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The role of green blue ocean strategy in enhancing frugal innovation through IoT and AI: A resource-based view perspective

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Abstract

***PURPOSE**: This study explores the role of Green Blue Ocean Strategy (GBOS) in promoting frugal innovation by leveraging IoT and AI from an RBV theoretical perspective, targeting creative entrepreneurs in Central Java, Indonesia. **METHODOLOGY**: A quantitative approach was used, with Structural Equation Modelling (SEM) analyzed via AMOS. Data from 262 creative entrepreneurs were collected through an online closed questionnaire using purposive sampling. **FINDINGS**: The study reveals that (1) IoT does not significantly impact frugal innovation, (2) AI positively influences frugal innovation, and (3) GBOS effectively mediates the relationship between IoT, AI, and frugal innovation, suggesting that integrating sustainable strategies with technology can lead to more cost-effective and inclusive innovations. **IMPLICATIONS** for theory and practice: The study extends the RBV framework by integrating the GBOS concept, demonstrating its effectiveness in optimizing digital technology for sustainability-driven innovation. It contributes to the literature on sustainability strategies and the Resource-Based View by introducing a novel theoretical model that links GBOS, IoT, and AI with frugal innovation. Practically, GBOS offers a pathway for creative entrepreneurs to overcome resource constraints and achieve competitive advantages through sustainable practices. **ORIGINALITY AND VALUE**: This study introduces Green Blue Ocean Strategy (GBOS) as a novel conceptual framework that extends the traditional Blue Ocean Strategy (BOS) by integrating sustainability principles. GBOS addresses both economic and environmental concerns, enabling businesses to achieve cost-effective innovation. Grounded in the Resource-Based View (RBV), this study systematically develops and empirically tests GBOS by linking it with IoT, AI, and frugal innovation. The framework offers a new lens for sustainable competitive advantage in resource-constrained environments.*

***Keywords:** internet of things, artificial intelligence, green blue ocean strategy, frugal innovation, resource-based view, sustainability, sustainable strategy, digital technology, sustainability-driven innovation, sustainable innovation*

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INTRODUCTION

Organizations need to prioritize innovation to achieve high levels of commercial and financial success (Donkor et al., 2018; Farida & Setiawan, 2022; Hameed et al., 2021). Nevertheless, some organizations lack the technological capabilities to gain a competitive advantage, primarily due to limitations in financial resources and knowledge. Other limitations that must be considered include the inability to embrace digital values (Panjaitan et al., 2023), the level of knowledge quality (Moonti et al., 2023), the absence of intellectual flexibility, and the complexity of technological advancements (Panjaitan et al., 2021; Vermesan et al., 2022) the absence of intellectual flexibility, and the complexity of technological advancements (Hiong et al., 2020; Panjaitan et al., 2022). To tackle these challenges, organizations must utilize the Internet of Things (IoT) and Artificial Intelligence (AI) to maximize the efficiency of their limited resources. By incorporating technology and AI, companies can encourage cost-effective innovation (Qin, 2024), decrease operational expenses (Calabrese et al., 2023; Nawaz et al., 2024), improve their ability to adapt to market fluctuations (Sullivan & Wamba, 2024) and minimize risks related to market unpredictability (Grimaldi et al., 2023). This study aims to investigate how the Green Blue Ocean Strategy (GBOS) mediates the relationship between IoT, AI, and frugal innovation, offering actionable insights for leveraging these technologies to drive cost-efficient, sustainable innovations in resource-constrained environments.

Integrating IoT and AI enhances frugal innovation by optimizing resource use and generating commercial value, particularly in creative sectors operating with limited resources (Huang et al., 2022). This study explores innovative strategies to optimize resource use and enhance cost efficiency while maintaining product quality. This study emphasizes the importance of cost-efficient innovations that streamline essential features, maintain product quality, and minimize expenses while generating value. Artificial Intelligence (AI) and the Internet of Things (IoT) play a crucial role in developing marketing strategies by creating shared consumer value and aligning with the aims of frugal innovation (Lee & Lee, 2015; Wu & Monfort, 2023). Although there have been disruptive technology improvements, the Internet of Things (IoT) can enhance company performance and facilitate effective consumer interactions (Lo & Campos, 2018). The study addresses the following research questions (RQs):

RQ1: How can the Green Blue Ocean Strategy (GBOS) leverage IoT and AI to drive frugal innovation?
RQ2: What are the strategic implications of integrating sustainability-driven strategies with digital technologies to enhance cost efficiency?

Past research emphasizes the increasing significance of technology adoption among those involved in business activities. Qin (2024) states that integrating IoT and AI infrastructure enables cost-effective innovation in less developed countries, resulting in sustainable and fair growth. In addition, AI technology improves services and boosts user satisfaction (Ghaith et al., 2023). IoT and AI working together enhance digital marketing decisions (Jia et al., 2021) and can predict how customers will act, like when airlines repurpose services. Additional research suggests that AI can assist organizations in digital marketing by generating advertising content, decreasing acquisition expenses, enhancing customer happiness, attracting potential employees, and broadening target demographics (Van Esch & Stewart Black, 2021). Nevertheless, there is a lack of understanding regarding business strategies that effectively utilize environmentally friendly technology, like the Internet of Things (IoT) and Artificial Intelligence (AI), sustainably. In aiming to achieve low-cost innovation using IoT and AI applications, this gap encourages academics to investigate perspectives rooted in RBV theory to synthesize the Blue Ocean Strategy (BOS) (Iruthayasamy & Iruthayasamy, 2021) and Green Innovation Process (GIP) concepts (M. Wang et al., 2021; Xie et al., 2019). This research extends the Blue Ocean Strategy framework by integrating sustainability considerations, offering a pathway for leveraging digital technologies such as IoT and AI for cost-effective and environmentally conscious innovation. This study explores strategic frameworks that enable firms to harness IoT and AI for sustainable innovation, focusing on cost-efficiency and environmental sustainability in resource-constrained contexts.

The path from environmentally friendly process innovation to economic performance is not as important as understanding the concept of the green innovation process from environmentally friendly technology innovation, which highlights the fundamental difference between ecologically friendly product innovation (Mingyue Wang et al., 2021). In other words, boosting technological innovation provides room for creativity in the business's eco-friendly operations, promoting the development of eco-friendly products. Meanwhile, Kim & Mauborgne (2017) presented the BOS concept, which highlights a strategy to steer clear of markets that are already saturated with competitors, or the "Red Ocean," by focusing on providing distinctive goods or services where businesses can create new demand and eliminate the relevance

of competitors. Consequently, there remains a theoretical and practical knowledge gap that prevents the development of a new perspective, known as GBOS, based on these two principles. To the best of our knowledge, the concept of Green Blue Ocean Strategy (GBOS) has not been explicitly established in prior literature. While studies on Blue Economy (Ni et al., 2024; Soma et al., 2018) and Green Ocean Strategy (Markopoulos & Ramonda, 2022) discuss sustainability-driven business models, none integrate these approaches into a unified framework that addresses cost efficiency, environmental sustainability, and digital transformation. This study introduces GBOS as a novel strategic framework that extends Blue Ocean Strategy by embedding sustainability into market innovation, GBOS provides firms with a strategic pathway to simultaneously address ecological and economic challenges. The concept of GBOS integrates sustainability into the Blue Ocean Strategy, aiming to create new market opportunities that are both cost-effective and environmentally sustainable (Barbosa et al., 2019). The objective is to achieve corporate growth, simultaneously produce ecological and economic value, and lessen adverse environmental effects. Therefore, the novelty of the GBOS idea aligns with the RBV theory's perspective, offering firms the potential to deliver unique talents and competencies to create sustainable excellence.

GBOS is conceptualized by integrating key principles from Blue Ocean Strategy (Kim & Mauborgne, 2004), sustainability-driven innovation (Xie et al., 2019), and the Resource-Based View (Barney, 1991). This study develops GBOS through a structured approach: (1) identifying gaps in Blue Economy and Green Innovation frameworks, (2) synthesizing core elements of cost-efficiency and environmental sustainability, and (3) empirically validating GBOS using Structural Equation Modeling (SEM) with data from creative entrepreneurs in Indonesia. By focusing on creating affordable and resource-efficient goods and services while considering the innovation's effects on the environment and society, the application of GBOS as a mediator can enhance the value of frugal innovations in the context described in this article. This strategy aligns with RBV because it leverages the business's unique ability to incorporate environmental considerations into innovation plans to generate a competitive advantage (Barney, 1991; Barney et al., 2001; Teece et al., 1997). Moreover, incorporating GBOS into frugal innovation can stimulate cost-effective, sustainable, and inclusive solutions that address broader market demands while considering environmental sustainability. This may open the door to developing a more comprehensive RBV theory, where resources are considered in terms of their effects on society and the environment, as well as their economic and competitive value (Tate & Bals, 2016). Therefore, using GBOS as a mediator in frugal innovation can be a profound innovation that extends RBV theory's application to include sustainability and social responsibility as crucial components of competitive advantage. This approach is also grounded in RBV theory, which focuses on utilizing internal resources and capabilities to achieve a competitive advantage. This suggests that our understanding of sources of competitive advantage is evolving, with social and environmental added value now seen as a component of what makes resources valuable and difficult for rivals to imitate (Gibson et al., 2021).

The researchers' study examines the ability of the Internet of Things (IoT) and Artificial Intelligence (AI) to provide consumer value and cost efficiency. The paper references the works of (Gellweiler & Krishnamurthi, 2020; Gupta & Maheshwari, 2024; Rath et al., 2024). Furthermore, there have been additional studies conducted on BOS, as documented by Dzingirai et al. (2023), Hossain et al. (2024), Vasiljeva et al. (2019), and Yunus and Sijabat (2021). While GBOS introduces a novel conceptual framework by integrating BOS and sustainability-driven innovation, its empirical validation is crucial to refine its theoretical foundations and practical applications. Future studies should explore its mediation role in linking IoT, AI, and frugal innovation across diverse industries, particularly in resource-constrained settings. There are limitations to research that combines the RBV perspective, IoT, and AI through the role of GBOS. This research conceptually separates IoT and AI to explore the role of each technology in frugal innovation. IoT is used for automatic and real-time data collection, while AI focuses on data analysis to generate cost-effective, data-driven decisions (Baccour et al., 2022; Raparthy & Dodda, 2023).

