

DOI: [https://doi.org/10.48009/1\\_iis\\_2024\\_131](https://doi.org/10.48009/1_iis_2024_131)

## Utilization of AI, big data, and internet of things (IoT) in sustainable innovation and their role in the emergence of novel business models

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### Abstract

AI, big data, and IoT (collectively called ABI technologies) enable revolutionary sustainability and sustainable development changes by providing organizations with previously unavailable tools to address complex environmental, social, and economic challenges. They enable digital sustainable transformation in organizations and play a vital role in improving supply and value creation. Given their importance and relevance, we conduct this research to understand their role in driving sustainable innovation and novel business models. This study employs qualitative meta-synthesis (QMS) and case study research (CSR) design. By reviewing the extant literature and studying 3 case countries, namely, Finland, Germany, and South Korea, this study indicates the vital role of ABI technologies in sustainable development, leading to the emergence of new green business models aimed at creating value while enhancing sustainability. This study contributes to the theoretical foundations of sustainable development by building a conceptual framework for a novel sustainable business model.

**Keywords:** artificial intelligence (AI), big data, sustainable development, qualitative meta-synthesis (QMS), case study research (CSR)

### Introduction

Artificial intelligence (AI), big data, and IoT or the internet of things (we will collectively refer to them as ABI technologies) have become part of many facets of our lives, from commerce and finance to education (Sushkova et al., 2021; Tang et al., 2021), communication, and social interaction (Gouvea et al., 2018), they have become deeply ingrained (Sen et al., 2022). This pervasive influence is emblematic of a profound transformation: the digital revolution (Ignat, 2017; Nosova et al., 2021). At its core lies digital transformation (Gomez-Trujillo & Gonzalez-Perez, 2021; Hilbert, 2020), a dynamic process fueled by digital innovations that drives digital disruptions in organizations and societies (Ignat, 2017; Vial, 2019). Its repercussions are vast, profoundly altering the landscape of organizational value creation, strategy, and structural mechanisms.

Notably, the role of ABI technologies in sustainability and development is gaining traction (Feroz et al., 2021; Holmström, 2022) as they enable organizations to bring enhancements in their operations, streamline value chain processes, digitalize operations, and foster efficiency (Feroz et al., 2023; Liu et al., 2020). The transformative capabilities of ABI technologies are so unprecedented that organizations are increasingly prioritizing the development of strategies to adapt them to their business operations (Singh et al., 2019; Verhoef et al., 2019). The transformations enabled by ABI technologies are seen not only in business

organizations (Vaska et al., 2021) but also at the government (Benjamin & Potts, 2018; Clarke, 2019), society (Hilbert, 2020), and country levels (Aly, 2022; Balogun et al., 2020; Nick et al., 2019).

ABI technologies have a wide range of applications in smart cities, smart manufacturing, sustainable supply chains, sustainable production, and smart farming (Feroz et al., 2023; Ghobakhloo, 2020). Their impact on green business trends is significant, revolutionizing how organizations address sustainability and environmental responsibility (Kamble et al., 2018; Liu et al., 2020). They drive innovation in areas such as sustainable product development, circular economy initiatives (Sinkovics et al., 2021; Truant et al., 2024), and the adoption of renewable energy, facilitating a transition toward a more sustainable world (Jain & Ranjan, 2020; Wahyudi Sumari, 2020).

These days, organizations are taking an interest in creating value through sustainable or green business practices because it creates monetary value for businesses and, at the same time, leads to sustainable development (Moşteanu et al., 2020; Sodhro et al., 2019; Weersink et al., 2018). Given the importance of these green disruptions enabled by ABI technologies, it is imperative to understand the resulting green business models (Nair & Paulose, 2014; Trapp & Kanbach, 2021).

This research paper investigates the role of ABI technologies in sustainable innovation and the emergence of new green business models that create value for organizations while enhancing sustainability. This article addresses these research questions;

**RQ1:** *What role do ABI technologies play in sustainable innovation?*

**RQ2:** *Does sustainable innovation enable by ABI technologies lead to new sustainable business models?*

This introduction section stresses the need to investigate ABI technologies in digital innovation and sustainable business models. The rest of the paper is organized as follows: in the next section of the theoretical back, we provide a literature review followed by the research methodology, where we provide details on the steps undertaken in consolidating the relevant literature and employing case study research. In the fourth and fifth sections, we present our results and provide detailed discussions, followed by a conclusion outlining the implications, limitations, and directions for future work.

