al., 2024; Ugbaja et al., 2023). Beyond immediate financial outcomes, AI is increasingly linked to innovation capabilities, particularly through faster prototyping and improved research and development cycles (Johnson et al., 2022; Truong & Papagiannidis, 2022). In resource-constrained settings, accessible AI tools may support smaller firms in sustaining innovation despite limited capital and personnel (Alzaghal et al., 2024; Chaudhuri et al., 2022; Govindan, 2024). Yet, benefits are shaped by readiness and infrastructure, and thus cannot be assumed as automatic outcomes of adoption.

Despite the promise of AI, MSMEs frequently encounter structural barriers that limit adoption, implementation quality, and long-term value creation. The literature emphasizes that AI impacts depend on firm size, industry, and technological capabilities, with firms possessing stronger digital infrastructure and managerial readiness experiencing greater returns (Alarefi, 2024; Uren & Edwards, 2023; Wamba-Taguimdje et al., 2020). In many developing economies, the diffusion of AI is constrained by limited financial resources, low digital literacy, and uneven access to enabling technologies, which reduces the ability of MSMEs to translate AI investment into measurable performance gains (Aderibigbe et al., 2023; Fajri et al., 2024; Yusuf et al., 2024). Empirical findings also show that management support and perceived organizational benefits shape adoption decisions, indicating that AI implementation is as much an organizational challenge as a technical one (Abaddi, 2024b, 2024a; Marocco et al., 2024; Neumann et al., 2024; Soomro et al., 2024). These barriers suggest a central research problem: AI adoption is widely promoted, yet its feasibility and value remain contingent on contextual conditions that are often underexplored.

The literature proposes several general solutions to address these constraints, commonly emphasizing digital readiness, skills development, and supportive ecosystems. Digital infrastructure, including cloud computing and data management capabilities, is frequently described as a prerequisite for effective AI integration (Adenuga et al., 2024; Kunungo et al., 2018; Mahmood et al., 2024). Human capital is similarly decisive, as MSMEs with a skilled workforce are more likely to implement AI successfully and adapt it to business needs (Rawashdeh et al., 2023; Saleem et al., 2023). Training initiatives that strengthen AI literacy and organizational learning can help reduce uncertainty and increase readiness for adoption (Enshassi et al., 2024; Omrani et al., 2024). At the policy level, regulatory support and incentives are often highlighted as mechanisms to reduce financial barriers and strengthen trust in AI systems (Badghish & Soomro, 2024; Madhavan et al., 2024). Nonetheless, general

solutions require adaptation to local realities, including sectoral structure, financing access, and socio-cultural dynamics.

In Indonesia, MSMEs represent the overwhelming majority of businesses and contribute substantially to national economic activity, yet they often operate with limited capacity to scale and innovate (Salsabillah et al., 2025; N. T. P. Sari & Kusumawati, 2022; Tambunan, 2019). In Yogyakarta, a region widely associated with cultural industries and creative entrepreneurship, MSMEs frequently take the form of family-owned or informal enterprises with constrained access to formal financing and technological resources (Suyatno, 2022; Widiyastuti et al., 2023). Digital capability remains uneven, with many enterprises struggling to adopt digital tools beyond basic marketing, and with e-commerce adoption still limited despite its recognized benefits (I. Hidayat et al., 2024; W. H. Hidayat & Kholik, 2024; Zhukhruffa, 2023). The pandemic accelerated digital experimentation for some MSMEs (Fathoni & Asfiah, 2024; Hamzah et al., 2023), but structural gaps in literacy, access, and managerial commitment continue to slow digital transformation. This profile raises the question of whether AI adoption is a realistic strategy for MSMEs in such contexts or a premature expectation.

Prior studies also identify region-specific opportunities and constraints that shape AI feasibility for MSMEs in Yogyakarta and comparable Indonesian regions. On the opportunity side, AI can improve productivity by automating routine tasks and supporting faster, more accurate decision-making, which may be particularly valuable for small firms with limited labor capacity (Kusumasari et al., 2024; Pratama et al., 2023; Sonianto et al., 2024). Digital technologies can also support sustainability by optimizing resource use and reducing waste, which is increasingly relevant in emerging economies, including Indonesia (Bukran & Ramdani, 2024; Wahyuningsih & Kholmi, 2024). Furthermore, the availability of local talent may gradually improve through digital literacy initiatives and educational programs, potentially expanding the pool of workers with exposure to AI concepts. Yet constraints remain substantial, including limited practical AI skills, infrastructural weaknesses such as connectivity and computing capacity, and affordability challenges where return on investment is uncertain for firms operating with thin margins. These findings suggest that targeted and context-sensitive strategies are required to convert AI potential into practical value.

The adoption challenge becomes more complex when ethical and cultural considerations are included, particularly for Muslim entrepreneurs whose business decisions may be shaped by Islamic ethical principles (Anggadwita et al., 2017; Fathallah et al., 2020; Sarib et al., 2023). Islamic business ethics places strong emphasis on trust, transparency, fairness, halal integrity, and social responsibility (Anggadwita et al., 2017; Hj Ramlli et al., 2024; Ilham S. et al., 2024; Putri et al., 2023; U-Mar et al., 2024), which can influence how AI tools are evaluated and implemented. Research on halal traceability systems among food SMEs shows that transparency-enhancing technologies can strengthen consumer trust and improve operational processes (Masudin et al., 2022; Muhamad et al., 2020). In the broader context of digital ethics, accountability and the protection of human dignity are increasingly discussed as essential principles for responsible technology use (Brall et al., 2019; Walton, 2016).

Studies also highlight that AI-related decision-making in Islamic finance requires fairness and alignment with Shariah governance (Ahmed, 2024; Eskandarany, 2024; Hemmet, 2023; Kausar et al., 2024), reinforcing the importance of ethical legitimacy in algorithmic systems. Moreover, concerns about harm and inequality underscore the need for innovation strategies that remain consistent with moral frameworks and inclusive economic goals (Buhmann & Fieseler, 2021; Kashefi et al., 2024; W. Li et al., 2023). These perspectives imply that AI adoption for Muslim entrepreneurs cannot be reduced to efficiency alone.

Although existing scholarship provides useful insights into AI performance outcomes, adoption drivers, and ethical considerations, important gaps remain when these streams are brought together in a specific regional context such as Yogyakarta. The empirical literature often examines AI adoption either as a general technology diffusion process or as a performance-enhancing strategy, while local MSME characteristics are discussed primarily through the lens of digitalization and entrepreneurship rather than AI readiness. Similarly, research on Islamic business ethics and technology tends to focus on sectors such as halal supply chains or Islamic finance, leaving limited integration with MSME-oriented AI adoption debates. This fragmentation limits the ability to assess whether AI adoption strategies proposed in the global literature can be responsibly and effectively translated into the lived realities of Muslim entrepreneurs in Yogyakarta. A more integrated review is needed to clarify what adoption may look like in practice and what ethical boundaries should guide it.

Accordingly, this study aims to develop an argumentative review of the importance of AI adoption for MSMEs, with a focused reflection on Muslim entrepreneurs in Yogyakarta, Indonesia. It synthesizes empirical findings on AI's performance effects, the drivers and barriers of adoption, and the contextual characteristics of Indonesian and Yogyakarta MSMEs to evaluate both feasibility and strategic value. The novelty of this study lies in positioning AI adoption not only as a technological and managerial issue but also as an ethical and community-oriented decision shaped by Islamic business values. The scope of the review covers global evidence, Indonesian regional conditions, and normative considerations relevant to responsible adoption, ultimately offering a grounded rationale for why AI matters for MSMEs in Yogyakarta and how it can be pursued without neglecting ethical commitments.

METHOD

Research Design and Rationale

This study employs an argumentative review approach to examine the importance of artificial intelligence (AI) adoption for micro, small, and medium enterprises (MSMEs), with a focused reflection on Muslim entrepreneurs in Yogyakarta, Indonesia. The argumentative review method was selected because the topic is not only empirical but also normative and contextual: AI adoption is often discussed in terms of measurable performance outcomes, yet its relevance for MSMEs depends on local readiness, sectoral realities, and ethical considerations. Rather than treating the literature as a set

of neutral findings, this method allows the study to critically evaluate claims, compare competing arguments, and identify the conditions under which AI adoption becomes a feasible and responsible strategy for small firms.

The review is structured to support inductive reasoning. It begins with global evidence on AI adoption impacts and determinants, then narrows to the Indonesian and Yogyakarta MSME context, and finally incorporates Islamic business ethics as an interpretive lens. This sequencing enables the study to move from general patterns to local implications while maintaining an argumentative logic that connects empirical findings with the specific socio-economic and moral environment of Muslim entrepreneurship in Yogyakarta.

Building on this design, the study is explicitly guided by five research questions that structure the argumentative synthesis and ensure analytical coherence across themes and contexts.

> RQ1: How does artificial intelligence adoption influence MSME performance in terms of productivity, cost efficiency, sales growth, and innovation across different contexts?

This research question evaluates how artificial intelligence adoption shapes MSME performance outcomes—productivity, cost efficiency, sales growth, and innovation—across different national and sectoral settings.

> RQ2: What key organizational, technological, and environmental drivers and barriers shape artificial intelligence adoption among MSMEs, and which factors appear most decisive in the literature?

This research question identifies the organizational, technological, and environmental drivers and barriers that most consistently influence adoption decisions, with attention to which determinants appear most decisive in prior empirical work.

> RQ3: What distinctive characteristics of MSMEs in Yogyakarta, Indonesia—particularly business structure, digital capability, sectoral concentration, and access to capital and technology—shape their readiness for artificial intelligence adoption?

This research question contextualizes these insights by examining the distinctive characteristics of MSMEs in Yogyakarta, including business structure, digital capability, sectoral concentration, and access to capital and technology, as key factors shaping readiness for adoption.

> RQ4: What opportunities and constraints affect the implementation of artificial intelligence among MSMEs in Yogyakarta, Indonesia, especially regarding workforce skills, infrastructure, affordability, data governance, and customer readiness?

This research question assesses locally grounded opportunities and constraints for implementation, focusing on workforce skills, infrastructure, affordability, data governance, and customer readiness.

RQ5: How do Islamic business ethics inform Muslim entrepreneurs' decision-making about artificial intelligence adoption in MSMEs, particularly in relation to trust, transparency, fairness, halal integrity, and social responsibility?

This research question incorporates Islamic business ethics as an interpretive lens to explain how Muslim entrepreneurs may evaluate AI adoption through principles of trust, transparency, fairness, halal integrity, and social responsibility, thereby linking technological choices to ethical legitimacy.

Data Sources and Literature Identification Strategy

The primary materials for this review consist of peer-reviewed journal articles indexed in Scopus database that address AI adoption, MSME performance, adoption barriers and drivers, digital readiness, and ethical governance of AI in business contexts. To ensure relevance and academic rigor, the review prioritizes sources that present empirical evidence, theoretical models, or systematic conceptual arguments about AI diffusion and implementation among small firms. Given the rapidly evolving nature of AI technologies and the expanding scholarly attention to MSME digital transformation, the literature search emphasized relatively recent publications while still incorporating foundational works when necessary to clarify theoretical frameworks.