This separation allows the study to investigate how IoT can facilitate innovation by enhancing real-time data collection and how AI can maximize efficiency in operational processes through data analysis. The rationale behind this separation is that AI relies on data gathered by IoT to analyze innovation processes. In the context of frugal innovation, IoT simplifies data collection from various production or distribution points with minimal costs, while AI processes this data to provide strategic, cost-saving recommendations in essence, IoT provides data, and AI generates solutions from that data. Furthermore, respondents' competencies, specifically creative entrepreneurs in Central Java, indicate a sufficient understanding of both IoT and AI technologies and their implications for sustainable business strategies (Baccour et al., 2022). Ultimately, the integrated use of these technologies drives cost-efficient innovation. This study aims to explore the role of GBOS in leveraging IoT and AI to drive frugal innovation, focusing on creative entrepreneurship in resource-constrained contexts. Thus, this study extensively examines the role of GBOS in addressing the evolving nature of creative

endeavors that prioritize environmentally sustainable technology to consistently generate cost-effective innovations. The goal is to achieve company expansion by creating ecological and economic value while minimizing environmental impact. The uniqueness of GBOS aligns with the Resource-Based View (RBV) paradigm, emphasizing the ability of companies to utilize their resources to attain long-lasting superiority. The introduction should establish the context of the research, demonstrating its relevance and importance. It should clearly state the research aim, questions, and identify gaps in the existing literature. The introduction must also define key terms and outline the manuscript's structure and objectives.

LITERATURE REVIEW

Resource-Based View (RBV)

According to the Resource-Based View (RBV) approach, a company's resources and capabilities are valuable for maximizing opportunities and mitigating environmental concerns. For instance, prominent corporations can decrease expenses to fulfill their products' requirements (Barney, 1995) The Resource-Based View (RBV) emphasizes that a firm's internal resources and unique capabilities are critical in sustaining a competitive advantage, particularly in rapidly evolving markets (Barney, 1991). However, RBV alone may not fully capture the dynamic nature of technological innovation, especially when considering the integration of AI and IoT. To address this gap, incorporating the Dynamic Capabilities (DC) framework, which focuses on the firm's ability to adapt, reconfigure, and leverage its resources in response to environmental changes, can provide a more robust theoretical grounding for this study (Singh et al., 2019). The Resource-Based View (RBV) highlights the importance of internal resources and unique capabilities as critical drivers of competitive advantage (Barney, 1991). However, given the dynamic and rapidly changing nature of technological innovation, particularly with the integration of IoT and AI, the Dynamic Capabilities (DC) framework is essential to complement RBV.

DC emphasizes the firm's ability to adapt, reconfigure, and leverage its resources in response to market changes, thereby offering a more robust foundation for understanding innovation and competitive advantage in volatile markets. This illustrates the possibility of foreseeing rival risks arising from a company's valued internal resources and competencies. The blue ocean strategy (BOS) aims to generate value and establish new markets by leveraging the company's untapped internal capabilities, thereby circumventing saturated (red ocean) and fiercely competitive markets (Kim & Mauborgne, 2017). Nevertheless, the BOS concept should prioritize the consideration of external resources in the formulation of business plans that are both cost-effective and environmentally sustainable. As a result, companies need to combine environmental management with the core idea of maintaining a competitive edge at the corporate level (Barney, 1986). Moreover, digital services enable enterprises to establish precise entry barriers and develop isolation mechanisms to preserve their competitive advantages in product offerings (Barney & Clark, 2007; Sánchez-Montesinos et al., 2018). Based on the RBV viewpoint, this study argues that a company can stay ahead of the competition over the long term by using a strategy that other companies cannot easily replicate (Barney, 1991).

Internet of Things (IoT) and Artificial Intelligence (AI)

Increased frugal innovation is significantly influenced by the Internet of Things (IoT) (Park et al., 2022). The Internet of Things (IoT) and Artificial Intelligence (AI) are interdependent technologies that drive innovation by leveraging large datasets for real-time analytics (Sasikumar et al., 2022). AI's capabilities in data analysis and automation are enhanced by the extensive data collection enabled by IoT devices, creating a synergistic relationship that drives both operational efficiency and sustainable innovation (Baccour et al., 2022; Zhang et al., 2020). Creatively utilizing available resources can facilitate frugal innovation by surpassing fundamental resource limitations, resulting in more economical and practical solutions (Quan et al., 2019). Organizations can develop creative processes that maximize productivity with minimal resources by utilizing IoT technology and a bricolage approach. While IoT provides the infrastructure for data collection, AI utilizes these data streams to optimize decision-making processes. IoT serves as the data collection backbone, enabling real-time monitoring of resources and processes, while AI processes these data streams to derive actionable insights. This synergistic relationship is critical for implementing the GBOS framework, as it allows businesses to make informed decisions that balance cost-efficiency with sustainability goals (Baccour et al., 2022; Patil & Gokhale, 2022). For instance, AI's predictive analytics optimize IoT-generated data, driving frugal innovation by minimizing resource waste and enhancing operational efficiency.

This integration is essential for implementing the GBOS framework, where real-time data insights drive sustainable value creation. This allows them to address the needs of various populations at a reasonable cost. Frugal innovation employs cost-saving strategies, such as leveraging inexpensive labor, and involves reconfiguring products and processes to minimize expenses, maximize energy efficiency, and improve overall effectiveness (Juhro & Aulia, 2019). When resources are limited, as they often are for low-income groups, frugal ideas can thrive, demonstrating that these solutions are both flexible and affordable (Santiago et al., 2019). The Internet of Things (IoT) is widely acknowledged as a crucial technology propelling innovation trends, especially in environmental monitoring (Scilimati et al., 2017). The integration of IoT and AI technologies is crucial for enabling real-time data analytics, which drives strategic decision-making and operational efficiency (Jankovic & Curovic, 2023). While IoT provides the data infrastructure, AI leverages these data streams to optimize resource allocation and enhance productivity (Patil & Gokhale, 2022). This interdependence is critical for deploying the GBOS framework, where sustainable innovations are driven by leveraging data analytics for cost-efficient solutions. By combining AI's data processing capabilities with IoT's extensive data collection infrastructure, firms can enhance their adaptability to market changes, thereby supporting frugal innovation. This approach addresses resource limitations, encourages sustainable development, and expands the accessibility of creative solutions to marginalized communities.

Artificial Intelligence (AI) enables cost-effective innovators to achieve superior performance by efficiently utilizing limited resources to offer solutions that involve understanding customer preferences (Cheng & Jiang, 2021; Xu et al., 2020), and enhancing outcomes from online customer engagement behaviors, whether solicited or unsolicited, through the use of information processing systems (Perez-Vega et al., 2021). AI improves the automation and effectiveness of marketing procedures (Esch & Black, 2021; Overgoor et al., 2019), optimizes the utilization of marketing data (Stone et al., 2020), and aids in the analysis of market trends and client requirements. This analysis helps businesses develop new goods and services even when they have limited financial resources, a practice known as "frugal innovation" (Huang & Rust, 2020; Jabeur et al., 2022). Thus, artificial intelligence plays a critical role in improving a business's operational efficiency and fostering long-term success.

Green Blue Ocean Strategy (GBOS)

Achieving a blue economy is challenging due to issues in various sectors, including business and government. The Green Blue Ocean Strategy (GBOS) extends the Blue Ocean Strategy (BOS) by embedding sustainability as a core principle, addressing the dual goals of economic growth and environmental preservation. Unlike traditional BOS, which focuses on creating uncontested market spaces, GBOS prioritizes innovations that align with ecological goals and global sustainability standards (Brozović et al., 2020; Freudenreich et al., 2020). This study differentiates GBOS from existing frameworks like sustainability-driven innovation by demonstrating its application in integrating AI and IoT for cost-efficient, eco-friendly solutions. Unlike traditional BOS, which focuses solely on untapped markets, GBOS emphasizes sustainable value creation by aligning economic and environmental objectives. This approach leverages unique resources to create value while addressing ecological concerns, differentiating it from sustainability-driven innovation frameworks (Brozović et al., 2020; Freudenreich et al., 2020). Policymakers have utilized recent advancements in the blue economy to effectively screen and regulate blue products and industrial chains, promoting sustainable development in this sector (Ni et al., 2024). Adopting a comprehensive strategy that fosters a blue economy by combining sustainable environmental management with economic growth is imperative. The Green Blue Ocean Strategy (GBOS) and the Blue Ocean Strategy (BOS) differ primarily in that BOS emphasizes expanding into untapped markets and avoiding competition.

However, the literature lacks comprehensive discussions on how GBOS integrates with digital innovations like AI and IoT. This study addresses this gap by exploring how GBOS can enhance the deployment of IoT and AI to drive sustainable innovation. GBOS can enhance organizational resilience by promoting eco-friendly innovations while reducing competitive pressures (El-Kassar & Singh, 2019; Song & Yu, 2018). In contrast, GBOS integrates environmental sustainability as a fundamental aspect of innovation and value development. Unlike the traditional Blue Ocean Strategy (BOS), which focuses solely on expanding into untapped markets, the Green Blue Ocean Strategy (GBOS) integrates environmental sustainability into strategic innovation efforts (Daly et al., 2021; Soma et al., 2018).