## Theoretical Background

ABI technologies are key drivers of digital transformation that play a role in sustainability (Feroz et al., 2021). The reliance of organizations on ABI technologies for engaging in sustainability-driven activities and fostering sustainable industries (El hilali et al., 2020; Kunkel & Matthes, 2020) is punctuated by their ability to enable a win-win scenario by enhancing sustainability while creating value. Table 1 provides the definitions and roles of ABI technologies in sustainable innovation.

**Table 1: AI, Bigdata and, and IoT**

Technology	Definition and Explanation	Role in Sustainable Innovation	Sources
Artificial intelligence (AI)	AI is about programming and machine learning to make machines intelligent enough to reason, solve problems, and conduct business transactions. It is the most prominent digital technology today, with significant implications for organizations and societies.	AI offers avenues for enhancing green product innovation and promoting greener industry practices by empowering organizations to cultivate efficient processes, capabilities, and energy conservation mechanisms.	(Bressanelli et al., 2018; Demartini et al., 2019; Roth, 2017)

Technology	Definition and Explanation	Role in Sustainable Innovation	Sources
Big data	Big data demonstrates the incredible size and complexity of data that conventional databases are not able to store or manage. It requires special analytics to examine and uncover hidden patterns in huge volumes of data. Big data is considered a valuable resource by organizations for creating insights for decision-making.	Big data plays a pivotal role in developing systems that efficiently manage diverse waste streams, minimize environmental damage, and advance the vision of zero-waste societies. Utilizing big data in organizational and industrial operations can lead to significant transformations in product life cycle management.	(Daki et al., 2017; Kumar et al., 2018; J. Wang et al., 2021)
Internet of Things (IoT)	IoT is characterized by a network of interconnected devices, objects, and systems that communicate and exchange data with each other over the Internet. IoT technology enables communication between devices by gathering data on the cloud and provides solutions to various issues.	IoT provides innovative solutions for organizations, industries, and governments to reduce carbon emissions and mitigate pollution. Their implementation can pave the way for a world free of carbon emissions and pollution. Moreover, IoT plays a crucial role in fostering smart and sustainable cities, contributing to society's sustainable development.	(Cirillo et al., 2019; Idrees & Zheng, 2020)

## Sustainable Innovation

To understand sustainable innovation, it is imperative to look at sustainable digital transformation (Figure 1). We adapt the framework development by Feroz et al. (2023) to define sustainable innovation as “a desired state of the convergence between sustainability and innovation culminated by sustainable processes, green products and services, and sustainable business models” (Figure 2). While sustainable digital transformation is more comprehensive than sustainable innovation, the objective in both cases seeks a “sustainable green digital world.”

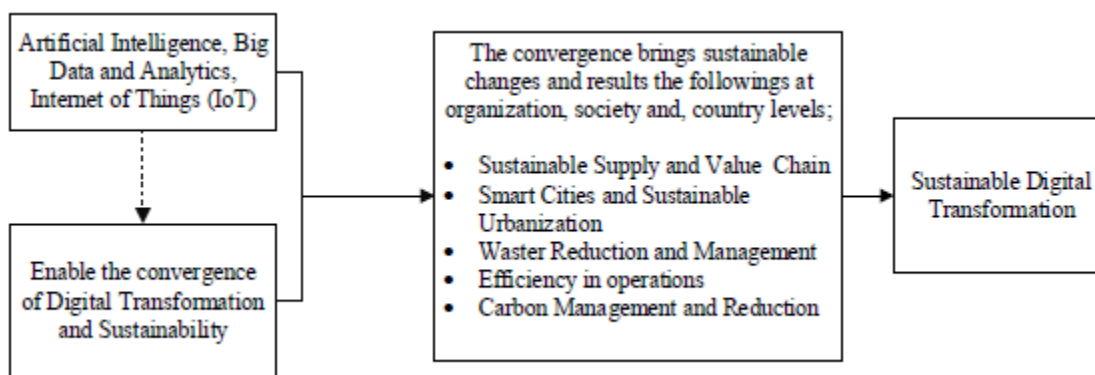


Figure 1: Sustainable Digital Transformation Framework Adapted from (Feroz et al., 2023)

## AI in Sustainable Innovation

AI and relevant technologies drive sustainable innovation by enabling organizations to enhance sustainability in their processes and operations (Kitsios & Kamariotou, 2021; Nishant et al., 2020). For example, various AI-based robotics are being industrialized to manage harmful waste generated by the mass consumption of goods (Sarc et al., 2019). AI can be a powerful enabler of the global effort to promote