To strengthen contextual grounding, the review also includes studies focusing on Indonesia and Yogyakarta, particularly those examining MSME characteristics, sectoral patterns, access to capital, digital literacy, and institutional support for technology adoption. In addition, literature on Islamic business ethics, halal integrity, and Muslim entrepreneurship was incorporated to clarify how moral principles may shape decision-making around AI adoption. This multi-stream approach was necessary because the study's research focus spans performance outcomes, adoption feasibility, and ethical responsibility.

To operationalize the literature identification process, a structured keyword search was conducted in the Scopus database by aligning each research question with targeted Boolean queries, as in Table 1. The search strategy used the Scopus field tag TITLE-ABS-KEY to retrieve studies in which the core concepts appeared in article titles, abstracts, or author keywords, thereby increasing topical relevance and minimizing peripheral results. For each research question, the review applied at least one "core" query to capture the broad evidence base and one or more "focused" queries to retrieve studies emphasizing specific constructs (e.g., performance outcomes, adoption determinants, regional context, implementation constraints, or Islamic ethical reasoning). This staged approach allowed the review to balance recall and precision: broad queries ensured comprehensive coverage of AI adoption in MSMEs, while focused queries captured empirical findings and conceptual debates most directly connected to the analytical themes of this study.

Table 1

Research Question and Scopus Keywords (Boolean Queries)

Research Question	Scopus Keywords
RQ1	*Core query (general)* TITLE-ABS-KEY("artificial intelligence" OR "AI" OR "machine learning" OR "generative AI" OR "automation") AND TITLE-ABS-KEY(MSME* OR "small and medium enterprise*" OR SME* OR "micro enterprise*" OR "small business*") AND TITLE-ABS-KEY(adoption OR implementation OR diffusion OR "technology adoption") *Impact/performance focus* TITLE-ABS-KEY("artificial intelligence" OR AI OR "machine learning" OR "generative AI") AND TITLE-ABS-KEY(SME* OR MSME* OR "small business*") AND TITLE-ABS-KEY(performance OR productivity OR profitability OR "business value" OR innovation OR efficiency OR competitiveness)
RQ2	*Determinants / barriers / readiness* TITLE-ABS-KEY("AI adoption" OR "artificial intelligence adoption" OR "technology adoption") AND TITLE-ABS-KEY(SME* OR MSME* OR "small business*") AND TITLE-ABS-KEY(barrier* OR challenge* OR determinant* OR driver* OR readiness OR capability OR "digital readiness") *Common frameworks* TITLE-ABS-KEY(SME* OR MSME*) AND TITLE-ABS-KEY("artificial intelligence" OR AI) AND TITLE-ABS-KEY(TOE OR "technology-organization-environment" OR TAM OR "technology acceptance model" OR UTAUT OR "diffusion of innovation*" OR "resource-based view" OR RBV OR "dynamic capability*") *Trust, risk, governance* TITLE-ABS-KEY("artificial intelligence" OR AI) AND TITLE-ABS-KEY(SME* OR MSME*) AND TITLE-ABS-KEY(trust OR risk OR "data privacy" OR cybersecurity OR "data governance" OR regulation OR ethics)
RQ3	*Indonesia MSMEs + digitalization* TITLE-ABS-KEY(Indonesia) AND TITLE-ABS-KEY(MSME* OR SME* OR "small and medium enterprise*" OR UMKM) AND TITLE-ABS-KEY(characteristic* OR profile OR typology OR "business model" OR digitalization OR "digital transformation") *Yogyakarta / DIY regional focus* TITLE-ABS-KEY(Yogyakarta OR "Daerah Istimewa Yogyakarta" OR DIY) AND TITLE-ABS-KEY(MSME* OR SME* OR UMKM OR "small business*") AND TITLE-ABS-KEY(digitalization OR "technology adoption" OR e-commerce OR innovation OR entrepreneurship) Sectoral patterns (tourism, creative economy, culinary, crafts) TITLE-ABS-KEY(Yogyakarta OR DIY OR Indonesia) AND TITLE-ABS-KEY(MSME* OR UMKM OR SME*) AND TITLE-ABS-KEY(tourism OR hospitality OR "creative industr*" OR culinary OR craft* OR batik OR retail)
RQ4	*AI + Indonesia context* TITLE-ABS-KEY(Indonesia) AND TITLE-ABS-KEY("artificial intelligence" OR AI OR "machine learning" OR "generative AI") AND TITLE-ABS-KEY(SME* OR MSME* OR UMKM) AND TITLE-ABS-KEY(opportunit* OR potential OR benefit* OR challenge* OR barrier* OR constraint*) *Skills + workforce + literacy*

	TITLE-ABS-KEY("artificial intelligence" OR AI) AND TITLE-ABS-KEY(SME* OR MSME* OR UMKM) AND TITLE-ABS-KEY(skill* OR "digital skill*" OR literacy OR training OR "human capital" OR workforce) AND TITLE-ABS-KEY(Indonesia OR Yogyakarta OR DIY) *Cost + access + infrastructure* TITLE-ABS-KEY("artificial intelligence" OR AI) AND TITLE-ABS-KEY(SME* OR MSME* OR UMKM) AND TITLE-ABS-KEY(cost OR affordability OR investment OR financing OR infrastructure OR internet OR cloud) AND TITLE-ABS-KEY(Indonesia OR "developing countr*" OR "emerging econom*")
RQ5	*Islamic entrepreneurship + technology* TITLE-ABS-KEY("Islamic entrepreneurship" OR "Muslim entrepreneur*" OR "Islamic business" OR "Islamic ethics") AND TITLE-ABS-KEY(technology OR digitalization OR "digital transformation" OR innovation OR "artificial intelligence" OR AI) AND TITLE-ABS-KEY(Indonesia OR Yogyakarta OR "Southeast Asia") *Ethics + trust + responsibility* TITLE-ABS-KEY("Islamic business ethics" OR "Islamic ethics" OR sharia* OR halal) AND TITLE-ABS-KEY(technology OR AI OR "artificial intelligence") AND TITLE-ABS-KEY(trust OR transparency OR accountability OR fairness OR "social responsibility" OR CSR) *Halal supply chain / integrity angle* TITLE-ABS-KEY(halal OR "halal integrity" OR "halal supply chain") AND TITLE-ABS-KEY(technology OR "digital transformation" OR AI OR "artificial intelligence" OR traceability OR blockchain) AND TITLE-ABS-KEY(SME* OR MSME* OR UMKM)

Source: Scopus (2025).

Inclusion, Exclusion, and Quality Assessment Criteria

Inclusion criteria were established to ensure that selected sources directly contributed to the analytical goals of the study. First, the literature had to address at least one of the following themes: (1) AI adoption or AI-enabled systems in MSMEs; (2) determinants, drivers, or barriers of AI adoption; (3) performance outcomes such as productivity, efficiency, innovation, or competitiveness; (4) Indonesian MSME conditions, with preference for regionally grounded discussions; or (5) Islamic ethical frameworks relevant to business technology decisions. Second, priority was given to studies published in reputable outlets, written in English, and supported by clear methodological reporting, including the use of surveys, case studies, interviews, econometric analysis, or structured conceptual frameworks.

Exclusion criteria were also applied to reduce noise and improve the credibility of the synthesis. Studies were excluded when they lacked clear relevance to MSMEs, focused exclusively on large corporations, or discussed AI in purely technical terms without business adoption implications. Articles that relied primarily on anecdotal claims without supporting evidence were not prioritized. To enhance quality, sources were assessed for clarity of research design, transparency of data and analysis, and coherence between conclusions and findings. This screening ensured that the argumentative review was grounded in verifiable academic evidence rather than speculative claims.

Analytical Framework and Synthesis Procedure

The synthesis process followed a structured thematic approach designed to support argumentative integration rather than descriptive listing. After the literature was identified and screened, each study was examined for its core claims, supporting evidence, and contextual conditions. Findings were then coded into thematic categories aligned with the structure of the Results and Discussion section: (1) global evidence on AI impacts on MSME performance, (2) drivers and barriers of adoption, (3) MSME characteristics in Indonesia and Yogyakarta, (4) opportunities and constraints for AI implementation in Yogyakarta, and (5) ethical reflections based on Islamic business principles. This structure allowed the review to compare how similar themes are treated across different geographic settings and methodological traditions.

The argumentative dimension of the review was developed by contrasting supportive and limiting findings within each theme. For example, studies reporting strong productivity gains were interpreted alongside research emphasizing infrastructural constraints and skill gaps, allowing the review to avoid overly deterministic conclusions. This method also enabled the identification of conditional arguments—such as the role of digital readiness, managerial support, and regulatory trust—as key factors explaining why AI adoption succeeds in some MSMEs but not in others. Through this approach, the review generates an evidence-based position on AI adoption as a strategic opportunity that remains dependent on local capability-building and ethical governance.

Contextualization: Yogyakarta and Muslim Entrepreneurship Lens

A central methodological feature of this review is its contextualization strategy. Rather than assuming that global findings can be directly applied to local settings, the study evaluates how the specific characteristics of MSMEs in Yogyakarta shape AI adoption feasibility. This includes attention to sectoral concentration in creative industries and small-scale production, the prevalence of informal business structures, uneven access to capital, and varying levels of digital capability. The review treats these contextual factors as explanatory variables that influence whether AI adoption becomes a realistic pathway for MSME upgrading or an aspirational discourse that fails to translate into implementation.

In addition, the study integrates Islamic business ethics as an interpretive lens to assess the normative dimensions of AI adoption among Muslim entrepreneurs. This perspective is methodologically important because AI systems may introduce ethical risks related to transparency, fairness, trust, privacy, and potential harm. By incorporating ethical reasoning into the synthesis, the review moves beyond purely instrumental evaluations of efficiency and profitability. Instead, it frames AI adoption as a strategic decision that must be aligned with moral commitments and social responsibility, particularly in communities where religious values shape entrepreneurial identity and legitimacy.

Limitations and Trustworthiness of the Review

This study acknowledges limitations inherent to argumentative review methods. Because the review synthesizes findings across diverse contexts, industries, and research designs, it cannot claim universal generalizability or causal certainty. AI adoption outcomes may vary substantially depending on sectoral dynamics, firm maturity, and national policy environments, and the review therefore emphasizes conditional interpretations rather than deterministic claims. In addition, the literature on AI adoption in Indonesian MSMEs—especially in Yogyakarta—remains less extensive than studies from Europe or other regions, which constrains the depth of locally specific evidence available for synthesis.

To strengthen trustworthiness, the review applies transparent inclusion criteria, thematic coding procedures, and comparative reasoning across studies. The analysis also prioritizes peer-reviewed sources and avoids unsupported generalizations. Finally, the review does not position AI adoption as inherently beneficial or harmful; instead, it evaluates AI as a socio-technical system whose value depends on readiness, governance, and ethical alignment. These limitations and safeguards ensure that the methodological approach remains academically defensible while producing context-sensitive insights relevant to MSMEs and Muslim entrepreneurs in Yogyakarta.

RESULTS AND DISCUSSION

The Impact of AI on MSME Performance

The adoption of Artificial Intelligence (AI) technologies in micro, small, and medium enterprises (MSMEs) is influencing business performance across various metrics including productivity, sales growth, innovation, and cost efficiency. The empirical literature suggests that the effects of AI adoption vary based on contextual factors such as geographic location, firm size, and technological capabilities. This synthesis aims to summarize the conclusions drawn from existing literature regarding the impact of AI on MSME performance, as well as the conditions under which these effects are most pronounced or diminished.