GBOS differentiates itself by emphasizing the simultaneous pursuit of economic growth and ecological preservation, thus aligning with sustainability-driven innovation frameworks. This study fills a gap in the literature by demonstrating how GBOS can be operationalized through the integration of AI and IoT to drive sustainable frugal innovation in resource-constrained settings. Recent research shows that an organizational culture valuing ecological sustainability and sharing a vision for protecting the environment can help spread green practices, which in turn improves the success of developing

eco-friendly products (Chen et al., 2020). Aligning economic goals with sustainable development objectives becomes even more crucial by incorporating environmental principles into strategic innovation frameworks. GBOS extends the RBV framework by integrating IoT and AI as strategic resources that fulfill VRIO criteria—valuable, rare, inimitable, and organized—driving sustainable innovation and competitive advantage in resource-constrained environments

Frugal innovation (FI)

According to Dabić et al. (2022), frugal innovation in transdisciplinary science aims to do more with fewer resources. Frugal Innovation (FI) focuses on maximizing resource efficiency, particularly in contexts with limited resources (Albert, 2019). The integration of IoT and AI enhances the capacity for FI by enabling firms to utilize real-time data analytics to optimize processes and reduce costs. This study explores how leveraging AI within the GBOS framework can drive frugal innovation by creating low-cost, sustainable solutions tailored to developing markets. In health sciences, empirical evidence addresses the challenge of innovation with constrained resources (Chakravarty, 2022). Prior scientific research has highlighted risk-taking behavior, proactiveness (Dost et al., 2019), leadership (Iqbal & Piwowar-Sulej, 2023), and resource constraints at the company level (Ploeg et al., 2021) as critical factors in frugal innovation. Weyrauch and Herstatt (2017) argue that the features of AI enable the development of inexpensive products and services that meet users' needs in emerging economies. Consequently, FI is essential to technological development in poor nations because scarce resources require creative solutions (Sarkar & Mateus, 2022). Furthermore, FI ensures the accessibility of cost-effective goods, tackling issues such as limited finances, infrastructure, and human resources. This promotes economic innovation in emerging economies (Zeschky et al., 2014) and facilitates the adoption of ecologically sustainable practices for the future (Levänen et al., 2016). Frugal innovation and cost-effective solutions to developing countries' unique challenges can promote sustainable growth.

Figure 1 presents the empirical research model:

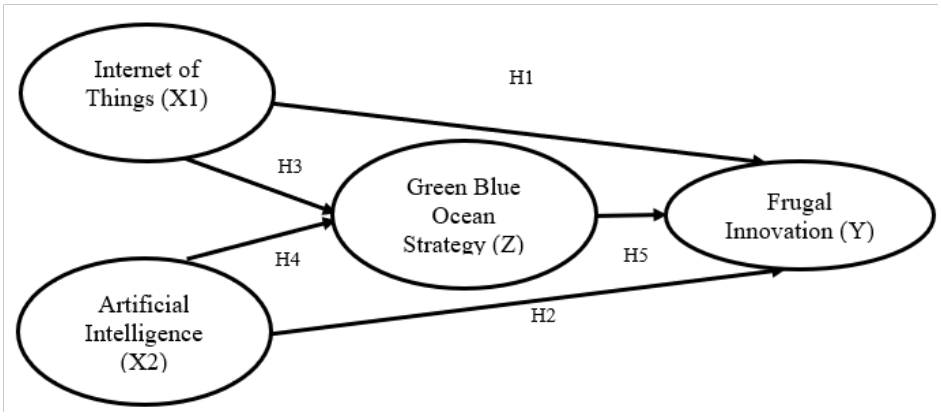

Figure 1: Empirical research model

The impact of Internet of Things and Artificial Intelligence on frugal innovation

To overcome fundamental resource limits, the Internet of Things (IoT) has become crucial in frugal innovation (Park et al., 2022; Quan et al., 2019). Although IoT holds great potential, various hurdles prevent its mainstream implementation. These include a lack of specialists with the expertise to manage IoT devices, additional expenses for staff training and device purchases, and significant privacy and security concerns. Moreover, the complexity is compounded by internet connectivity issues, industry participants' awareness, regulatory requirements, and government enforcement (Dosumu & Uwayo, 2023). The implementation of IoT can present risks and obstacles that may disrupt organizational processes, potentially resulting in financial losses (Mercan et al., 2020). Problems with IoT technology, questions about its benefits and costs, and external pressures for its adoption pose challenges to acceptance in many areas, such as transportation and supply chain management (Tu, 2018). Furthermore, several research findings highlight negative interaction factors from IoT, particularly in developing countries with limited resources, where the ability to adopt IoT technology effectively is constrained. Implementing IoT technology in developing nations with limited resources presents significant challenges. As interconnectivity grows, the likelihood of privacy breaches and security risks also increases, making IoT deployments more vulnerable.

The Resource-Based View (RBV) theory influences how AI and frugal innovation (FI) affect company performance. AI enhances operational efficiency and adaptability to market changes (Åström et al., 2022). The RBV emphasizes unique resources and capabilities as key to sustainable competitive advantage. AI, through intelligent marketing automation, improves sales forecasting and operational procedures, thereby boosting firm performance (Ameen et al., 2022; Paschen et al., 2019). Frugal innovation enables companies to use limited resources creatively to innovate. Levänen et al. (2016) found that AI and frugal innovation can maximize resource potential, operational efficiency, and quality product production at low cost. FI helps organizations produce cheaper and more effective goods and services, enhancing their competitiveness (Jayabalan et al., 2021). Thus, a strong hypothesis is that AI and frugal innovation, guided by RBV principles, optimize resources for sustainable innovation and growth. These hypotheses are formulated based on the theoretical understanding that while IoT provides data infrastructure, its adoption might face barriers due to high costs and resource constraints in MSMEs. In contrast, AI's capability to analyze data and optimize operations directly supports frugal innovation. GBOS, as a mediator, integrates these technologies into a cohesive framework that overcomes these barriers, enabling sustainable and cost-effective innovation. The literature review above leads to the following hypothesis:

H1: Internet of Things (IoT) influences frugal innovation negatively.
H2: Artificial Intelligence influences frugal innovation positively.

The impact of Internet of Things and Green Blue Ocean Strategy

With improved connectivity and automation, Internet of Things (IoT) technology has enormous potential to transform businesses completely The Green Blue Ocean Strategy enables organizations to achieve sustainability and drive innovative growth in unexplored markets simultaneously. The Resource-Based View (RBV) emphasizes the importance of a company's distinctive resources in establishing long-lasting competitive advantages (Barney & Hesterly, 2019). Integrating IoT with the Green Blue Ocean Strategy has the potential to become a beneficial strategic resource. By using IoT effectively, businesses can improve their data analysis, automation, and operational efficiency. This can lead to new market opportunities for innovation and value creation (Olorunyomi Stephen Joel et al., 2024; Shahi & Sinha, 2020). This integration could result in the identification of novel "blue oceans," characterized by limited competition because of the generation of distinctive value. IoT can also create new resources and skills, giving businesses a more potent edge in a business world that is becoming more complex and rapidly changing (Markfort et al., 2021). So, the hypothesis that can be developed is:

H3: Internet of Things (IoT) influences Green Blue Ocean Strategy positively.

The impact of Artificial Intelligence and Green Blue Ocean Strategy

The Green Blue Ocean Strategy (GBOS) focuses on creating new markets by minimizing competition, while Frugal Innovation (FI) is concerned with efficiently using resources to develop quality products and services at low costs. This aligns with one of the FI criteria (Barney, 1991; Barney, 1995). AI can help companies optimize their operations, while the Green Blue Ocean Strategy aims to create new market space by minimizing competition. When these two concepts are combined, companies can leverage AI to increase efficiency and innovation in creating new products and services. At the same time, a Green Blue Ocean Strategy ensures that these products and services are unique and difficult for competitors to replicate. The research findings of Kamble et al. (2020), emphasize that integrating AI with other information technologies has significantly increased product and service innovation. This solution efficiently uses resources while maintaining quality, aligning with frugal innovation's goals. In line with Boons and Lüdeke-Freund (2013), frugal innovation is essential to create value through cost efficiency in developing cost-effective methods, especially when facing global economic challenges. Furthermore, AI supports this logistics relationship, namely: 1) AI helps companies improve tactics by utilizing real-time data to respond quickly to market changes in line with GBOS principles (Qin, 2024); 2) AI assists companies run GBOS by gaining strategic insights through data analysis, enabling identifying new market opportunities and tailoring products or services to the unique needs of those markets (Jarrahi, 2018); 3) AI allows companies to produce innovative products or services at low costs, and continuously adapt to market competition, which is the essence of the GBOS concept (Erik & Andrew, 2017). Therefore, based on the explanation above, the hypothesis that can be proposed in this relationship is:

H4: Artificial Intelligence influences Green Blue Ocean Strategy positively.

The impact of Green Blue Ocean Strategy and frugal innovation

The Green Blue Ocean Strategy (GBOS) aims to create new markets by reducing rivalry. Frugal Innovation (FI) optimizes resource utilization to create high-quality products and services at minimal expense. This is consistent with one of the criteria for frugal innovation provided by Weyrauch and Herstatt (2017), which involves reducing excessive costs, focusing on essential functions, and enhancing optimal performance. The Resource-Based View (RBV) methodology applies to financial institutions' criteria regarding the caliber of a company's distinctive resources in creating a sustainable competitive advantage (Barney & Clark, 2007). Although little literature explicitly examines the connection between GBOS and FI, earlier studies have explored the potential of frugal innovations for market attractiveness (Albert, 2019; Dima et al., 2022). Due to its potential synergistic convergence with GBOS principles in structuring critical strategies for pursuing innovation, environmental sustainability, and market formation, the FI concept emerges as an appealing paradigm. GBOS offers the potential to circumvent saturated markets (red oceans) and establish pioneering industrial success in ecological, social, and governance accomplishments (Markopoulos & Ramonda, 2022). Ultimately, GBOS can push businesses to develop new products and ideas by combining ambition, social impact, and profit, helping them follow global innovation trends and build long-lasting wealth for society. Thus, a beneficial effect on FI is anticipated from deploying GBOS.