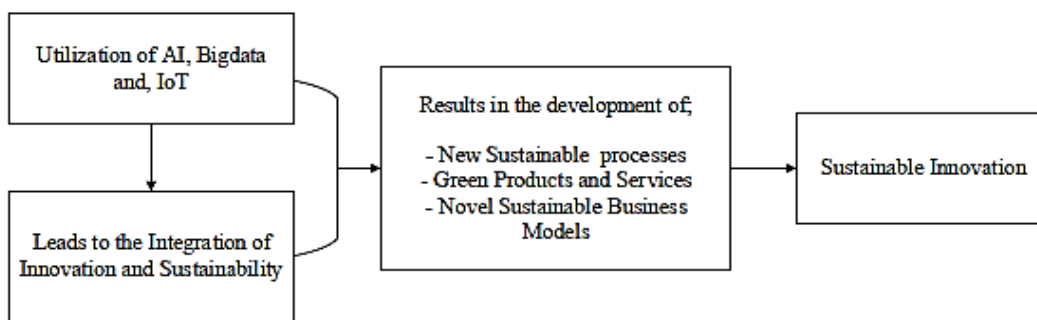
economic development and, at the same time, sustainably address the impact of our production and consumption on our societies, governance systems, and the environment.

## *Bigdata in Sustainable Innovation*

Bigdata is considered a key technology in driving sustainable innovation by enabling the development and expansion of intelligent manufacturing, smart cities, and sustainable production (Kurniawan et al., 2022; Osman, 2019; Ren et al., 2019). It provides tools for organizations to obtain data-driven insights and intelligence needed to address pressing environmental, social, and economic challenges (Herman et al., 2018; Soroka et al., 2017).

## *IoT in Sustainable Innovation*

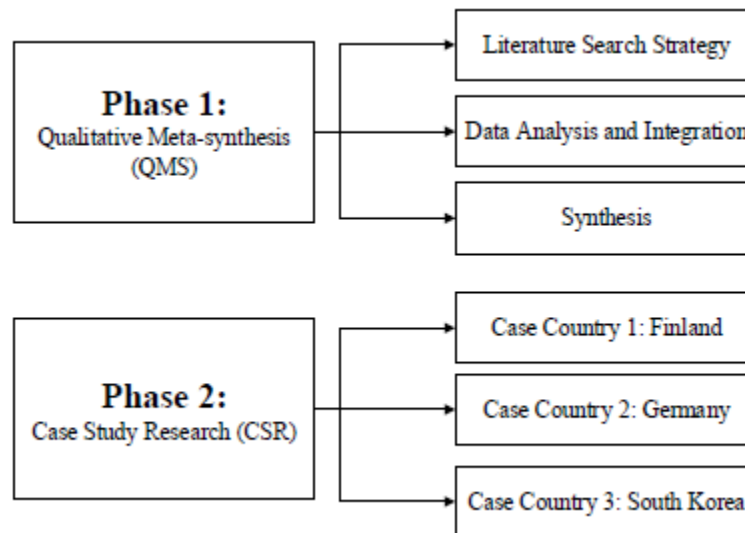
IoT and relevant technologies offer solutions to sustainability issues (de Vass et al., 2021; Manavalan & Jayakrishna, 2019). Studies show that IoT and relevant technologies are reshaping the manufacturing arena and transforming businesses to adopt sustainable innovation for reducing carbon emissions and other harmful waste to the environment (Demartini et al., 2019; Manavalan & Jayakrishna, 2019).



**Figure 2: Framework for Sustainable Innovation**

## **Methodology**

In this article, we aim to assess the role of ABI technologies in sustainable innovation and the emergence of sustainable business models. Given the multidisciplinary nature of our study, we used a mixed-methods approach to arrive at solid conclusions. We developed a multiphase research design (Figure 3). We formulated a literature search strategy based on established academic guidelines (Jones, 2004; Tranfield et al., 2003). This included a strategy for selecting databases, which is important regarding accessibility to full-length articles. In addition to the openly available databases like Google Scholar, we relied on ScienceDirect, JSTOR, and Wiley in line with guidelines from the literature (Harzing & Alakangas, 2016; Tober, 2011). Key words included; “artificial intelligence” AND “green business,” “artificial intelligence” AND “innovation,” “big data analytics” AND “green business,” “big data” AND “innovation,” “big data” AND “green business,” “big data” AND “sustainability,” “internet of things” and “green business,” “internet of things” and “sustainability,” “IoT” and “green business,” “IoT” and “sustainability” and, “IoT” AND “innovation.”