Productivity and Cost Efficiency

Studies indicate that AI technologies can significantly enhance productivity and cost efficiency in MSMEs. For example, Badghish and Soomro found that AI can improve operational performance by optimizing processes, which leads to reduced operational costs and increased efficiency (Badghish & Soomro, 2024). Additionally, Tawil et al. (2024) emphasize the role of AI in facilitating data-driven decision-making that enables MSMEs to manage resources more effectively, thus enhancing overall productivity.

AI's application in automated inventory management has shown potential for reducing errors and improving efficiency in supply chains, affirming its positive impact on operational costs (Salih et al., 2023). However, some studies suggest that high initial costs and technological complexities may prevent some SMEs from fully realizing these

benefits, particularly in developing regions with inadequate infrastructure (Nićin et al., 2024).

Sales Growth and Market Competitiveness

The relationship between AI adoption and sales growth is also supported in the empirical literature. Ardito et al. (2024) found that AI technologies, when combined with Big Data Analytics and the Internet of Things (IoT), can lead to substantial revenue growth among European SMEs. This synergy allows firms to better anticipate customer needs, enhancing market responsiveness and sales performance.

Moreover, Hermansyah (2023) illustrates that AI-based accounting systems can improve financial analysis capabilities, which contributes to sales growth through better pricing strategies. Nonetheless, these benefits can vary based on firm size and industry; medium-sized enterprises often experience a stronger relationship between AI adoption and sales performance compared to smaller firms (Badghish & Soomro, 2024).

Innovation Capabilities

AI plays a crucial role in fostering innovation within MSMEs. Lemos et al. (2022) highlight that the deployment of AI facilitates novel product and service development by enhancing research and development processes, leading to faster iterations and prototyping. In contexts where resources are limited, innovative AI tools can help these firms compete with larger enterprises in innovation (Abaddi, 2024b, 2024a). Furthermore, Wulandari & Diko (2024) showcase AI's transformative impact on HR management practices, optimizing talent acquisition and management processes, which can enhance a firm's creative capacities.

Variability of AI Impacts Based on Contextual Factors

The impacts of AI adoption on MSME performance are not uniform; they vary based on several contextual factors. Firm size, industry type, and regional economic characteristics significantly influence the effectiveness of AI integration. Firms with more established technological infrastructures typically experience greater benefits from AI compared to those with limited capabilities (Díaz-Arancibia et al., 2024). Additionally, factors such as technological readiness and management support are pivotal in influencing the relationship between AI adoption and business performance (Abaddi, 2024b, 2024a).

In developing economies, barriers including limited financial resources, low digital literacy among employees, and inadequate access to necessary technologies can restrict the extent to which MSMEs can effectively harness AI benefits. Research conducted on Jordanian MSMEs identified several factors influencing AI adoption, including management support and the perceived organizational benefits (Abaddi, 2024b).

Previous passages inform that AI adoption profoundly impacts MSME performance by enhancing productivity, driving sales growth, and fostering innovation. However, the degree of impact is contingent upon various factors, including firm size, technological readiness, and contextual challenges unique to different regions. As MSMEs navigate

these challenges, establishing an infrastructure conducive to AI integration will be vital for realizing its full potential benefits.

Drivers and Barriers of AI Adoption Among MSMEs

Artificial Intelligence (AI) adoption within Micro, Small, and Medium Enterprises (MSMEs) is shaped by a complex interplay of several drivers and barriers. This discourse distills the most frequently supported factors influencing AI adoption globally, detailing both the enabling and inhibiting aspects faced by these enterprises.

Key Drivers of AI Adoption

1) Digital Readiness and Infrastructure: The foundation for successful AI integration hinges significantly on the digital readiness of MSMEs, which encompasses both technological infrastructure and human capital. Improved computing capabilities, the rise of cloud computing, and advanced data management systems contribute substantially to this readiness (Ghobakhloo et al., 2022; Tariq et al., 2021). These technological advancements allow MSMEs to leverage AI for operational excellence, effectively reducing costs, enhancing productivity, and optimizing decision-making processes (Badghish & Soomro, 2024; Tariq et al., 2021).
2) Skills and Human Capital: The presence of skilled labor is crucial to AI adoption. Research indicates that enterprises with a skilled workforce are more likely to successfully integrate AI technologies (Abaddi, 2024a; Rawashdeh et al., 2023; Saleem et al., 2023). Training programs focusing on AI and digital competencies can bridge the knowledge gap among MSME employees, fostering a culture of innovation and adaptability (Omrani et al., 2024). This aligns with findings suggesting that organizational readiness, which includes employee skills and knowledge, is a critical factor influencing technology adoption (Enshassi et al., 2024; Tawil et al., 2024).
3) Data Accessibility and Management: An abundance of high-quality data is essential for effectively implementing AI solutions. MSMEs with systematic data management practices are better positioned to utilize AI for meaningful insights and enhanced performance (Burggräf et al., 2024; Tawil et al., 2024). The ability to harness data analytics leads to improved customer engagement, predictive maintenance, and operational efficiency, underscoring the importance of data availability (Falahat et al., 2022; Rawashdeh et al., 2023).
4) Regulatory Support and Trust: Trust in AI technologies, coupled with a favorable regulatory environment, amplifies the prospects for adoption. Government initiatives and policies that support digital transformation, such as subsidies and tax incentives for technology adoption, can significantly alleviate financial constraints (Badghish & Soomro, 2024). Additionally, developing trust through transparent AI operations fosters acceptance among users, facilitating smoother implementation (Madhavan et al., 2024).
5) Financial Factors: Access to financing plays a pivotal role in enabling MSMEs to adopt AI technologies. Investments in AI can be costly, and without adequate

funding options, firms may hesitate to commit to AI adoption (Badghish & Soomro, 2024; Díaz-Arancibia et al., 2024). Financing mechanisms, including grants and affordable loans targeted at technology development, are critical elements in promoting AI utilization among smaller enterprises (Eze et al., 2021; Tariq et al., 2021).

Barriers to AI Adoption

1) Resource Constraints: Limited financial and technological resources are significant barriers hindering AI adoption among MSMEs. Many smaller firms struggle with the upfront costs associated with AI implementation (Burggräf et al., 2024; Ghobakhloo et al., 2022). They often lack the infrastructure required to support advanced technologies due to their constrained budgets (Mousa et al., 2024; Msomi et al., 2020). This indicates that enhancing financial accessibility is critical for alleviating such pressures.
2) Lack of Awareness and Knowledge: Insufficient awareness about the benefits and functionalities of AI presents a major stumbling block for many MSMEs. A prevalent uncertainty regarding AI's relevance and return on investment often leads to hesitation in adoption (Abaddi, 2024b; Saleem et al., 2023). This barrier is compounded by the often scarce training programs available to enhance the workforce's digital skills, crucial for effective AI integration (Rawashdeh et al., 2023; Roux et al., 2023).
3) Cultural Resistance: Organizational culture within MSMEs can resist change, especially regarding the adoption of new technologies. Established practices and mindsets can inhibit the open-mindedness necessary for embracing AI (Abaddi, 2024b; Burggräf et al., 2024). Engaging leadership to foster a culture of innovation is vital; otherwise, even the most promising technology may be underutilized (Eze et al., 2021; Rawashdeh et al., 2023).
4) Data Security and Privacy Concerns: The apprehension regarding data security and privacy risks complicates AI adoption. Many MSMEs fear potential breaches, leading to reluctance in handling sensitive data required for AI algorithms (Omrani et al., 2024; Saleem et al., 2023). Such fears can deter firms from pursuing AI, despite the acknowledged benefits.
5) Regulatory and Compliance Challenges: Complex regulatory frameworks surrounding data usage and AI implementations can deter MSMEs. Navigating these regulations often requires legal expertise that smaller firms might lack, leading to inaction or avoidance of AI projects altogether (Badghish & Soomro, 2024; Eze et al., 2021).

The decision to adopt AI in MSMEs does not rest on a single factor; rather, it is the outcome of various interconnected elements that can either facilitate or obstruct the process. Drivers such as digital readiness, skills development, and supportive regulations are critical for the successful integration of AI, while barriers including resource constraints, cultural resistance, and data security concerns must be strategically addressed. By understanding and leveraging these factors, MSMEs can

enhance their operational efficiency and maintain competitive advantages in a rapidly evolving technological landscape.

Differences in Business Structure, Digital Capability, Sectoral Concentration, and Access to Capital and Technology of MSMEs in Yogyakarta, Indonesia

Micro, Small, and Medium Enterprises (MSMEs) play a significant role in Indonesia's economy, particularly in Yogyakarta, which is known for its concentration of creative industries and cultural heritage. Recent studies and reports provide insights into the varied characteristics of MSMEs in this region regarding their business structure, digital capability, sectoral concentration, and access to capital and technology.

Business Structure

MSMEs in Yogyakarta typically exhibit diverse business structures that reflect a mix of traditional and modern practices. The majority are family-owned, often characterized by informal operations and limited resources. Research indicates that nearly 100% of businesses in Indonesia are MSMEs, but their contribution to GDP is modest, estimated between 58% to 61% (Suryanti et al., 2021; Zuhroh et al., 2024). This suggests that while numerous, many operate at subsistence levels, with structures that might not support rapid scaling or significant economic impact.

Additionally, businesses within the MSME sector often engage in informal partnerships and networking, which, while beneficial for resource sharing, may limit their access to formal financial systems and technological innovations (Zuhroh et al., 2024). This reliance on informal structures may hinder their competitiveness on a larger scale, especially when facing more formalized organizations.

Digital Capability

The digital capability of MSMEs in Yogyakarta is variable. Recent studies show a significant gap in digital literacy and the adoption of digital tools. One study highlights that only a portion of MSMEs have embraced digital platforms for marketing or operations (Bening et al., 2023). The COVID-19 pandemic acted as a catalyst for some MSMEs to pivot towards digital solutions, but many still struggle with digital transformation due to factors such as inadequate access to technology, low levels of digital literacy among owners and employees, and insufficient management support for digital initiatives (Anatan & Nur, 2023; Suasih & Budhi, 2023).

This digital divide is particularly clear concerning e-commerce, where estimates indicate that only about 22% of MSMEs in Indonesia have fully adopted e-commerce technologies, despite the evident benefits (Bening et al., 2023).

Sectoral Concentration

The sectoral concentration of MSMEs in Yogyakarta leans heavily toward the creative industries, notably batik and other cultural handicrafts, as well as the food and beverage sectors (Al-Shami et al., 2024; Prabowo et al., 2020). Research has demonstrated that batik MSMEs significantly contribute to the local identity and economy, positioning these businesses as not only economic entities but also cultural preservations (Al-Shami et al., 2024).

However, there is a disparity in growth and support across sectors. For instance, batik MSMEs often benefit from niche markets at home and abroad, whereas local businesses in sectors such as agriculture or manufacturing may experience stunted growth due to market saturation and lack of innovation (Rita et al., 2022).

Access to Capital and Technology

Access to capital remains a significant challenge for MSMEs in Yogyakarta. A study indicates that many MSME owners report difficulties in obtaining financing due to high-interest rates and stringent borrowing requirements set by financial institutions (Zuhroh et al., 2024). Another study specifically on batik SMEs noted that despite their cultural and economic significance, financing options are limited and often dependent on informal sources or personal savings (Hadi et al., 2023).

Moreover, the technological landscape in which MSMEs operate is influenced by regional economic policies and local government initiatives aimed at enhancing access to financial technology (Hadi et al., 2023). However, the effectiveness of these initiatives can vary widely, often depending on the entrepreneurial mindset of MSME owners and their willingness to engage with new technologies (Anatan & Nur, 2023; Sulastri et al., 2023).