H7: The Green Blue Ocean Strategy (GBOS) directly and positively influences frugal innovation by integrating ecological considerations into resource optimization.

Internet of Things on frugal innovation through Green Blue Ocean Strategy

The acquisition and development of value-based, rare, inimitable, and organized (VRIO) internal resources, coupled with sustainable development approaches, alliance and partnership strategies, and a robust organizational culture, are critical to improving corporate performance (Barney, 1991; Barney & Hesterly, 2019). As firms aim to improve their business operations, IoT technology becomes essential for making informed decisions (Brous et al., 2019; Chatterjee et al., 2024). The Internet of Things (IoT) can stimulate economic innovation through its ability to enhance data collection efficiency (Andrade et al., 2023), enable automation and remote control (Froiz-Míguez et al., 2018), detect device or machine failures in advance (Banaamah & Ahmad, 2022) and facilitate the development of novel business models (Ceipek et al., 2020). A Green Blue Ocean Strategy encourages economic innovation. IoT is crucial because it provides data analysis and insights from technological solutions that help markets stay open and stand out in the long term. The Green Blue Ocean Strategy (GBOS) mediates the relationship between Internet of Things (IoT) and frugal innovation, enabling firms to leverage real-time data for sustainable and cost-efficient product development (Ni et al., 2024). This hypothesis explores how IoT, through the GBOS framework, enhances operational efficiencies and market responsiveness in resource-limited environments. As a result, the Green Blue Ocean Strategy aims to improve and propel the blue ocean strategy towards attaining corporate objectives in a sustainable and eco-friendly manner. The results of this hypothesis can be developed:

H5: The significant effect of Internet of Things on frugal innovation mediated by Green Blue Ocean Strategy.

Artificial Intelligence on frugal innovation through Green Blue Ocean Strategy

Innovation is emphasized in a blue ocean strategy by providing new, distinctive goods or services that build demand beyond the reach of irrelevant competitors (Kim & Mauborgne, 2017). This lack of relevance motivates ongoing enhancement in the intangible assets of human knowledge and abilities. Nevertheless, the limits inherent in human understanding often necessitate assistance to keep up with innovation demands. The Knowledge-Based View (KBV) was created by recognizing these limitations and adding knowledge assets to the Resource-Based View (RBV). The Knowledge-Based View (KBV) highlights the importance of diverse knowledge bases and competencies for company success, especially in knowledge-intensive economies (Cuthbertson & Furseth, 2022; Grant, 1996). Artificial Intelligence (AI) is of utmost importance as it utilizes computer algorithms to imitate intelligent human behavior when carrying out intricate activities (Akçay & Etiz, 2020; Morandín-Ahuerma, 2022). Prior studies emphasize the impact of AI in facilitating cost-effective innovation by advancing sustainability (Qin, 2024). To prevent complacency, GBOS must adopt a strategy that aligns with transitioning

from a Resource-Based View (RBV) to a Knowledge-Based View (KBV). This approach should involve utilizing physical and knowledge-based resources to promote sustainable innovation.

When AI is integrated with GBOS, businesses can find new opportunities, avoid direct competition by opening up new markets with creative AI solutions, optimize resources in business processes, and identify environmental issues sooner. Artificial Intelligence (AI) enhances the impact of the Green Blue Ocean Strategy (GBOS) on frugal innovation by providing tools for data-driven decision-making, optimizing resource allocation, and enabling the development of sustainable, low-cost products (Govindan, 2022; Jankovic & Curovic, 2023). This integration helps firms identify new market opportunities while minimizing competition. These factors provide significant leverage for economic innovation (Ma et al., 2020). AI can enhance the connection between GBOS and frugal innovation by providing tools for in-depth data analysis, forecasting market trends, and creating sustainable and cost-effective products or services. These hypotheses reflect the interdependence of AI and IoT technologies in driving sustainable innovation within the GBOS framework, ensuring that firms can achieve long-term competitive advantages through resource optimization and sustainability.

H6: The Green Blue Ocean Strategy (GBOS) mediates the positive impact of Artificial Intelligence (AI) on frugal innovation by facilitating sustainable and cost-efficient strategies.

METHODOLOGY

Research design and sample

This study employed a quantitative approach to test six hypotheses. The respondents in this study were collected through questionnaires distributed to 285 MSMEs in the creative business sector in Central Java, Indonesia. However, only 262 samples were considered complete for data processing. To establish a rigorous foundation for the Green Blue Ocean Strategy (GBOS), this study systematically developed the concept through three stages:

1) Theoretical synthesis: The GBOS framework integrates core principles from Blue Ocean Strategy (Kim & Mauborgne, 2004; Kim & Mauborgne, 2017), sustainability-driven innovation (Xie et al., 2019) and Resource-Based View (RBV) (Barney, 1991). This synthesis identifies the gap in existing strategic frameworks by incorporating sustainability as a central element in market expansion.
2) Empirical validation: The study empirically tests GBOS using Structural Equation Modeling (SEM) with AMOS based on survey data from 262 creative entrepreneurs in Central Java, Indonesia. The construct validity and reliability of GBOS were assessed using Confirmatory Factor Analysis (CFA) to ensure its robustness as a measurable construct.
3) Comparative analysis: GBOS is compared with existing sustainability frameworks such as Green Process Innovation (Xie et al., 2019) and Blue Economy models (Soma et al., 2018) to highlight its novel contribution. Unlike prior models that focus solely on environmental or market expansion strategies, GBOS uniquely integrates cost-efficiency, ecological sustainability, and digital transformation (IoT & AI) into a unified strategic framework

The purposive sampling method was utilized to ensure that respondents possessed sufficient exposure to digital technologies, which is essential for assessing the impact of AI and IoT on business innovation. Given that the study focuses on GBOS and frugal innovation, targeting respondents with a demonstrated use of digital tools helps provide more accurate insights into the research questions. This approach is aligned with previous studies that emphasize the importance of targeted sampling in technology adoption research. This study employed a quantitative approach to test seven hypotheses. The purposive sampling method was chosen to target MSMEs in the creative business sector who are actively utilizing digital technologies such as AI and IoT for business development (Hosseini & Rajabipoor Meybodi, 2023; Liu et al., 2020). Respondents were selected not only based on their industry but also on their demonstrated engagement with digital technologies, ensuring that the sample is relevant to the research objectives, particularly in examining the impact of digital competencies on frugal innovation. The respondents were specifically selected from sectors with varying levels of digital adoption, such as Film, Animation, Culinary, and App Development, to assess their technological competence.

Additionally, a digital competency assessment was included in the questionnaire to ensure that respondents possessed the necessary technological understanding to provide informed responses. To address the concerns regarding the digital competency of respondents, this study included a section in the questionnaire to assess their familiarity with IoT and AI technologies. Respondents were asked to rate their proficiency in using digital tools on a 5-point Likert scale, where 1 =

No experience and 5 = Expert level. The results indicated that 74% of the respondents rated themselves at level 3 or above, suggesting adequate competencies to participate in this study. The inclusion of specific questions in the questionnaire (IoT_3 and AI_1) ensures that respondents can provide informed answers based on their practical exposure to these technologies. This approach strengthens the validity of the data collected. The questionnaires that had been returned with complete answers were further tested to confirm the RBV approach related to the empirical data within the research constructs. Despite the strengths of the sampling approach, it is acknowledged that purposive sampling may introduce bias due to the non-random selection of respondents. Additionally, the cross-sectional nature of the study limits the ability to infer causality over time. Future studies are encouraged to adopt longitudinal designs to better understand the evolving impact of digital technologies on frugal innovation.

In this study, respondents were not solely chosen based on their industry affiliation (Film and Culinary sectors) but were also selected based on an objective assessment of their digital competence. This decision was driven by the varying levels of technology adoption within these industries. In the Film industry, digital technologies such as IoT and AI are increasingly utilized in production and distribution for automated video editing, audience data analysis, and content distribution optimization. However, the degree of technology adoption varies significantly depending on the scale and technological capabilities of the company. Therefore, merely being part of the film industry does not guarantee that respondents possess the necessary digital competence to evaluate technologies like IoT and AI (Daniels et al., 2019). Similarly, in the culinary sector, IoT and AI are used in areas such as supply chain optimization, inventory management, and customer preference analysis. Although these technologies play an essential role, their adoption and understanding can vary widely among businesses (Wu et al., 2022). Therefore, assessing digital competence was crucial to ensure that respondents could provide informed insights into the application of these technologies. To enhance the validity of the data collected, a digital competence assessment was integrated into the questionnaire. This ensured that only respondents with a genuine understanding of IoT and AI technologies were included, thereby strengthening the robustness of the analysis (Trenerry et al., 2021).

This study utilized Structural Equation Modeling (SEM) with the AMOS program to test the research hypotheses. A quantitative approach for data analysis with Structural Equation Modeling in the AMOS 21 program was employed for this research. To validate the measurement instruments, convergent validity was assessed using Average Variance Extracted (AVE) values, with all constructs exceeding the 0.5 threshold. Reliability was evaluated through Composite Reliability (CR), with values above 0.7 confirming the consistency of the constructs (Anderson & Gerbing, 1988). These steps ensure that the measurement model meets the criteria for validity and reliability, aligning with SEM best practices. The Maximum Likelihood Estimation (MLE) method was applied, given its robustness in handling multivariate normality and ensuring the reliability of the path coefficients. The multivariate normality requirement in SEM testing was necessary to estimate the structural (path) coefficients. MLE required endogenous variables to be normally distributed (Anastasiou & Gaunt, 2020). This method aligns with the study's objective of empirically validating the impact of IoT and AI on GBOS and frugal innovation. The measurement model applied convergent validity to ensure the validity of the indicators in measuring the tested variables. The significance of the indicators assessed the appropriateness of the indicators in forming the latent variables. Therefore, the SEM analysis was performed by testing the goodness of fit parameters and the research hypotheses on the causal relationships in the model. The SEM assumptions that were required to be met included a small Chi-Square value, Probability ≥ 0.05, CMIN/DF ≤ 2.00, GFI ≥ 0.90, AGFI ≥ 0.90, TLI ≥ 0.95, CFI ≥ 0.95, and RMSEA ≤ 0.08 (Arbuckle, 2011).