Based on previous passages, MSMEs in Yogyakarta exhibit distinct differences in their business structure, digital capabilities, sectoral concentrations, and access to capital and technology. While they form the backbone of the regional economy, challenges such as digital literacy gaps, limited access to formal financing, and varying success across sectors impede their potential for growth and sustainability. Addressing these challenges through targeted support and investment can bolster their contributions to the local and national economy.

Opportunities and Constraints for Implementing AI Among MSMEs in Yogyakarta, Indonesia

The implementation of Artificial Intelligence (AI) among micro, small, and medium enterprises (MSMEs) in Yogyakarta presents both significant opportunities and constraints, particularly in the areas of workforce skills, infrastructure, affordability, data governance, and customer readiness. The existing literature highlights these aspects, illuminating the landscape for AI adoption in this specific region of Indonesia.

Opportunities for AI Implementation

1) Enhanced Productivity and Decision-Making: AI can boost productivity by automating routine tasks, allowing MSMEs to allocate resources more effectively (Behl et al., 2023; Kumar et al., 2024; P. Sharma et al., 2022). The potential for AI technologies to improve operational efficiencies is well-established, suggesting that Yogyakarta's MSMEs could benefit from enhanced decision-making capabilities.
2) Support for Sustainable Practices: The integration of AI into MSMEs has the potential to facilitate sustainable business practices. Akbari & Hopkins (2022) discuss how digital technologies, including AI, can enable better resource

management and sustainability initiatives in emerging economies. For MSMEs focused on sustainability, leveraging AI can help in optimizing supply chains and reducing waste.

3) Availability of Local Talent: Research indicates that initiatives aimed at increasing digital literacy among students can lead to a skilled workforce adept in AI technologies (Mustopa et al., 2024). By investing in educational programs around AI, MSMEs can tap into a pool of talent that is increasingly familiar with emerging technologies.
4) Government Support and Policy Frameworks: Regulatory frameworks and governmental initiatives aimed at promoting technological adoption can create conducive environments for MSMEs (Aggarwal & Joshi, 2024; Jomon T. K., 2024; Loo et al., 2023). For example, policy incentives can lower the barriers to AI adoption through financial support or subsidies for technology investment.

Constraints to AI Implementation

1) Limited Workforce Skills: A significant barrier to the adoption of AI technologies among MSMEs is the lack of skilled personnel (Oldemeyer et al., 2024; Peretz-Andersson et al., 2024; Schwaeke et al., 2025). Current research suggests that while there is an emerging pool of students with theoretical knowledge, practical skills in AI implementations are limited (Aminullah et al., 2024). This gap in technical expertise can lead to difficulties in effectively integrating AI technologies into business processes.
2) Infrastructural Challenges: The existing infrastructure in many areas of Indonesia is often inadequate for advanced technology implementation (Ray & Ing, 2016; Salim & Negara, 2018; Sandee, 2016). Issues related to internet connectivity, data storage facilities, and computational resources can impede the effective use of AI (Wang et al., 2021). Without a robust technological infrastructure, the potential benefits of AI may remain unrealized.
3) Affordability and Financial Constraints: The financial burden of adopting AI can be substantial, particularly for smaller businesses operating on tight margins. Many MSMEs may find it challenging to invest in AI technologies because the return on investment (ROI) is often unclear or slow to materialize (Akbari & Hopkins, 2022; Cannas et al., 2024; Enholm et al., 2022; Oldemeyer et al., 2024; Schwaeke et al., 2025). This factor can dissuade businesses from taking the plunge into AI, especially if they lack access to external funding.
4) Data Governance and Privacy Concerns: Effective data governance is critical for the successful adoption of AI. The literature suggests that many MSMEs lack robust data management practices, which can lead to issues regarding data quality, privacy, and compliance with regulations (Aldoseri et al., 2023; Derhab & Elkhwesky, 2023; Hernández et al., 2024; M. Sharma et al., 2022; Whang et al., 2023). In regions like Yogyakarta, ensuring data integrity and security is foundational for building trust in AI applications.

5) Customer Readiness and Acceptance: The willingness of customers to accept AI-driven services or products also constitutes a significant constraint. Research shows that if customers are skeptical about the reliability and benefits of AI, MSMEs may face challenges in convincing them to engage with new technologies (Ameen et al., 2021; Kelly et al., 2023; Puntoni et al., 2021; Wang et al., 2021). The readiness of the customer base can thus influence the success of AI initiatives significantly.

The landscape for implementing AI among MSMEs in Yogyakarta is characterized by a mix of promising opportunities and notable constraints. The potential for improved productivity, enhanced sustainability, local talent development, and government support provides a clear path forward. However, constraints in skills, infrastructure, affordability, data governance, and customer readiness present formidable challenges that policymakers and business leaders must address to facilitate effective AI adoption in this region.

The Informing Role of Islamic Business Ethics in MSME Decision-Making about AI Adoption

The growing incorporation of Artificial Intelligence (AI) in micro, small, and medium enterprises (MSMEs) poses notable implications for decision-making processes, particularly within the context of Muslim entrepreneurship where Islamic business ethics play a pivotal role. Research indicates that core Islamic ethical principles—such as trust, transparency, fairness, halal integrity, and social responsibility—significantly impact how Muslim entrepreneurs approach AI adoption and its associated challenges, including risk of harm and inequality.

Trust and Transparency

Trust is a foundational pillar in Islamic business ethics. Kamarulzaman et al. (2022) emphasize that the adoption of halal traceability systems among food SMEs enhances operational processes and promotes trust among consumers, leading to informed decision-making. This reflects a broader trend where transparency in AI applications, especially regarding data handling and consumer privacy, is critical for building trust (Balasubramaniam et al., 2023; B. Li et al., 2023; Zerilli et al., 2022). Gorian & Osman (2024) further elucidate that Islamic digital ethics necessitate accountability and human dignity, which can be reinforced through transparent AI practices. When MSMEs prioritize transparent AI systems, they foster consumer trust, which is essential for cultivating long-term client relationships.

Fairness in AI Implementation

Fairness is another core aspect guided by Islamic principles. Abdullah et al. (2024) discuss the importance of ensuring AI applications in Islamic finance are accepted by Shariah committees, which underscores the need for fairness in algorithmic decision-making. This is particularly pertinent for MSMEs that deploy AI for customer financing or resource distribution, ensuring equitable treatment of all stakeholders. The ethical implications of AI in business processes cannot be overlooked; hence, incorporating

Islamic ethical frameworks ensures that decision-making aligns with the objective of justice, a fundamental tenet in Islam.

Halal Integrity and Social Responsibility

The concept of halal integrity extends beyond mere compliance with dietary restrictions and resonates profoundly within the sphere of AI in MSMEs. Previous studies (Cahyono et al., 2023; R. K. Sari et al., 2024; Susiang et al., 2024; Tumiwa et al., 2023) emphasize the relevance of halal business management as a guiding principle for MSMEs engaged in the halal industry, advocating for adherence to ethical standards throughout the decision-making process. This approach contributes to social responsibility by ensuring that business practices do not harm the community or undermine the welfare of consumers. The integration of AI should thus align with halal principles, promoting a sustainable environment and ethical operations.

Risk of Harm and Inequality

The deployment of AI solutions poses inherent risks related to harm and inequality, a concern echoed in studies on Islamic finance. Hartanto et al. (2023) indicate that ethical considerations in Islamic finance are crucial in enhancing MSME growth, aligning innovation with moral frameworks. The potential of AI to exacerbate existing inequalities (Al-kfairy et al., 2024; Bankins & Formosa, 2023; Dankwa-Mullan, 2024; Madan & Ashok, 2023; Ong et al., 2024; Sartori & Theodorou, 2022) should be mitigated through strategic planning that incorporates Islamic ethical values (Elmahjub, 2023; Gorian & Osman, 2024), promoting inclusive growth that benefits all segments of society. MSME leaders must engage in thoughtful discourse regarding the implications of AI, ensuring that the benefits are equitably distributed and do not lead to the marginalization of specific community segments.

Previous passages inform that the intersection of Muslim entrepreneurship and Islamic business ethics significantly informs MSME decision-making regarding AI adoption. Trust, transparency, fairness, halal integrity, and social responsibility emerge as salient themes guiding these decisions. To navigate the complexities of AI implementation responsibly, Muslim entrepreneurs can draw upon Islamic ethical principles as a framework, emphasizing moral and socially responsible outcomes. This approach not only aligns with their faith but also fosters a sustainable business environment that takes into consideration the welfare of the community and industry standards. This synthesis demonstrates how the principles of Islamic business ethics inform crucial areas of MSME decision-making, shaping their approach to AI adoption within a framework that prioritizes ethical standards and community welfare.

CONCLUSION

This argumentative review shows that artificial intelligence (AI) adoption can generate meaningful performance benefits for micro, small, and medium enterprises (MSMEs), especially through improvements in productivity, cost efficiency, and data-driven decision-making. Across multiple studies, AI-enabled tools are associated with operational optimization, reduced errors in routine processes, and stronger internal

coordination, which collectively enhance business resilience and performance. Evidence also indicates that AI adoption may contribute to sales growth and competitiveness when it is integrated with complementary digital capabilities such as data analytics and connected technologies. However, the review highlights that AI-driven value creation is not automatic; it is strongly dependent on contextual readiness, including infrastructure quality, managerial commitment, and workforce competence.

The study also emphasizes that AI adoption among MSMEs is shaped by a persistent gap between potential and feasibility. Key barriers include limited financial resources, inadequate digital infrastructure, low levels of AI-related skills, and weak data governance practices. These constraints are especially relevant for MSMEs in developing contexts, where adoption is frequently constrained by uncertainty regarding return on investment and by limited access to technical support. In Indonesia, and particularly in Yogyakarta, MSMEs often operate in informal or family-based structures, with uneven digital capability and restricted access to capital. These conditions suggest that AI adoption strategies must be practical, incremental, and aligned with sectoral realities, rather than framed as a one-size-fits-all transformation agenda.

Finally, this review contributes to existing knowledge by integrating an ethical and religious lens into the AI adoption debate. For Muslim entrepreneurs in Yogyakarta, adoption decisions are not purely economic but also shaped by Islamic business ethics emphasizing trust, transparency, fairness, halal integrity, and social responsibility. This perspective clarifies that responsible AI adoption requires not only technical feasibility but also ethical legitimacy and community-oriented outcomes. By connecting global AI adoption evidence, Indonesian MSME characteristics, and Islamic ethical considerations, the study offers a more context-sensitive framework for understanding AI as both an opportunity and a governance challenge. Future research can extend this framework through empirical studies in Yogyakarta that test adoption pathways, measure outcomes, and examine ethical decision-making in real MSME settings.

Limitation of the Study

This study has several limitations that should be acknowledged when interpreting its conclusions. First, as an argumentative review, it synthesizes findings from diverse empirical contexts, sectors, and methodological designs, which limits the ability to draw causal conclusions about AI adoption outcomes. The reviewed studies vary in how they define AI adoption, measure performance effects, and assess organizational readiness, making direct comparison challenging. In addition, many published works emphasize success cases or positive outcomes, which may introduce publication bias and underrepresent unsuccessful implementations, hidden costs, or unintended consequences of AI use in small firms.

Second, the availability of region-specific evidence remains limited, particularly for MSMEs in Yogyakarta. While Indonesian MSME research provides valuable context, detailed empirical studies that directly examine AI adoption processes, decision-making dynamics, and implementation outcomes in Yogyakarta are still relatively

scarce. As a result, some contextual interpretations in this review rely on broader Indonesian findings or comparable emerging-economy evidence, which may not fully capture Yogyakarta's unique sectoral composition, institutional environment, and cultural-economic conditions. Finally, although the study integrates Islamic business ethics as an analytical lens, the review does not empirically measure how religious values are operationalized in real adoption decisions. This limitation suggests the need for caution in translating ethical principles into assumed behavioral patterns without field-based validation.

Recommendations for Future Research

Future research should prioritize empirical investigations that directly examine AI adoption among MSMEs in Yogyakarta, using designs capable of capturing both outcomes and implementation processes. Mixed-method studies that combine surveys, interviews, and case-based analysis would be particularly useful for identifying adoption pathways, capability requirements, and sector-specific constraints. Researchers may also develop and test contextual readiness models that incorporate infrastructure, managerial orientation, workforce skill levels, and data governance maturity as predictors of successful AI integration. In addition, longitudinal studies are needed to assess whether AI adoption produces sustained performance improvements over time, rather than short-term efficiency gains that may fade without continuous learning and investment.

Further research is also needed to refine the ethical dimension of AI adoption for Muslim entrepreneurs. Qualitative studies could explore how principles such as trust, fairness, transparency, and halal integrity influence technology evaluation, vendor selection, data practices, and customer communication strategies. Researchers may also examine whether ethical commitments shape the choice of AI applications, such as marketing automation, financial analytics, or halal traceability systems, and how these choices affect consumer trust and community legitimacy. Finally, future studies should evaluate policy and ecosystem interventions—such as subsidized AI training, university–MSME partnerships, and affordable AI-as-a-service programs—to determine which strategies most effectively reduce adoption barriers for small firms. This line of research can produce actionable evidence for policymakers and local institutions seeking to support responsible and inclusive AI diffusion in Yogyakarta.

Author Contributions

Conceptualization	E.S.H. & B.A.	Resources	E.S.H. & B.A.
Data curation	E.S.H. & B.A.	Software	E.S.H. & B.A.
Formal analysis	E.S.H. & B.A.	Supervision	E.S.H. & B.A.
Funding acquisition	E.S.H. & B.A.	Validation	E.S.H. & B.A.
Investigation	E.S.H. & B.A.	Visualization	E.S.H. & B.A.
Methodology	E.S.H. & B.A.	Writing – original draft	E.S.H. & B.A.
Project administration	E.S.H. & B.A.	Writing – review & editing	E.S.H. & B.A.

All authors have read and agreed to the published version of the manuscript.

Funding

This study received no direct funding from any institution.

Institutional Review Board Statement

The study was approved by Program Studi Ilmu Ekonomi (S3), Universitas Islam Indonesia, Kab. Sleman, Indonesia.

Informed Consent Statement

Informed consent was not required for this study.

Data Availability Statement

The data presented in this study are available upon request to first author.

Acknowledgments

The authors thank Program Studi Ilmu Ekonomi (S3), Universitas Islam Indonesia, Kab. Sleman, Indonesia for administrative support for the research on which this article was based.

Conflicts of Interest

The authors declare no conflicts of interest.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors used ChatGPT, DeepL, Grammarly, and PaperPal to translate from Bahasa Indonesia into American English and improve the clarity of the language and readability of the article. After using these tools, the authors reviewed and edited the content as needed and took full responsibility for the content of the published article.

REFERENCES

Abaddi, S. (2024a). AI's call: Jordan's MSMEs answer with intent. *Journal of Entrepreneurship in Emerging Economies*. https://doi.org/10.1108/JEEE-11-2023-0446

Abaddi, S. (2024b). Factors and moderators influencing artificial intelligence adoption by Jordanian MSMEs. *Management & Sustainability: An Arab Review*. https://doi.org/10.1108/MSAR-10-2023-0049

Abdullah, O., Shaharuddin, A., Wahid, M. A., & Harun, M. S. (2024). AI applications for fiqh rulings in Islamic banks – Shariah committee acceptance. *ISRA International Journal of Islamic Finance*, *16*(1), 111–126. https://doi.org/10.55188/ijif.v16i1.685

Adenuga, T., Ayobami, A., & Mike-Olisa, U. (2024). Enabling AI-driven decision-making through scalable and secure data infrastructure for enterprise transformation. *International Journal of Scientific Research in Science, Engineering and Technology*, *11*, 482–510. https://doi.org/10.32628/IJSRSET241486

Aderibigbe, A. O., Ohenhen, P. E., Nwaobia, N. K., Gidiagba, J. O., & Ani, E. C. (2023). Artificial intelligence in developing countries: Bridging the gap between potential and implementation. *Computer Science & IT Research Journal*, *4*(3), 185–199. https://doi.org/10.51594/csitrj.v4i3.629

Aggarwal, A., & Joshi, N. (2024). MSMEs' innovation: A barrier approach. *Journal of Small Business and Enterprise Development*, *31*(3), 552–573. https://doi.org/10.1108/JSBED-07-2023-0304

Ahmed, S. (2024). Fatwā and AI: A literature-based assessment on how AI impacts the role of the muftī. *Journal for Islamic Studies*, *42*(1–2), 1–19. https://doi.org/10.25159/2957-9163/14400

Akbari, M., & Hopkins, J. L. (2022). Digital technologies as enablers of supply chain sustainability in an emerging economy. *Operations Management Research*, *15*(3–4), 689–710. https://doi.org/10.1007/s12063-021-00226-8

Al-Amin, K. O., Ewim, C. P.-M., Igwe, A. N., & Ofodile, O. C. (2024). AI-Driven end-to-end workflow optimization and automation system for SMEs. *International Journal of Management & Entrepreneurship Research*, *6*(11), 3666–3684. https://doi.org/10.51594/ijmer.v6i11.1688

Alarefi, M. (2024). The impact of artificial intelligence on business performance in Saudi Arabia: The role of technological readiness and data quality. *Engineering, Technology & Applied Science Research*, *14*(5), 16802–16807. https://doi.org/10.48084/etasr.7871

Aldoseri, A., Al-Khalifa, K. N., & Hamouda, A. M. (2023). Re-thinking data strategy and integration for artificial intelligence: Concepts, opportunities, and challenges. *Applied Sciences*, *13*(12), 7082. https://doi.org/10.3390/app13127082

Al-kfairy, M., Mustafa, D., Kshetri, N., Insiew, M., & Alfandi, O. (2024). Ethical challenges and solutions of Generative AI: An interdisciplinary perspective. *Informatics*, *11*(3), 58. https://doi.org/10.3390/informatics11030058

Al-Shami, S. A., Damayanti, R., Adil, H., Farhi, F., & Al Mamun, A. (2024). Financial and digital financial literacy through social media use towards financial inclusion among batik small enterprises in Indonesia. *Heliyon*, *10*(15), e34902. https://doi.org/10.1016/j.heliyon.2024.e34902

Alzaghal, Q., Salah, O., & Ayyash, M. (2024). *Leveraging artificial intelligence for SMEs' sustainable competitive advantage*: *The moderating role of managers digital literacy*. *102*(21), 7731–7748.

Ameen, N., Tarhini, A., Reppel, A., & Anand, A. (2021). Customer experiences in the age of artificial intelligence. *Computers in Human Behavior*, *114*, 106548. https://doi.org/10.1016/j.chb.2020.106548

Aminullah, E., Fizzanty, T., Nawawi, N., Suryanto, J., Pranata, N., Maulana, I., Ariyani, L., Wicaksono, A., Suardi, I., Azis, N. L. L., & Budiatri, A. P. (2024). Interactive components of digital MSMEs ecosystem for inclusive digital economy in Indonesia. *Journal of the Knowledge Economy*, *15*(1), 487–517. https://doi.org/10.1007/s13132-022-01086-8

Anatan, L. & Nur. (2023). Micro, small, and medium enterprises' readiness for digital transformation in Indonesia. *Economies*, *11*(6), 156. https://doi.org/10.3390/economies11060156

Anggadwita, G., Ramadani, V., Alamanda, D. T., Ratten, V., & Hashani, M. (2017). Entrepreneurial intentions from an Islamic perspective: A study of Muslim entrepreneurs in Indonesia. *International Journal of Entrepreneurship and Small Business*, *31*(2), 165–179. https://doi.org/10.1504/IJESB.2017.084086

Ardito, L., Filieri, R., Raguseo, E., & Vitari, C. (2024). Artificial intelligence adoption and revenue growth in European SMEs: Synergies with IoT and big data analytics. *Internet Research*. https://doi.org/10.1108/INTR-02-2024-0195

Badghish, S., & Soomro, Y. A. (2024). Artificial Intelligence adoption by SMEs to achieve sustainable business performance: Application of technology–organization–environment framework. *Sustainability*, *16*(5), 1864. https://doi.org/10.3390/su16051864

Balasubramaniam, N., Kauppinen, M., Rannisto, A., Hiekkanen, K., & Kujala, S. (2023). Transparency and explainability of AI systems: From ethical guidelines to requirements. *Information and Software Technology*, *159*, 107197. https://doi.org/10.1016/j.infsof.2023.107197

Bankins, S., & Formosa, P. (2023). The ethical implications of artificial intelligence (AI) for meaningful work. *Journal of Business Ethics*, *185*(4), 725–740. https://doi.org/10.1007/s10551-023-05339-7

Barton, M., Budjac, R., Tanuska, P., Gaspar, G., & Schreiber, P. (2022). Identification overview of Industry 4.0 essential attributes and resource-limited embedded artificial-intelligence-of-things devices for small and medium-sized enterprises. *Applied Sciences*, *12*(11), 5672. https://doi.org/10.3390/app12115672

Behl, A., Sampat, B., Pereira, V., & Chiappetta Jabbour, C. J. (2023). The role played by responsible artificial intelligence (RAI) in improving supply chain performance in the MSME sector: An empirical inquiry. *Annals of Operations Research*. https://doi.org/10.1007/s10479-023-05624-8

Bening, S. A., Dachyar, M., Pratama, N. R., Park, J., & Chang, Y. (2023). E-commerce technologies adoption strategy selection in Indonesian SMEs using the decision-makers, technological, organizational and environmental (DTOE) framework. *Sustainability*, *15*(12), 9361. https://doi.org/10.3390/su15129361

Brall, C., Schröder-Bäck, P., & Maeckelberghe, E. (2019). Ethical aspects of digital health from a justice point of view. *European Journal of Public Health*, *29*(Supplement_3), 18–22. https://doi.org/10.1093/eurpub/ckz167

Buhmann, A., & Fieseler, C. (2021). Towards a deliberative framework for responsible innovation in artificial intelligence. *Technology in Society*, *64*, 101475. https://doi.org/10.1016/j.techsoc.2020.101475

Bukran, B., & Ramdani, R. (2024). Pengaruh kebijakan ekonomi hijau terhadap inovasi bisnis berkelanjutan di sektor manufaktur [The impact of green economic policies on sustainable business innovation in the manufacturing sector]. *ECONOMIST: Jurnal Ekonomi Dan Bisnis*, *1*(3), 35–42. https://doi.org/10.63545/economist.v1i3.58