The reason for selecting this region was the presence of creative MSME clusters currently utilizing technology for business development. Secondly, the collection of empirical data confirmed how resource limitations, particularly cost efficiency, could be reduced using AI and IoT in areas that had relatively low regional income. Thirdly, by leveraging the government's Go-Digital MSME program, it was anticipated that businesses could continue to innovate cost-effectively while maintaining environmental sustainability. This study aimed to empirically demonstrate the impact of independent variables on dependent variables. The author collected data by distributing questionnaires to the research sample. The sample characteristics were presented in Table 1 below.

Table 1. Respondents of the research sample

Sample characteristics	Description	Number of samples	Percent
Educational Level	Elementary	23	8.78
	Junior high school	34	12.98
	Senior high school	76	29.01
	Diploma	34	12.98
	Bachelor's degree	95	36.26
Age	< 25	40	15.27
	26 - 30	32	12.21
	31 – 35	62	23.66
	36 – 40	78	29.77
	41 – 45	29	11.07
	> 45	21	8.02
Sector Creative:	Photography	18	6.87
	Film, Animation, and Video	32	12.21
	Publishing	21	8.02
	Advertising	19	7.25
	Visual Communication Design	17	6.49
	Music	18	6.87
	Television and Radio	5	1.91
	Product Design	24	9.16
	Apps and Game Developers	19	7.25
	Art	18	6.87
	Fashion	22	8.40
	Interior Design	17	6.49
	Culinary	20	7.63
	Architecture	12	4.58
Operating Duration	< 3 years	48	18.32
	> 3 to 5 years	104	39.69
	> 5 to 10 years	85	32.44
	> 10 years	25	9.54
Average income per month	< IDR 5 million	69	26.34
	> IDR 5 million to 10 million	79	30.15
	> IDR 10 million	114	43.51
Number of employees	< 5 persons	117	44.66
	> 5 to10 persons	89	33.97
	> 10 persons	56	21.37
Business capital	< IDR 25 million	145	55.34
	> IDR 25 million to 50 million	72	27.48
	> IDR 50 million	45	17.18

Note: n = 262.

Variable and measurement of construct

This study used a quantitative research design to test hypotheses and the empirical research model. The research sample was drawn from a cluster of creative MSME industries by identifying four relevant constructs: IoT, AI, GBOS, and FI. A thorough literature review was conducted to identify the research variables, followed by reliability and validity testing. Each construct was measured using a 7-point Likert scale (1 = strongly disagree to 7 = strongly agree). The endogenous constructs in this study were GBOS and FI, while the exogenous constructs were IoT and AI.

This study included dimensions for each construct. The exogenous construct of IoT had two dimensions: first, resource usage management, which was measured with three statements, and second, integration with cost-effective innovation, which was measured with four statements. The artificial intelligence construct had three dimensions: resource efficiency improvement (REI), sustainable supply chain management (SSCM), and lifecycle impact reduction (LIR). REI was reflected by two statements, SSCM was measured with two statements, and LIR was reflected by two statements. The GBOS construct had two dimensions: sustainable value creation, which consisted of three items, and sustainable value proposition, which consisted of three items. For FI, there were six statement items in total, with the first three items from the dimension of Sustainable Creative Product Development and the next two statements from the dimension of Affordability and Accessibility. Each statement item within the dimensions was described in Table 3. Thus, a total of 24 statement items were tested to measure each construct.

RESULTS

Descriptive statistics and correlations

IoT, AI, GBOS, and FI are presented in Table 2 as descriptive data and correlation matrices. The table also provides the average values, standard deviations, and correlation matrix of the study variables. The means range between 3.45 and 3.71, indicating that the level of adoption is moderate to high. The responses are consistent, as evidenced by the standard deviations ranging from 0.72 to 0.81. The correlations are strong and positive, with GBOS and FI showing the strongest connection (0.75). These figures support the testing models for the hypotheses. More specifically, the 0.63 correlation between AI and FI indicates a strong positive relationship, suggesting that greater AI usage is associated with higher FI.

Table 2. Mean, standard deviation, and correlation of the construct

Construct	Mean	Std. Dev.	IoT	AI	GBOS	FI
IoT	3.45	0.76	1	0.65	0.70	0.60
AI	3.52	0.81	0.65	1	0.68	0.63
GBOS	3.68	0.72	0.7	0.68	1	0.75
FI	3.71	0.78	0.6	0.63	0.75	1

Note: IoT: Internet of Things; AI; Artificial Intelligence GBOS: Green Blue Ocean Strategy; FI: Frugal Innovation. The p-values for the correlations between constructs are not displayed in this table but are statistically significant at the 0.05 level. Correlations represent the strength and direction of relationships between constructs, with values closer to 1 indicating a stronger positive relationship.

Validity and reliability testing

This study assessed validity by conducting confirmatory factor analysis (CFA) and evaluated reliability by examining construct reliability using the Critical Ratio (CR) value. Additional testing was performed to determine the values of Construct Reliability (CR), Average Variance Extracted (AVE), and Discriminant Validity (DV) for each exogenous and endogenous construct. The validity and reliability of each construct were evaluated by analyzing the coefficient alpha value. As shown in Table 3, the constructs of IoT, AI, GBOS, and FI not only met but significantly exceeded the necessary conditions for validity and reliability, with values greater than 0.7. The test findings for the average variance extracted value indicated a value above 0.5, further reinforcing the robustness of the constructs. The Discriminant Validity value for each construct exceeded 0.7, providing strong evidence of their distinctiveness. Table 3 presents the computations for assessing validity and reliability using the AMOS program, underscoring the thoroughness of the analysis.

Table 3. Scale item for measures

Variable	Indicator	Scale item	Reference	Std. loading (Lambda value)	Critical ratio ≥1.96
Internet of Things	RUM_1	Our business has used IoT to cut down on energy use	Adapted from: Azzawi et al. (2016); Bhatti (2012); Govindan (2024); Qin (2024); Sullivan et al. (2023); Tiwari (2021)	0.803	-
	RUM_2	With the help of IoT, our company has been able to cut down on material loss.		0.733	11.291
Construct Reliability = 0.703	RUM_3	IoT systems let businesses keep an eye on how resources are being used and report on it in real time.		0.793	11.952
AVE = 0.574	ICEI_1	Our company uses IoT to make successful products and services that meet the wants of the market at a low cost.		0.750	-
	ICEI_2	Our company's IoT products can give more people access and reach a wider audience, even those with low incomes.		0.773	11.433
	ICEI_3	Using IoT to improve innovation has led to big results for both our business and outside groups.		0.692	10.346
	ICEI_4	Our company has been able to successfully bring IoT applications to new places.		0.751	11.162
Artificial Intelligence	REI_1	Our business uses AI to make the best use of energy in its processes.	Adapted from: Alliance (2020); Govindan (2024); Masanja and Mkumbo (2020); Qin (2024); Stroumpoulis et al. (2022); Thakare et al. (2022)	0.833	-
	REI_2	AI is used by our company to help find energy waste and leaks.		0.681	10.637
Construct Reliability = 0.847	SSCM_1	AI is used by our company to find sources that meet environmental standards.		0.867	-
AVE =0.719	SSCM_2	Using AI helps people decide what to buy.		0.786	11.712
	LIR_1	Our business makes products that are better for the world.		0.817	6,406
	LIR_2	With the help of artificial intelligence, goods can last longer.		0.814	6.406
Green Blue Ocean Strategy	SVC_1	Implement strategies to reduce the environmental impact throughout the lifecycle of products.	Adapted from: Ottman and Books (1998); Pickett-Baker and Ozaki (2008); Russo and Fouts (1997); Sen and Bhattacharya (2001)	0.689	-
	SVC_2	Enhance the efficiency of resources.		0.786	10.502
Construct Reliability = 0.775 AVE = 0.708	SVC_3	Integrate sustainability into supply chain, from sourcing to distribution.		0.760	10.274
	SVP_1	Offer products with specific green features that reduce environmental impact		0.593	-
	SVP_2	Build a reputation for sustainability that enhances brand value and customer loyalty		0.800	8.738
	SVP_3	Acquire environmental certifications and labels to communicate our commitment to sustainability to customers		0.737	8.481
Frugal Innovation	SCPD_1	When our company makes products, we consider how they will affect the world.	Adapted from: Bhatti (2012); Govindan (2024); Hossain et al. (2023); Park et al. (2018); Qin (2024)	0.777	-
CR = 0.711 AVE = 0.602	SCPD_2	Our business uses data analysis and AI predictions to find trends.		0.701	8.709
	SCPD_2	When it comes to using eco-friendly materials in new ways, our company is proud.		0.723	-
	AA_1	Our business is done so that people from all walks of life can use it.		0.709	9.654
	AA_2	Our company uses IoT technology to lower output costs and make them affordable.		0.712	9.684

Note: RUM: Resource Usage Management; ICEI: Integration with Cost effective Innovation SSCM: Sustainable Supply Chain management; LIR: Lifecycle Impact Reduction; SVC: Sustainable Value Creation; SVP: Sustainable Value Proposition; SCPD: Sustainable Creative Product Development; AA: Affordability and Accessibility; AVE: Average Variance Extracted; CR: Construct Reliability.

The loading factor values demonstrated the reliability and validity of the four constructs: IoT, AI, GBOS, and FI. The IoT loading factor value was divided into two parts: Resource Usage Management (RUM) and Integration with Cost-effective Innovation (ICEI). The four indicators for RUM were 0.803, 0.733, and 0.793 for RUM_1, RUM_2, and RUM_3, respectively. The four indicators for ICEI were 0.750, 0.773, 0.692, and 0.751 for ICEI_1, ICEI_2, and ICEI_3, respectively.