Burggräf, P., Steinberg, F., Sauer, C. R., & Nettesheim, P. (2024). Machine learning implementation in small and medium-sized enterprises: Insights and recommendations from a quantitative study. *Production Engineering*, *18*, 751–764. https://doi.org/10.1007/s11740-024-01274-2

Cahyono, Y., Purwoko, D., Koho, I., Setiani, A., Supendi, S., Setyoko, P., Sosiady, M., & Wijoyo, H. (2023). The role of supply chain management practices on competitive advantage and performance of halal agroindustry SMEs. *Uncertain Supply Chain Management*, *11*(1), 153–160. https://growingscience.com/beta/uscm/5834-the-role-of-supply-chain-management-practices-on-competitive-advantage-and-performance-of-halal-agroindustry-smes.html

Cannas, V. G., Ciano, M. P., Saltalamacchia, M., & Secchi, R. (2024). Artificial intelligence in supply chain and operations management: A multiple case study research. *International Journal of Production Research*, *62*(9), 3333–3360. https://doi.org/10.1080/00207543.2023.2232050

Chaudhuri, R., Chatterjee, S., Vrontis, D., & Chaudhuri, S. (2022). Innovation in SMEs, AI dynamism, and sustainability: The current situation and way forward. *Sustainability*, *14*(19), 12760. https://doi.org/10.3390/su141912760

Dankwa-Mullan, I. (2024). Health equity and ethical considerations in using artificial intelligence in public health and medicine. *Preventing Chronic Disease*, *21*, 240245. https://doi.org/10.5888/pcd21.240245

Derhab, N., & Elkhwesky, Z. (2023). A systematic and critical review of waste management in micro, small and medium-sized enterprises: Future directions for theory and practice. *Environmental Science and Pollution Research*, *30*(6), 13920–13944. https://doi.org/10.1007/s11356-022-24742-7

Dey, P. K., Chowdhury, S., Abadie, A., Vann Yaroson, E., & Sarkar, S. (2024). Artificial intelligence-driven supply chain resilience in Vietnamese manufacturing small- and medium-sized enterprises.

International Journal of Production Research, *62*(15), 5417–5456. https://doi.org/10.1080/00207543.2023.2179859

Díaz-Arancibia, J., Hochstetter-Diez, J., Bustamante-Mora, A., Sepúlveda-Cuevas, S., Albayay, I., & Arango-López, J. (2024). Navigating digital transformation and technology adoption: A literature review from small and medium-sized enterprises in developing countries. *Sustainability*, *16*(14), 5946. https://doi.org/10.3390/su16145946

Elmahjub, E. (2023). Artificial intelligence (AI) in Islamic ethics: Towards pluralist ethical benchmarking for AI. *Philosophy & Technology*, *36*(4), 73. https://doi.org/10.1007/s13347-023-00668-x

Enholm, I. M., Papagiannidis, E., Mikalef, P., & Krogstie, J. (2022). Artificial intelligence and business value: A literature review. *Information Systems Frontiers*, *24*(5), 1709–1734. https://doi.org/10.1007/s10796-021-10186-w

Enshassi, M., Nathan, R. J., Soekmawati, S., Al-Mulali, U., & Ismail, H. (2024). Potentials of artificial intelligence in digital marketing and financial technology for small and medium enterprises. *IAES International Journal of Artificial Intelligence (IJ-AI)*, *13*(1), 639. https://doi.org/10.11591/ijai.v13.i1.pp639-647

Eskandarany, A. (2024). Adoption of artificial intelligence and machine learning in banking systems: A qualitative survey of board of directors. *Frontiers in Artificial Intelligence*, *7*. https://doi.org/10.3389/frai.2024.1440051

Eze, S. C., Chinedu-Eze, V. C., & Bello, A. O. (2021). Some antecedent factors that shape SMEs adoption of social media marketing applications: A hybrid approach. *Journal of Science and Technology Policy Management*, *12*(1), 41–61. https://doi.org/10.1108/JSTPM-06-2019-0063

Fajri, F., Perdana, K. A., Manurung, D. U., Dharmawan, P. K. N., & Dewi, N. G. (2024). The role of early adoption of artificial intelligence in supporting the growth of micro and ultra-micro enterprises in Indonesia: Challenges and opportunities. *Jurnal Akuntansi Dan Bisnis*, *10*(02), 133–143. https://doi.org/10.47686/jab.v10i02.744

Falahat, M., Cheah, P. K., Jayabalan, J., Lee, C. M. J., & Kai, S. B. (2022). Big data analytics capability ecosystem model for SMEs. *Sustainability*, *15*(1), 360. https://doi.org/10.3390/su15010360

Fathallah, R., Sidani, Y., & Khalil, S. (2020). How religion shapes family business ethical behaviors: An institutional logics perspective. *Journal of Business Ethics*, *163*(4), 647–659. https://doi.org/10.1007/s10551-019-04383-6

Fathoni, I., & Asfiah, N. (2024). Transformasi digital bisnis UMKM di Indonesia setelah masa pandemi [The digital transformation of MSMEs in Indonesia after the pandemic]. *Innovative: Journal Of Social Science Research*, *4*(3), 10219–10236. https://doi.org/10.31004/innovative.v4i3.11354

Ghobakhloo, M., Iranmanesh, M., Vilkas, M., Grybauskas, A., & Amran, A. (2022). Drivers and barriers of Industry 4.0 technology adoption among manufacturing SMEs: A systematic review and transformation roadmap. *Journal of Manufacturing Technology Management*, *33*(6), 1029–1058. https://doi.org/10.1108/JMTM-12-2021-0505

Gorian, E., & Osman, N. D. (2024). Digital ethics of artificial intelligence (AI) in Saudi Arabia and United Arab Emirates. *Malaysian Journal of Syariah and Law*, *12*(3), 583–597. https://doi.org/10.33102/mjsl.vol12no3.798

Govindan, K. (2024). How artificial intelligence drives sustainable frugal innovation: A multitheoretical perspective. *IEEE Transactions on Engineering Management*, *71*, 638–655. https://doi.org/10.1109/TEM.2021.3116187

Hadi, D. P., Adi, P. H., Arintoko, & Ahmad, A. A. (2023). The impact of the Omnibus Law Cipta Kerja on the sustainability of MSMEs and economic growth by applying the canvas model business method and the use of financial technology, especially crowdfunding and microfinance. *International Journal of Sustainable Development and Planning*, *18*(2), 505–513. https://doi.org/10.18280/ijsdp.180219

Hamzah, M., Ningsih, R. F. Y., Faria Z.A., U., Ummah, M. U., & Fitriya, L. (2023). Peran transformasi digital dan tantangan inovasi terhadap keberlanjutan UMKM di Indonesia (Studi literature review) [The role of digital transformation and innovation challenges on the sustainability of MSMEs in Indonesia (Literature review study)]. *Hatta: Jurnal Pendidikan Ekonomi dan Ilmu Ekonomi*, *1*(2), 109–118. https://doi.org/10.62387/hatta.v1i2.53

Hartanto, S., Suparyanto, T., & Azwar. (2023). Islamic finance practices in micro, small, and medium enterprises in Indonesia: A systematic literature review. *Millah: Journal of Religious Studies*, *22*(2), 435–464. https://doi.org/10.20885/millah.vol22.iss2.art6

Hemmet, A. (2023). Harmonizing artificial intelligence with Islamic values—A thoughtful analysis of religious, social, and economic impacts of technological advancements. *American Journal of Smart Technology and Solutions*, *2*(2), 65–76. https://doi.org/10.54536/ajsts.v2i2.2239

Hermansyah, Y. (2023). Assessing the impact of communicative artificial intelligence based accounting information systems on small and medium enterprises. *Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications*, *14*(3), 230–239. https://doi.org/10.58346/JOWUA.2023.I3.017

Hernández, V., Revilla, A., & Rodríguez, A. (2024). Digital data-driven technologies and the environmental sustainability of micro, small, and medium enterprises: Does size matter? *Business Strategy and the Environment*, *33*(6), 5563–5582. https://doi.org/10.1002/bse.3765

Hidayat, I., Qurotulaini, D. L., Safitri, N. A., & Novitasari, R. (2024). Transformasi digital pada UMKM di Indonesia dalam menghadapi tantangan dan peluang pada akses pembiayaan [Digital transformation in Indonesian MSMEs in facing challenges and opportunities in access to financing]. *Jurnal Intelek Insan Cendikia*, *1*(10), 7414–7413. https://jicnusantara.com/index.php/jiic/article/view/1992

Hidayat, W. H., & Kholik, N. (2024). Implikasi hukum atas perubahan bisnis UMKM: Strategi adaptasi era digital dan E-commerce di Indonesia [Legal implications of changes in MSME businesses: Adaptation strategies for the digital era and e-commerce in Indonesia]. *Jurnal Analisis Hukum*, *7*(1), 70–84. https://doi.org/10.38043/jah.v7i1.5052

Hj Ramlli, N., Hj Shahrin, H., Azmar, Z., Hj Brahim, M., & Aghwan, Z. A. (2024). Ethical considerations in halal supply chain management: Balancing religious principles and business practices. *Journal of Halal Science and Technology*, *3*(2), 29–42. https://doi.org/10.59202/jhst.v3i2.795

Ilham S., W., Andriansyah, Y., & Sobirov, B. (2024). Application of Islamic business ethics in online marketplace: A study among Bukalapak users in Yogyakarta, Indonesia. *Journal of Islamic Economics Lariba*, *10*(1), 593–622. https://doi.org/10.20885/jielariba.vol10.iss1.art30

Johnson, P. C., Laurell, C., Ots, M., & Sandström, C. (2022). Digital innovation and the effects of artificial intelligence on firms' research and development – Automation or augmentation, exploration or exploitation? *Technological Forecasting and Social Change*, *179*, 121636. https://doi.org/10.1016/j.techfore.2022.121636

Jomon T. K. (2024). Legal frameworks and regulatory challenges in fostering sustainable growth for micro, small, and medium enterprises (MSMEs): A management perspective. *Russian Law Journal*, *12*(1), 2041–2046. https://cyberleninka.ru/article/n/legal-frameworks-and-regulatory-

challenges-in-fostering-sustainable-growth-for-micro-small-and-medium-enterprises-msmes-a

Kamarulzaman, N. H., Muhamad, N. A., & Mohd Nawi, N. (2022). An investigation of adoption intention of halal traceability system among food SMEs. *Journal of Islamic Marketing*, *13*(9), 1872–1900. https://doi.org/10.1108/JIMA-11-2020-0349

Kashefi, P., Kashefi, Y., & Ghafouri Mirsaraei, A. (2024). Shaping the future of AI: Balancing innovation and ethics in global regulation. *Uniform Law Review*, *29*(3), 524–548. https://doi.org/10.1093/ulr/unae040

Kausar, S., Leghari, A. R., & Soomro, A. S. (2024). Analysis of the islamic law and its compatibility with artificial intelligence as a emerging challenge of the modern world. *Annals of Human and Social Sciences*, *5*(1), 99–114. https://doi.org/10.35484/ahss.2024(5-I)10

Kelly, S., Kaye, S.-A., & Oviedo-Trespalacios, O. (2023). What factors contribute to the acceptance of artificial intelligence? A systematic review. *Telematics and Informatics*, *77*, 101925. https://doi.org/10.1016/j.tele.2022.101925

Kumar, M., Raut, R. D., Mangla, S. K., Ferraris, A., & Choubey, V. K. (2024). The adoption of artificial intelligence powered workforce management for effective revenue growth of micro, small, and medium scale enterprises (MSMEs). *Production Planning & Control*, *35*(13), 1639–1655. https://doi.org/10.1080/09537287.2022.2131620

Kunungo, S., Ramabhotla, S., & Bhoyar, M. (2018). The integration of data engineering and cloud computing in the age of machine learning and artificial intelligence. *Iconic Research And Engineering Journals*, *1*(12), 79–84. https://www.irejournals.com/

Kusumasari, I. R., Hidayat, R., Sophia, Z. A., Maghfiroh, F. M., & Anggraini, A. D. (2024). Dampak sosial pengambilan keputusan berbasis artificial intelligence terhadap dinamika ketenagakerjaan [The social impact of artificial intelligence-based decision-making on employment dynamics]. *Journal of Macroeconomics and Social Development*, *2*(2), 1–12. https://doi.org/10.47134/jmsd.v2i2.531

Lemos, S. I. C., Ferreira, F. A. F., Zopounidis, C., Galariotis, E., & Ferreira, N. C. M. Q. F. (2022). Artificial intelligence and change management in small and medium-sized enterprises: An analysis of dynamics within adaptation initiatives. *Annals of Operations Research*. https://doi.org/10.1007/s10479-022-05159-4

Li, B., Qi, P., Liu, B., Di, S., Liu, J., Pei, J., Yi, J., & Zhou, B. (2023). Trustworthy AI: From principles to practices. *ACM Computing Surveys*, *55*(9), 177:1-177:46. https://doi.org/10.1145/3555803

Li, W., Yigitcanlar, T., Browne, W., & Nili, A. (2023). The making of responsible innovation and technology: An overview and framework. *Smart Cities*, *6*(4), 1996–2034. https://doi.org/10.3390/smartcities6040093

Loo, M. K., Ramachandran, S., & Raja Yusof, R. N. (2023). Unleashing the potential: Enhancing technology adoption and innovation for micro, small and medium-sized enterprises (MSMEs). *Cogent Economics & Finance*, *11*(2), 2267748. https://doi.org/10.1080/23322039.2023.2267748

Madan, R., & Ashok, M. (2023). AI adoption and diffusion in public administration: A systematic literature review and future research agenda. *Government Information Quarterly*, *40*(1), 101774. https://doi.org/10.1016/j.giq.2022.101774

Madhavan, M., Sharafuddin, M. A., & Wangtueai, S. (2024). Measuring the Industry 5.0-readiness level of SMEs using Industry 1.0–5.0 practices: The case of the seafood processing industry. *Sustainability*, *16*(5), 2205. https://doi.org/10.3390/su16052205

Mahi, R. (2024). Optimizing supply chain efficiency in the manufacturing sector through AI-powered analytics. *International Journal of Management Information Systems and Data Science*, *1*(1), 41–50. https://doi.org/10.62304/ijmisds.v1i1.116

Mahmood, H., Abdulqadir, D., Abdullah, R., Rasheed, H., Najat, Z., & Sami, T. (2024). Conducting in-depth analysis of AI, IoT, web technology, cloud computing, and enterprise systems integration for enhancing data security and governance to promote sustainable business practices. *Journal of Information Technology and Informatics (JITI)*, *3*, 297–322. https://www.researchgate.net/publication/383087255_Conducting_In-Depth_Analysis_of_AI_IoT_Web_Technology_Cloud_Computing_and_Enterprise_Systems_Integration_for_Enhancing_Data_Security_and_Governance_to_Promote_Sustainable_Business_Practices

Marocco, S., Barbieri, B., & Talamo, A. (2024). Exploring facilitators and barriers to managers' adoption of AI-based systems in decision making: A systematic review. *AI*, *5*(4), 2538–2567. https://doi.org/10.3390/ai5040123

Masudin, I., Rahmatullah, B. B., Agung, M. A., Dewanti, I. A., & Restuputri, D. P. (2022). Traceability system in Halal procurement: A bibliometric review. *Logistics*, *6*(4), 67. https://doi.org/10.3390/logistics6040067

Mousa, K., Zhang, Z., Sumarliah, E., & Hamdan, I. K. A. (2024). The impact of cloud computing adoption on firm performance among SMEs in Palestine: A machine learning approach. *International Journal of Intelligent Information Technologies*, *20*(1), 1–24. https://doi.org/10.4018/IJIIT.338715

Msomi, M. P., Ngibe, M., & Bingwa, L. L. (2020). The integration of management accounting practices as an innovative strategy towards sustaining small businesses operating in eThekwini Metropolitan, South Africa. *Problems and Perspectives in Management*, *18*(3), 268–281. https://doi.org/10.21511/ppm.18(3).2020.23

Muhamad, N. A., Kamarulzaman, N. H., & Nawi, N. M. (2020). Agro-food SMEs' intention to adopt halal traceability system. *Food Research*, *4*(S1), 93–98. https://doi.org/10.26656/fr.2017.4(S1).S28

Mustopa, M., Nasikhin, N., Chamami, R., Nihayah, H., Habibullah, M. R., & Manshur, A. (2024). Challenges in artificial intelligence development in higher education in China, India, and Indonesia: International students' perspectives. *International Journal of Learning, Teaching and Educational Research*, *23*(2), 354–373. https://doi.org/10.26803/ijlter.23.2.17

Neumann, O., Guirguis, K., & Steiner, R. (2024). Exploring artificial intelligence adoption in public organizations: A comparative case study. *Public Management Review*, *26*(1), 114–141. https://doi.org/10.1080/14719037.2022.2048685

Nićin, V., Nićin, S., & Mirkov, M. (2024). Impact of AI technologies on operations of small and medium transport businesses. *Communications - Scientific Letters of the University of Zilina*, *26*(3), E12–E24. https://doi.org/10.26552/com.C.2024.038

Odonkor, B., Kaggwa, S., Uwaoma, P. U., Hassan, A. O., & Farayola, O. A. (2024). The impact of AI on accounting practices: A review: Exploring how artificial intelligence is transforming traditional accounting methods and financial reporting. *World Journal of Advanced Research and Reviews*, *21*(1), 172–188. https://doi.org/10.30574/wjarr.2024.21.1.2721

Oldemeyer, L., Jede, A., & Teuteberg, F. (2024). Investigation of artificial intelligence in SMEs: A systematic review of the state of the art and the main implementation challenges. *Management Review Quarterly*. https://doi.org/10.1007/s11301-024-00405-4

Omrani, N., Rejeb, N., Maalaoui, A., Dabić, M., & Kraus, S. (2024). Drivers of digital transformation in SMEs. *IEEE Transactions on Engineering Management*, *71*, 5030–5043. https://doi.org/10.1109/TEM.2022.3215727

Ong, J. C. L., Seng, B. J. J., Law, J. Z. F., Low, L. L., Kwa, A. L. H., Giacomini, K. M., & Ting, D. S. W. (2024). Artificial intelligence, ChatGPT, and other large language models for social determinants of health: Current state and future directions. *Cell Reports Medicine*, *5*(1), 101356. https://doi.org/10.1016/j.xcrm.2023.101356

Pamungkas, M. R. S. P., Asyivadibrata, A., Susilawati, T., & Huda, M. N. (2023). Unleashing the potentials of artificial intelligence for micro, small, and medium enterprises: A systematic literature review. *Jurnal Teknologi Dan Sistem Informasi Bisnis*, *5*(3), 303–310. https://doi.org/10.47233/jteksis.v5i3.860

Peretz-Andersson, E., Tabares, S., Mikalef, P., & Parida, V. (2024). Artificial intelligence implementation in manufacturing SMEs: A resource orchestration approach. *International Journal of Information Management*, *77*, 102781. https://doi.org/10.1016/j.ijinfomgt.2024.102781

Prabowo, R., Singgih, M. L., Karningsih, P. D., & Widodo, E. (2020). New product development from inactive problem perspective in Indonesian SMEs to open innovation. *Journal of Open Innovation: Technology, Market, and Complexity*, *6*(1), 20. https://doi.org/10.3390/joitmc6010020

Pratama, A. S., Sari, S. M., Hj, M. F., Badwi, M., & Anshori, M. I. (2023). *Pengaruh artificial intelligence, big data dan otomatisasi terhadap kinerja SDM di era digital [The impact of artificial intelligence, big data, and automation on human resource performance in the digital age]*. *2*(4), 108–123. https://ejurnal.politeknikpratama.ac.id/index.php/jupiman/article/view/2739

Puntoni, S., Reczek, R. W., Giesler, M., & Botti, S. (2021). Consumers and artificial intelligence: An experiential perspective. *Journal of Marketing*, *85*(1), 131–151. https://doi.org/10.1177/0022242920953847

Putri, N. E., Andriansyah, Y., & Badjie, F. (2023). Product development strategies in Yogyakarta's Muslim fashion industry: Innovation and ethics. *Journal of Islamic Economics Lariba*, *9*(2), 591–620. https://doi.org/10.20885/jielariba.vol9.iss2.art15

Rawashdeh, A., Bakhit, M., & Abaalkhail, L. (2023). Determinants of artificial intelligence adoption in SMEs: The mediating role of accounting automation. *International Journal of Data and Network Science*, *7*(1), 25–34. https://doi.org/10.5267/j.ijdns.2022.12.010

Ray, D., & Ing, L. Y. (2016). Addressing Indonesia's infrastructure deficit. *Bulletin of Indonesian Economic Studies*, *52*(1), 1–25. https://doi.org/10.1080/00074918.2016.1162266

Rita, M. R., Wahyudi, S., Muharam, H., Thren, A. T., & Robiyanto, R. (2022). The role of entrepreneurship oriented finance in improving MSME performance: The demand side of the entrepreneurial finance perspective. *Contaduría y Administración*, *67*(3), 340. https://doi.org/10.22201/fca.24488410e.2022.3217

Roux, M., Chowdhury, S., Kumar Dey, P., Vann Yaroson, E., Pereira, V., & Abadie, A. (2023). Small and medium-sized enterprises as technology innovation intermediaries in sustainable business ecosystem: Interplay between AI adoption, low carbon management and resilience. *Annals of Operations Research*. https://doi.org/10.1007/s10479-023-05760-1

Saleem, I., Hoque, S. Md. S., Tashfeen, R., & Weller, M. (2023). The interplay of AI adoption, IoT edge, and adaptive resilience to explain digital innovation: Evidence from German family-owned SMEs. *Journal of Theoretical and Applied Electronic Commerce Research*, *18*(3), 1419–1430. https://doi.org/10.3390/jtaer18030071

Salih, H. S., Ghazi, M., & Aljanabi, M. (2023). Implementing an automated inventory management system for small and medium-sized enterprises. *Iraqi Journal for Computer Science and Mathematics*, *4*(2), 238–244. https://doi.org/10.52866/ijcsm.2023.02.02.021

Salim, W., & Negara, S. D. (2018). Infrastructure development under the Jokowi administration: Progress, challenges and policies. *Journal of Southeast Asian Economies*, *35*(3), 386–401. https://www.jstor.org/stable/26545320

Salsabillah, W., Hafizzallutfi, Nur Azizah, Tarissyaa, U., Fathona, T., & Raihan, M. (2025). The role of micro, small, and medium enterprises (MSMEs) in supporting the Indonesian economy. *Indonesian Journal of Multidisciplinary Sciences (IJoMS)*, *2*(2), 255–263. https://doi.org/10.59066/ijoms.v2i2.339