Artificial intelligence was divided into three components: Resource Efficiency Improvement (REI), Sustainable Supply Chain Management (SSCM), and Lifecycle Impact Reduction (LIR). The AI values were 0.833 for REI_1, 0.681 for REI_2, 0.867 for SSCM_1, 0.786 for SSCM_2, and 0.817 and 0.814 for LIR_1 and LIR_2, respectively. Sustainable Value Creation (SVC) and Sustainable Value Proposition (SVP) comprised the two components of GBOS. For items SVC_1, SVC_2, and SVC_3, the loading factor values were 0.689, 0.786, and 0.760, respectively. The loading factors for SVP_1, SVP_2, and SVP_3 were 0.593, 0.800, and 0.737, respectively. Finally, FI consisted of two components: Affordability and Accessibility (AA) and Sustainable Creative Product Development (SCPD). The SCPD values were 0.777 for SCPD_1, 0.701 for SCPD_2, and 0.723 for SCPD_3. The values for AA_1 and AA_2 were 0.709 and 0.712, respectively.

The construct reliability of the IoT, AI, GBOS, and FI constructs was demonstrated by values exceeding 0.7. The average variance extracted value also exceeded 0.5. The validation testing for IoT, AI, GBOS, and FI is summarized in Table 3. A loading factor value greater than 0.6, as defined by Hair et al. (2013)U, is the necessary criterion. Therefore, the four constructs were deemed valid.

Discriminant validity

The discriminant validity values for the GBOS, FI, AI, and IoT variables are presented in Table 4. To assess discriminant validity, the square root of the Average Variance Extracted (AVE) for each construct must be examined and compared to the correlations between the constructs. A construct is considered discriminant valid if its square root of AVE is higher than its correlations with other constructs. The constructs used in this study were valid because IoT, AI, GBOS, and FI all demonstrated good discriminant validity, indicating that they each measured a distinct aspect of the data.

Table 4. Discriminant validity

Variable		**GBOS**		**FI**		**AI**			**IoT**	
SVP		**SVC**	**AA**	**SCPD**	**SSCM**	**REI**	**LIR**	**ICI**	**RUM**	
GBOS	SVP	**0.715**								
	SVC	0.704	**0.746**							
FI	AA	0.573	0.634	**0.715**						
	SCPD	0.556	0.615	0.602	**0.740**					
AI	SSCM	0.410	0.454	0.538	0.522	**0.827**				
	REI	0.502	0.556	0.659	0.640	0.751	**0.761**			
	LIR	0.413	0.457	0.542	0.527	0.618	0.757	**0.816**		
IoT	ICI	0.338	0.375	0.298	0.290	0.242	0.297	0.244	**0.742**	
	RUM	0.362	0.401	0.319	0.310	0.259	0.317	0.261	0.573	**0.777**

Source: Data Processed from software AMOS.

Structural model

Hypothesis testing

The table presents the discriminant validity values for the GBOS, FI, AI, and IoT factors. To assess discriminant validity, the square root of the Average Variance Extracted (AVE) for each construct should be compared to the correlations between the constructs. A construct exhibits discriminant validity if its square root of AVE is higher than the correlations with other constructs. The research models were considered valid because IoT, AI, GBOS, and FI all demonstrated the ability to distinguish between different data types and showed strong discriminant validity.

Table 5. Results of the hypothesis testing and goodness-of-fit analysis

Hypothesis variable		**Std estimate**	**Coefficient**	**T value**	**P**	**Conclusion**
H1	IoT → FI	0.079	-0.036	-0.460	0.646	Not supported
H2	IoT → GBOS	0.074	0.255	3.456	***	Supported
H3	AI → FI	0.064	0.271	4.250	***	Supported
H4	AI → GBOS	0.052	0.251	4.837	***	Supported
H5	GBOS mediates the influence of IoT to FI	Full-mediation effect is confirmed.				
	Mediation Process	Std estimate	Coefficient	T-value	P	Conclusion
	P1: IoT → GBOS	0.048	0.358	7.432	***	Supported
	P2: GBOS → FI	0.456	0.502	11.000	***	Supported
	P3: IoT → FI	0.429	0.258	6.018	***	Supported
	P4: IoT → FI	0.390	0.078	2.006	0,458	Not supported
H6	GBOS mediates the influence of AI to FI	Full-mediation effect is confirmed.				
	P1: AI → GBOS	0.418	0.377	9.032	***	Supported
	P2: GBOS → FI	0.411	0.349	8.494	***	Supported
	P3: AI → FI	0.313	0.435	13.923	***	Supported
	P4: AI → FI	0.318	0.303	9.557	***	Supported
H7	GBOS → FI	0.175	0.689	3.949	***	Supported
Goodness of fit Test				Cut-off value	Result	Conclusion
Significance of Chi-square				≥0.05	0.000	Poor fit
The goodness of Fit Index				≥0.90	0.919	Fit
The Adjusted Goodness of Fit Index				≥0.90	0.879	Marginal fit
Comparative Fit Index				≥0.90	0.958	Fit
Tucker Lewis Index				≥0.90	0.952	Fit
RMSEA-Root mean square error of approximation				0.03 – 0.08	0.042	Fit

Note: ***p <0.05.
Source: Data Processed from software AMOS.

Table 5 presents the full structural equation model employed to examine the empirical research model:

- IoT did not have a significant effect on FI, as indicated by the p-value for H1 (0.646), which exceeds the significance level of 0.05, and the negative path coefficient (-0.036). These results provide insufficient evidence to establish a significant relationship between IoT and FI. Consequently, hypothesis 1 is not supported.
- H2, regarding how IoT affected GBOS, had a path coefficient value of 0.255 and a significance value of 0.000, suggesting that IoT positively impacted GBOS. Therefore, hypothesis 2 was confirmed.
- AI had a substantial positive impact on FI, as evidenced by the path coefficient value of 0.271 and the significance value of 0.000 for H3. Therefore, hypothesis 3 was confirmed.
- H4 showed a significant positive influence of AI on GBOS, with a significance value of 0.000 and a path coefficient value of 0.251. Therefore, hypothesis 4 was confirmed.
- H5, which examined GBOS's mediating role in the relationship between IoT and FI, revealed that the direct impact of IoT on FI was no longer significant when GBOS was included in the regression model. The study found that including GBOS in the regression model did not eliminate AI's significant direct influence on FI. This suggests that GBOS partially mediates the association between AI and FI.
- H6, which tested the mediating role of GBOS in the relationship between AI and FI, indicates that GBOS acts as a significant mediator. This is evidenced by the substantial positive impact of AI on GBOS (0.377, $p < 0.05$), and the effect of GBOS on FI (0.349, $p < 0.001$). Therefore, hypothesis 6 is supported, suggesting that GBOS fully mediates the relationship between AI and FI.
- GBOS significantly enhanced FI, as shown by H7's significance value of 0.000 and a path coefficient value of 0.689. Therefore, hypothesis 7 was confirmed.

Overall, the findings confirmed hypotheses 2, 3, and 4, as well as the mediation processes outlined in hypotheses 5 and 6. However, hypothesis 1 was not supported by the results. Based on the findings, GBOS plays a significant role in how IoT and AI affect FI. This underscores the importance of employing Green Blue Ocean Strategy to enhance cost-effective innovation. The connection model between IoT, AI, GBOS, and FI is illustrated in Figure 2.

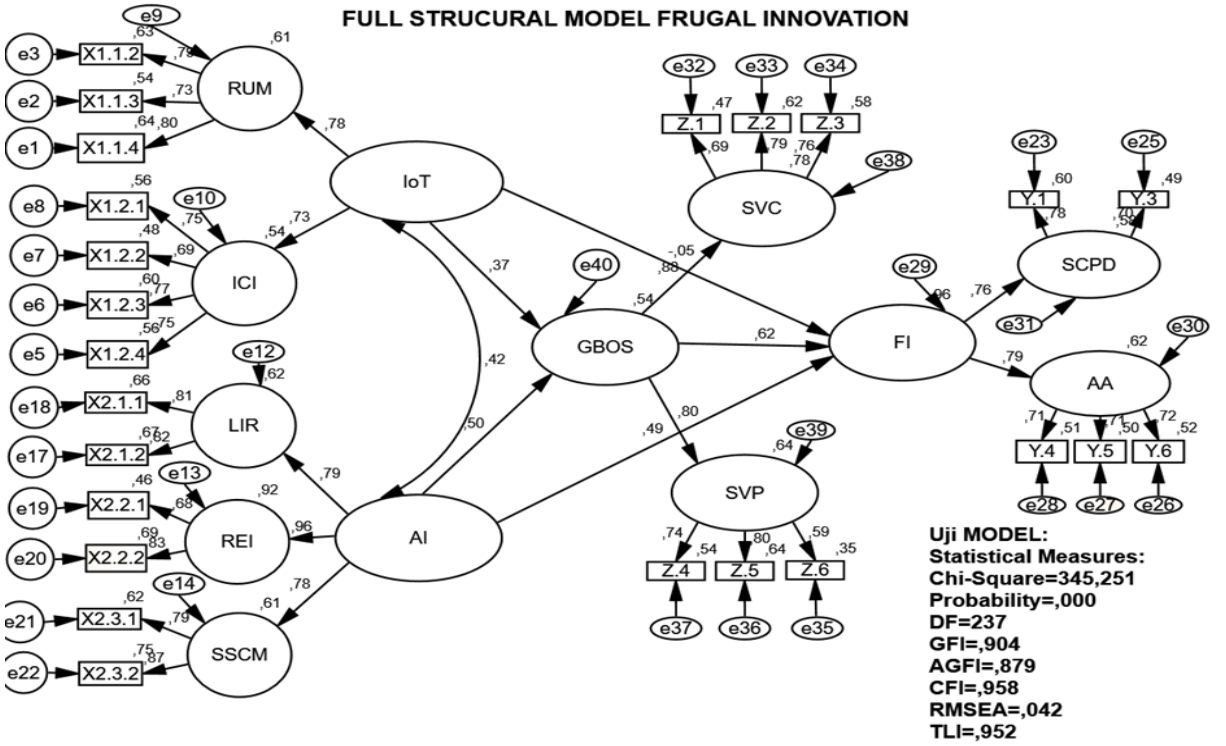

Figure 2. Full structural model – Frugal Innovation

Source: Output SEM-AMOS.