Sandee, H. (2016). Improving connectivity in Indonesia: The challenges of better infrastructure, better regulations, and better coordination. *Asian Economic Policy Review*, *11*(2), 222–238. https://doi.org/10.1111/aepr.12138

Sari, N. T. P., & Kusumawati, A. (2022). Literature review: The efforts to strengthening of micro, small and medium-sized enterprises (MSME) in Indonesia. *Asian Journal of Management, Entrepreneurship and Social Science*, *2*(1), 98–115. https://doi.org/10.63922/ajmesc.v2i01.52

Sari, R. K., Alfarizi, M., & Ab Talib, M. S. (2024). Sustainable strategic planning and management influence on sustainable performance: Findings from halal culinary MSMEs in Southeast Asia. *Journal of Modelling in Management*, *19*(6), 2034–2060. https://doi.org/10.1108/JM2-12-2023-0324

Sarib, S., Komaruddin, K., Chairunnisa, M. D., Majdi, A. L., & Mokodenseho, S. (2023). Qualitative study of the role of Islamic law in shaping Muslim identity and business ethics. *Sanskara Hukum Dan HAM*, *2*(1), 58–65. https://doi.org/10.58812/shh.v2i01.242

Sartori, L., & Theodorou, A. (2022). A sociotechnical perspective for the future of AI: Narratives, inequalities, and human control. *Ethics and Information Technology*, *24*(1), 4. https://doi.org/10.1007/s10676-022-09624-3

Schönberger, M. (2023). Artificial intelligence for small and medium-sized enterprises: Identifying key applications and challenges. *Journal of Business Management*, *21*, 89–112. https://journals.riseba.eu/index.php/jbm/article/view/336

Schwaeke, J., Peters, A., Kanbach, D. K., Kraus, S., & Jones, P. (2025). The new normal: The status quo of AI adoption in SMEs. *Journal of Small Business Management*, *63*(3), 1297–1331. https://doi.org/10.1080/00472778.2024.2379999

Sharma, M., Luthra, S., Joshi, S., & Kumar, A. (2022). Implementing challenges of artificial intelligence: Evidence from public manufacturing sector of an emerging economy. *Government Information Quarterly*, *39*(4), 101624. https://doi.org/10.1016/j.giq.2021.101624

Sharma, P., Shah, J., & Patel, R. (2022). Artificial intelligence framework for MSME sectors with focus on design and manufacturing industries. *Materials Today: Proceedings*, *62*, 6962–6966. https://doi.org/10.1016/j.matpr.2021.12.360

Sonianto, S., Fatoni, F., & Hartono, S. (2024). Dampak implementasi artificial intelligence terhadap proses bisnis dan pengambilan keputusan di perusahaan teknologi [The impact of artificial intelligence implementation on business processes and decision-making in technology companies]. *Technologia : Jurnal Ilmiah*, *15*(4), 735–741. https://doi.org/10.31602/tji.v15i4.16138

Soomro, S., Fan, M., Sohu, J. M., Soomro, S., & Shaikh, S. N. (2024). AI adoption: A bridge or a barrier? The moderating role of organizational support in the path toward employee well-being. *Kybernetes*. https://doi.org/10.1108/K-07-2024-1889

Suasih, N. N. R., & Budhi, M. K. S. (2023). Mitigation policies for fashion SMEs affected by the COVID-19 pandemic. *Quality - Access to Success*, *24*(194), 274–285. https://doi.org/10.47750/QAS/24.194.31

Sulastri, S., Mulyadi, H., Disman, D., Hendrayati, H., & Purnomo, H. (2023). Resilience acceleration model of small and medium enterprises through digital transformation. *Journal of Eastern European and Central Asian Research (JEECAR)*, *10*(4), 609–619. https://doi.org/10.15549/jeecar.v10i4.1355

Suryanti, N., Wahjoedi, Utomo, S. H., & Haryono, A. (2021). The learning model and the development of small medium enterprises in Indonesia. *Pegem Journal of Education and Instruction*, *11*(4), 138–147. https://doi.org/10.47750/pegegog.11.04.13

Susiang, M. I. N., Siswanti, I., Permana, D., & Wibowo, M. W. (2024). Effects of competitive intelligence and halal integrity on Halalan Tayyiban implementation strategy in Indonesian MSMEs: The mediating role of halal orientation strategy. *Journal of Islamic Marketing*. https://doi.org/10.1108/JIMA-10-2023-0344

Suyatno, S. (2022). Kelembagaan dan potensi lokal dalam mendukung UMKM di Daerah Istimewa Yogyakarta [Institutional and local potential in supporting MSMEs in the Special Region of Yogyakarta]. *Nusantara Hasana Journal*, *2*(1), 1–9. https://www.nusantarahasanajournal.com/index.php/nhj/article/view/323

Tambunan, T. (2019). Recent evidence of the development of micro, small and medium enterprises in Indonesia. *Journal of Global Entrepreneurship Research*, *9*(1), 18. https://doi.org/10.1186/s40497-018-0140-4

Tariq, M. U., Poulin, M., & Abonamah, A. A. (2021). Achieving operational excellence through artificial intelligence: Driving forces and barriers. *Frontiers in Psychology*, *12*, 686624. https://doi.org/10.3389/fpsyg.2021.686624

Tawil, A.-R. H., Mohamed, M., Schmoor, X., Vlachos, K., & Haidar, D. (2024). Trends and challenges towards effective data-driven decision making in UK small and medium-sized enterprises: Case studies and lessons learnt from the analysis of 85 small and medium-sized enterprises. *Big Data and Cognitive Computing*, *8*(7), 79. https://doi.org/10.3390/bdcc8070079

Truong, Y., & Papagiannidis, S. (2022). Artificial intelligence as an enabler for innovation: A review and future research agenda. *Technological Forecasting and Social Change*, *183*, 121852. https://doi.org/10.1016/j.techfore.2022.121852

Tumiwa, R., Ningsih, G., Romarina, A., Setyadjit, S., Slamet, B., Waruwu, E., Ie, M., & Utomo, Y. (2023). Investigating halal food Supply chain management, halal certification and traceability on SMEs performance. *Uncertain Supply Chain Management*, *11*(4), 1889–1896. https://growingscience.com/beta/uscm/6323-investigating-halal-food-supply-chain-management-halal-certification-and-traceability-on-smes-performance.html

Ugbaja, U. S., Nwabekee, U. S., Owobu, W. O., & Abieba, O. A. (2023). Revolutionizing sales strategies through AI-driven customer insights, market intelligence, and automated engagement tools. *International Journal of Social Science Exceptional Research*, *2*(1), 193–210. https://doi.org/10.54660/IJSSER.2023.2.1.193-210

U-Mar, N., Andriansyah, Y., & Hattabou, A. (2024). Islamic business ethics in Muslim fashion store: A study at 3 Nur Shop, Pattani, Thailand. *Journal of Islamic Economics Lariba*, *10*(1), 569–592. https://doi.org/10.20885/jielariba.vol10.iss1.art29

Uren, V., & Edwards, J. S. (2023). Technology readiness and the organizational journey towards AI adoption: An empirical study. *International Journal of Information Management*, *68*, 102588. https://doi.org/10.1016/j.ijinfomgt.2022.102588

Wahyuningsih, F., & Kholmi, M. (2024). Tren inovasi hijau dan transformasi digital dalam mendorong kinerja UKM: Studi bibliometrik pada tata kelola dan pembangunan berkelanjutan di Indonesia [Green innovation and digital transformation trends in driving SME performance: A bibliometric study on governance and sustainable development in Indonesia]. *Bulletin of Community Engagement*, *4*(3), 886–899. https://doi.org/10.51278/bce.v4i3.1684

Walton, R. (2016). Supporting human dignity and human rights: A call to adopt the first principle of human-centered design. *Journal of Technical Writing and Communication*, *46*(4), 402–426. https://doi.org/10.1177/0047281616653496

Wamba-Taguimdje, S.-L., Fosso Wamba, S., Kala Kamdjoug, J. R., & Tchatchouang Wanko, C. E. (2020). Influence of artificial intelligence (AI) on firm performance: The business value of AI-based transformation projects. *Business Process Management Journal*, *26*(7), 1893–1924. https://doi.org/10.1108/BPMJ-10-2019-0411

Wang, K., Zhao, Y., Gangadhari, R. K., & Li, Z. (2021). Analyzing the adoption challenges of the internet of things (IoT) and artificial intelligence (AI) for smart cities in China. *Sustainability*, *13*(19), 10983. https://doi.org/10.3390/su131910983

Whang, S. E., Roh, Y., Song, H., & Lee, J.-G. (2023). Data collection and quality challenges in deep learning: A data-centric AI perspective. *The VLDB Journal*, *32*(4), 791–813. https://doi.org/10.1007/s00778-022-00775-9

Widiyastuti, D., Azmi, F. N., Adhitama, S. Y., Destiana, K., Dahlan, A. D., & Syakbana, Z. P. (2023). Strategi adaptasi pelaku usaha kecil dan menengah sektor ekonomi kreatif dan pariwisata di Daerah Istimewa Yogyakarta selama pandemi COVID-19 [Adaptation strategies of small and medium-sized enterprises in the creative economy and tourism sectors in the Special Region of Yogyakarta during the COVID-19 pandemic]. *COMPACT: Spatial Development Journal*, *2*(1), 159–170. https://doi.org/10.35718/compact.v2i1.854

Wong, J. W., & Yap, K. H. A. (2024). Factors influencing the adoption of artificial intelligence in accounting among micro, small medium enterprises (MSMEs). *Quantum Journal of Social Sciences and Humanities*, *5*(1), 16–28. https://doi.org/10.55197/qjssh.v5i1.323

Wulandari, A., & Diko, M. A. I. M. J. (2024). HR management transformation in Indonesia MSMEs: The role of AI in SOP making and recruitment. *Journal of Ecohumanism*, *3*(7), 5325–5338. https://doi.org/10.62754/joe.v3i7.4641

Yusuf, S. O., Durodola, R. L., Ocran, G., Abubakar, J. E., Echere, A. Z., & Paul-Adeleye, A. H. (2024). Challenges and opportunities in AI and digital transformation for SMEs: A cross-continental perspective. *World Journal of Advanced Research and Reviews*, *23*(3), 668–678. https://doi.org/10.30574/wjarr.2024.23.3.2511

Zerilli, J., Bhatt, U., & Weller, A. (2022). How transparency modulates trust in artificial intelligence. *Patterns*, *3*(4). https://doi.org/10.1016/j.patter.2022.100455

Zhukhruffa, S. (2023). Pemanfaatan ekosistem digital pada platform E-commerce dalam meningkatkan pemasaran dan penjualan produk UMKM [Utilization of digital ecosystems on e-commerce platforms to improve marketing and sales of MSME products]. *Cakrawala Repositori IMWI*, *6*(4), 1072–1088. https://doi.org/10.52851/cakrawala.v6i4.343

Zuhroh, D., Jermias, J., Ratnasari, S. L., Sriyono, S., Nurjanah, E., & Fahlevi, M. (2024). The role of GoJek and Grab sharing economy platforms and management accounting systems usage on performance of MSMEs during COVID-19 pandemic: Evidence from Indonesia. *Uncertain Supply Chain Management*, *12*(1), 249–262. https://doi.org/10.5267/j.uscm.2023.10.001

This page intentionally left blank.