Mediation role testing

Through data processing results on the AMOS SEM path coefficient, which was studied by Baron and Kenny (1986), researcher looked at how GBOS affected the link between IoT and AI with FI. The successful outcome of mediation was assessed by analyzing the significant correlation between the independent and dependent variables. The results indicated no statistically significant correlation between IoT and FI ($\beta = 0.079$, $p = 0.646$). Therefore, Baron and Kenny (1986) criteria for their test were not fulfilled. The first mediating role of the indirect association between IoT and FI through GBOS was found to be statistically significant (P1: $\beta = 0.048$, $p < 0.001$) and (P2: $\beta = 0.456$, $p < 0.001$). Therefore, the initial mediation test proposed by Baron and Kenny (1986) was satisfied. GBOS served as a mediator in the link between the Internet of Things (IoT) and Financial Inclusion (FI). The indirect association of AI on FI through GBOS was found to have a statistically significant mediating impact. Specifically, the first path (P1: $\beta = 0.418$, $p < 0.001$) and the second path (P2: $\beta = 0.411$, $p < 0.001$) were both significant. Therefore, the second mediation test proposed by Baron and Kenny (1986) was successfully fulfilled. GBOS acted as a mediator in the relationship between AI and FI.

DISCUSSION

According to the study's findings, the empirical data does not support the initial hypothesis that the Internet of Things (IoT) would have a substantial adverse impact on frugal innovation. The observed effect was indeed negative, but it was not statistically significant. The outcomes of this study contradict prior studies, which indicated that IoT would enhance cost efficiency and improve time management (Jones & Graham, 2020; Widjaja & Gunawan, 2024), thereby significantly

facilitating frugal innovation. This study indicates that the utilization of IoT has a negative and negligible effect on frugal innovation. The initial cost of implementing IoT is significantly high for small and medium-sized enterprises (SMEs) in Indonesia. Alongside investing in the acquisition and development of technology, SMEs must also engage in ensuring their human resources are capable of operating it. Small and medium-sized firms encounter greater challenges when it comes to incurring the additional costs associated with skill enhancement and organizational changes required for the adoption and utilization of technology (Organisation for Economic Co-operation and Development, 2019). Jones and Graham (2020) asserted that several human resources lack an adequate understanding of the Internet of Things (IoT). This substantial investment is clearly inconsistent with the principle of frugal innovation, which seeks to develop cost-effective and efficient solutions for populations with constrained resources (Wooldridge, 2010), low cost (Dabić et al., 2022), and flexible-oriented (Fu et al., 2024). Secondly, not all SMEs are prompt in adopting IoT inside their operations. The insignificant impact of IoT on frugal innovation can be attributed to high implementation costs, which pose a barrier for MSMEs in resource-constrained contexts (Organisation for Economic Co-operation and Development, 2019). This finding suggests that while IoT has potential for cost-efficiency, its practical adoption among MSMEs is limited by additional costs related to technological acquisition and employee training.

Some researchers think that the manufacturing and industrial sectors are the primary and swiftest users of IoT technology (Cook, 2019; Varaniūtė et al., 2018). Artificial Intelligence (AI) may enhance frugal innovation by optimizing resource use and improving efficiency. The results of this study align with the conclusions of Qin (2024) research. Artificial intelligence (AI) revolutionizes creative endeavors, as evidenced Füller et al. (2022). Artificial intelligence (AI) enables the creation of economic, highly efficient, and user-focused solutions. Artificial intelligence enables the swift and extensive advancement of economics (Schwaeke et al., 2024). The ability of AI to analyze consumer patterns and behaviors allows innovators to discover new opportunities that adhere to the tenets of frugal innovation, which focuses on providing optimal value with few resources. The significant positive impact of AI on frugal innovation underscores its ability to optimize resource allocation and drive sustainable solutions. This study demonstrates that AI enables MSMEs to identify cost-saving opportunities through data-driven decision-making, aligning with the principles of frugal innovation. By leveraging AI, MSMEs can enhance their capacity for sustainable value creation, a key element of the Green Blue Ocean Strategy. Artificial intelligence facilitates the development of sustainable and economical solutions. The efficacy of AI use aligns with the emphasis on cost-effectiveness in frugal innovation. Besides efficiency, the elements affecting the ease of AI adoption in SMEs and its impact on innovation include the usability of AI, the advantages of AI implementation (Chatterjee et al., 2022), the effectiveness of digital transformation (Dörr et al., 2023), available resources, and managerial conduct (Korherr et al., 2023). Therefore, artificial intelligence (AI) has a significant role in enhancing the societal influence of frugal innovation, thereby increasing its accessibility to needy individuals.

This study discovered that the Internet of Things (IoT) has a beneficial influence on the Green Blue Ocean Strategy. This strategy focuses on ongoing innovation and value generation in unexplored areas, while also ensuring environmental equilibrium. The Internet of Things (IoT) enables firms to gather and analyze data instantly (Jeba & Rathi, 2021; Yu & Wang, 2022), leading to faster discovery of new prospects and the adoption of eco-friendly solutions (Almalki et al., 2023; Memić et al., 2022). Through IoT, MSMEs may oversee resource utilization in real-time, thereby minimizing waste and ineffective energy usage (Hariyani et al., 2024; Yen Ting et al., 2017). Furthermore, IoT empowers MSMEs to develop innovative eco-friendly goods (Almalki et al., 2023), including smart irrigation systems (Badrun & Manaf, 2021) and gadgets that use recycled materials. These technologies not only create new markets but also facilitate carbon footprint reduction and promote sustainable business practices. Conversely, IoT enhances transparency and consumer confidence for MSMEs by facilitating ecologically sustainable supply chain data tracking (Sallam et al., 2023). Consumers can access information on the provenance of raw materials, carbon emissions, or product recycling methods, therefore enhancing brand value among sustainability-conscious consumers. Moreover, IoT enhances logistics efficiency by improving distribution routes and reducing gasoline use. This not only reduces operational expenses but also enhances sustainability.

The findings of this study demonstrate that Artificial Intelligence (AI) has a substantial and beneficial influence on the execution of the Green Blue Ocean Strategy. Artificial intelligence is ideally suited to propel the Green Blue Ocean Strategy, facilitating the emergence of new chances for enterprises to establish uncontested market sectors and provide novel goods or services. Artificial intelligence may assist in identifying trends (Okeleke et al., 2024; Temitayo Oluwadamilola et al., 2024), identifying novel market possibilities (Mani, 2024; Perifanis & Kitsios, 2023), fostering value innovation (Perifanis & Kitsios, 2023), and surmounting entry obstacles, are all critical elements for the success of the Green Blue Ocean Strategy. AI plays a crucial role in assisting this approach by offering comprehensive and predictive data

analysis (GhorbanTanhaei et al., 2024), allowing organizations to find unexplored market potential and address customer demands with greener solutions. The integration of environmental peculiarities with novel market value characterizes this approach. The progress of artificial intelligence promotes environmental sustainability (Nastasa et al., 2024; Raman et al., 2024). By leveraging AI, firms may enhance production processes, minimize inefficiencies, and create new goods and services that not only align with the principles of sustainability but also adhere to the core principles of the Green Blue Ocean Strategy plan. This study contributes to our comprehension of how sophisticated technologies, such as artificial intelligence (AI), might enhance corporate strategies that prioritize sustainable innovation. These findings align with prior research indicating that AI has the potential to enhance operational efficiency and stimulate eco-friendly innovation.

This study illustrates that the adoption of the Green Blue Ocean Strategy positively influences frugal innovation. The Green Blue Ocean Strategy plan integrates the blue ocean strategy (Kim & Mauborgne, 2004) with the green ocean strategy (Hou, 2007). We integrate the two techniques to emphasize the cultivation of sustained value innovation. The Green Blue Ocean Strategy Approach substantially influences the promotion of frugal innovation in MSMEs by fostering the development of economic solutions that are both environmentally sustainable and inventive. The Green Blue Ocean Strategy can promote continuous innovation (Abdulkareem, 2022). This method prioritizes value innovation, which not only generates new goods or services but also minimizes expenses by removing superfluous elements or procedures. The Green Blue Ocean Strategy Approach facilitates MSMEs in optimizing local resource use and reducing waste within the framework of frugal innovation. For instance, MSMEs might diminish the utilization of costly raw materials by substituting them with more affordable and sustainable recycled resources, thus generating cost-effective solutions that align with the expanding green market. This study enhances existing research by illustrating the significance of the Green Blue Ocean Strategy as a vital driver for the progression of cost-efficient and sustainable innovation. This illustrates that a strategy focused on ambition and creativity benefits not just companies aiming to lead emerging sectors but also in promoting an effective method for innovation. The company will get a competitive advantage through the adoption of frugal innovation (Shahid et al., 2023).

The Green Blue Ocean Strategy facilitates the connection between the Internet of Things (IoT) and frugal innovation by integrating sophisticated technology with sustainability. The Internet of Things (IoT), which produces real-time data via sensors and connections (Soori et al., 2023), allows organizations to enhance operational efficiency and minimize resource wastage (Doniirawan, 2023). Nonetheless, the application of IoT frequently necessitates substantial expenditures. The Green Blue Ocean Strategy is pivotal in directing IoT implementation towards more economical, inclusive, and sustainable solutions. This method not only utilizes IoT for technical efficiency but also promotes social value and sustainability. Frugal innovation arises from the amalgamation of IoT and the Green Ocean Strategy. We utilize IoT data to create economical goods and services available to the broader community, especially in resource-limited settings (Nassani et al., 2022; Qin, 2024). This technique guarantees that the resultant innovation is both cost-effective and possesses a minimum environmental footprint, aligning with sustainability objectives.

This study demonstrates that the green ocean approach acts as a substantial mediator in the correlation between Artificial Intelligence (AI) and frugal innovation. AI facilitates frugal innovation by implementing the green ocean approach, which prioritizes sustainability and innovation in the exploration of undiscovered market prospects. Artificial intelligence (AI) allows firms to find cost-effective and environmentally friendly creative solutions (Bolón-Canedo et al., 2024). The blue ocean strategy provides a framework that promotes the production of new value (Kim & Mauborgne, 2004) by utilizing AI technology to develop goods and services that suit the changing demands of the market. These findings highlight the significance of implementing a green ocean strategy to integrate modern technologies like AI with cost-effective and environmentally friendly innovation approaches. The green ocean strategy serves as a mediator between AI and frugal innovation, enabling organizations to combine their sustainability objectives with inventive requirements that are adaptable to limited resources.

This study enhances the theoretical understanding of RBV by demonstrating how IoT and AI fulfill Valuable, Rare, Inimitable, Organized (VRIO) criteria, making them critical resources for achieving competitive advantages. Furthermore, GBOS introduces a novel perspective by integrating these technologies into a sustainability-driven framework, differentiating it from traditional BOS. This positions GBOS as a dynamic capability that allows SMEs to adapt to market demands while maintaining ecological balance, a contribution that expands the applicability of RBV in sustainable innovation research. The mediation role of GBOS highlights its function as a strategic framework that integrates sustainability into innovation processes, enabling MSMEs to leverage IoT and AI effectively. This finding contributes to the Resource-Based View (RBV) by emphasizing GBOS as a unique organizational capability that aligns

with the VRIO framework—valuable, rare, inimitable, and organized resources (Barney, 1991; Barney & Clark, 2007). By embedding sustainability principles, GBOS offers a practical extension to RBV, addressing the dynamic demands of resource-constrained environments (Teece et al., 1997). The Internet of Things facilitates real-time resource management, while artificial intelligence enhances corporate process optimization and predictive analytics. Both technologies satisfy the RBV criteria as valuable, rare, inimitable, and well-structured resources that underpin durable competitive advantages. Nonetheless, the deployment of IoT and AI necessitates considerable upfront investment, particularly in the enhancement of human resource competencies. Consequently, SMEs must enhance their organizational ability to proficiently manage and leverage these technologies as an integral component of a resource-based strategy. Furthermore, the use of these technologies underscores the need for dynamic capability within the Resource-Based View (RBV), necessitating that SMEs consistently adjust and reorganize their resources to remain pertinent amid market fluctuations. The capacity to leverage real-time data from IoT enhances operational efficiency, while AI's capability to comprehend customer behavior enables SMEs to develop goods and services that align more closely with market demands. This indicates that investment in technological advancement and associated human competencies is not only a reaction to immediate demands but also a strategic approach to sustain competitiveness in a more intricate market.

This study demonstrates that, within the Green Blue Ocean Strategy (GBOS) framework, the integration of IoT and AI allows SMEs to generate sustainable value ideas and access new markets. The Internet of Things (IoT) assists small and medium-sized enterprises (SMEs) in minimizing resource waste via real-time monitoring, aligning with the sustainability tenets of the green ocean strategy. Simultaneously, AI enables the identification of unexploited market possibilities and the development of creative solutions that are more efficient and ecologically sustainable. This strategy not only generates competitive benefits but also assists organizations in fulfilling customer requests for more ecologically sustainable business operations. Moreover, GBOS advocates for SMEs to develop products and services that are both pertinent to market demands and possess a small ecological footprint. By utilizing AI, SMEs may create goods that include recycled materials or minimize energy usage, thereby generating new value in a competitive marketplace. This approach emphasizes that sustainability and innovation don't have to conflict; they can combine to create relevant, economical, and significant solutions. Consequently, GBOS functions as a proficient framework for SMEs to not only endure but also thrive against market fluctuations and worldwide environmental adversities.

CONCLUSION

This study extends the Resource-Based View (RBV) by demonstrating how IoT and AI can serve as strategic resources that fulfill the VRIO criteria, driving frugal innovation in resource-constrained environments. Furthermore, the Green Blue Ocean Strategy (GBOS) framework highlights the integration of sustainability into innovation processes, enabling businesses to achieve economic growth while reducing ecological footprints. By extending the application of the Resource-Based View (RBV) theory, this study demonstrates how integrating IoT and AI can promote frugal innovation strategies that drive both economic efficiency and ecological sustainability in Asian developing markets. The findings indicate that leveraging AI significantly enhances energy efficiency (factor loading 0.833), while IoT contributes to sustainable innovation, albeit with challenges in infrastructure and data management. The study's hypothesis testing yields theoretical and practical implications for Asian businesses. The researcher enhances our comprehension of the blue ocean strategy's function by utilizing the theoretical implications of the RBV theory approach. RBV theory views the GBOS concept as having theoretical implications, such as leveraging the company's unique and difficult-to-replicate internal resources, acquiring company resources at a cost lower than their potential value, and creating economic value for the company while maintaining resource scarcity. This research enriches the existing literature by demonstrating that combining the RBV framework with GBOS provides a robust approach for leveraging technology-driven sustainable innovation, thus enhancing competitive advantages in resource-scarce environments.

The RBV theoretical perspective addresses the following questions in the study's findings: First, by utilizing economic innovation efforts from the highest factor loading of 0.833, it shows that AI can be used to maximize energy in operations. However, IoT facilities must aid in optimizing cost-effective innovation despite organizational, business, and technical hurdles. Furthermore, only a few companies have the necessary infrastructure and technology to optimize data management and collection. Second, the GBOS solution can directly or indirectly foster economic innovation by fusing AI and IoT with environmentally friendly, sustainable innovation components. By establishing guidelines for the use of ecologically friendly technical raw materials to boost resource efficiency, GBOS broadens scientists' and marketing professionals'

understanding of BOS, allowing them to focus on sustainable value development. Third, actors in Asia's creative economy can benefit practically from the role of GBOS. The theoretical implications emphasize the synergy between GBOS and RBV in fostering sustainable innovation, particularly in cost-constrained contexts. From a managerial perspective, this study provides actionable insights for businesses in adopting IoT and AI to improve resource efficiency and achieve competitive advantages. Socially, the application of frugal innovation through GBOS enables inclusive economic growth by promoting eco-friendly and culturally significant products, addressing the growing demand for sustainable practices in developing regions. Traditional goods or regional services can offer distinctive products that introduce the history of regional Asian goods and open up new markets to the outside world. The sustainable demand for inventive, ecologically friendly products is driven by Asia's rapid economic growth. Innovative enterprises in Asia's developing nations can achieve cost savings in operations through the application of technology in GBOS. Additionally, GBOS is proactive in developing improvements to environmentally friendly technology innovation policies and promotes environmentally friendly regulatory changes.

In a circular economy framework, the integration of parsimonious innovation practices generates value by facilitating the exchange of knowledge and innovation capability (Yousaf et al., 2022). This study provides actionable insights for business managers in developing regions. By adopting low-cost IoT and AI technologies, firms can enhance their resource efficiency and reduce operational costs. Additionally, the GBOS framework offers a pathway for creative industries to penetrate new markets by promoting sustainable, culturally significant products. The adoption of frugal innovation practices through GBOS can support community-driven enterprises by promoting the use of affordable technologies, thereby contributing to inclusive economic growth and sustainable development. Frugal innovations, which are typically low-cost and practical solutions that emerge from contexts of institutional vacancies and resource constraints, involve the creative use of existing resources (Manta et al., 2021). Adopting low-cost innovation methods helps build long-lasting business management skills and abilities in uncertain situations. Creative industry companies can support innovation and make necessary changes to their structure and business technologies by working with internal and external stakeholders, enhancing creative thinking skills, and upgrading and integrating business technologies. Policymakers are encouraged to support regulatory frameworks that incentivize the use of eco-friendly technologies and foster strategic partnerships between industries to drive frugal innovation.

The contextual scope of this investigation is restricted in several ways. The empirical results were exclusively obtained from Central Java, Indonesia, which is still classified as a developing Asian country. This study's empirical scope is limited to Central Java, which may restrict the generalizability of the findings to more developed regions. Additionally, the cross-sectional design limits the understanding of long-term impacts of IoT and AI adoption on sustainable innovation. Consequently, the findings cannot be applied to developed countries. Unlike a longitudinal study, the data collection procedure was conducted cross-sectionally within a limited timeframe. However, these findings highlight the necessity of conducting additional research on AI applications in other industries, emphasizing the importance of this study in the broader context of AI and innovation. As a result of these constraints, future researchers may apply network theory or strategic partnership theory to further develop the results of this study in various business contexts. This may entail creating concepts related to green innovation partnerships, sustainable innovation orchestration, and green value adaptability. Future research should adopt longitudinal designs to assess the evolving impact of IoT and AI on sustainability in diverse economic contexts. Additionally, integrating network theory and strategic partnership frameworks could enhance the applicability of GBOS across various sectors, including healthcare and logistics. Exploring green innovation partnerships and sustainable orchestration strategies will further expand the understanding of GBOS in promoting cost-effective, eco-friendly solutions. Expanding the data from this study will provide valuable insights for marketing scientists, business proprietors, and marketing managers in the development of sustainable, eco-friendly product innovation strategies.

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Diana Aqmala: Conceptualization, Funding Acquisition, Supervision, Validation. **Roymon Panjaitan**: Conceptualization, Methodology, Writing – Original Draft, Writing – Review & Editing. **Elia Ardyan**: Data Curation, Formal Analysis, Software, Visualization. **Febrianur Ibnu Fitroh Sukono Putra**: Data Curation, Investigation, Project Administration, Resources.

Conflicts of interest

The authors have no conflict of interest to declare.

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