**Figure 3: Research Design of this study**

In phase two, we shifted our focus to case study research. The objective was to analyze European and Asian countries for a broader and more diverse understanding of sustainable innovation and what lessons they may have for the United States. The selection of case countries was done in line with the literature (Crowe et al., 2011; Shakir, 2002; Yin, 2009) where we considered the purpose of our research and the phenomenon. We selected three countries with reasonably good performance on the Sustainable Development Goals (SDGs) index of the United Nations (United Nations, 2023). For instance, Finland is ranked 1st, Germany is 4th, and South Korea is ranked 31st on the UN’s SDG Index (see: <https://dashboards.sdgindex.org/profiles>). We analyzed several official reports and publicly available documents relevant to these countries from the United Nations (<https://sdgs.un.org/goals>), the Organization for Economic Co-operation and Development or OECD (<https://www.oecd.org/>), the European Commission ([https://ec.europa.eu/info/index\\_en](https://ec.europa.eu/info/index_en)).

## Results

The analysis of data from the literature and case studies revealed patterns of sustainable innovation (Bonilla et al., 2018; Nasiri et al., 2017) leading to novel sustainable business models (Nair & Paulose, 2014; Weking et al., 2020) through the utilization of ABI technologies (Bressanelli et al., 2018; Çetin et al., 2021; Kumar et al., 2018). Based on the analysis of data from the literature and case studies, a framework for sustainable business models emerged (Figure 4). ABI technologies play vital roles in the creation of novel sustainable business models (Di Vaio et al., 2020; Kohtamäki et al., 2019). ABI is utilized to enhance sustainability by bringing more efficiency and productivity in the supply chain process and stimulating green business innovation (Balogun et al., 2020; George et al., 2020; Gregori & Holzmann, 2020). They are behind the digital disruptions in areas related to sustainability (Bag et al., 2020; Fernández Núñez et al., 2017; Goralski & Tan, 2020) and producing an overall positive impact on the environment while creating business value (Bican & Brem, 2020; Demartini et al., 2019; Ghezzi & Cavallo, 2020).

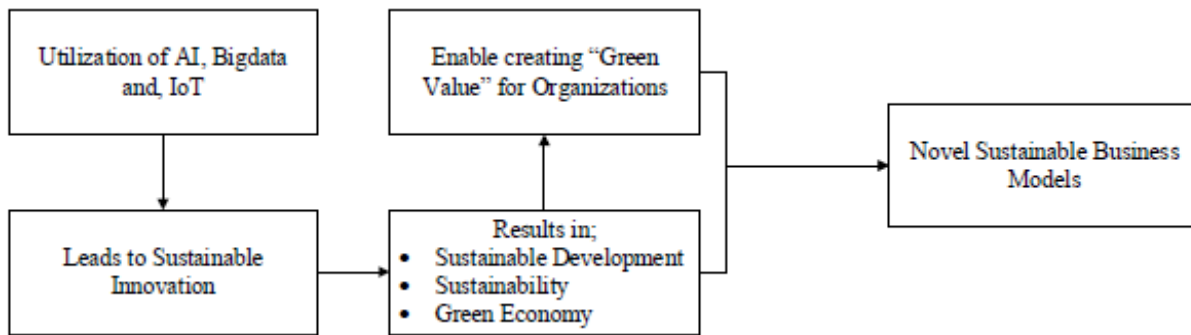


Figure 4: Framework for Novel Sustainable Business Models

**Key Factors Driving ABI Technologies Role in Sustainable Business Models**

The data analysis revealed that certain factors contribute to ABI technologies’ role in creating sustainable business models. Table 2 provides and explains these factors.

**Table 2: Key Factors Driving ABI Technologies Role in Sustainable Business Models**

Drivers	Explanations	Relevant sources
Green Digital Deal	The convergence of sustainability and ABI forms a new paradigm wherein businesses strive to create and capture value sustainably. For example, in South Korea, we discovered that the government is investing millions of dollars in the “Korean New Deal” for green growth and digitalization.	(Javaid et al., 2022; Lee & Woo, 2020; Ruggerio, 2021; R. Sharma et al., 2021)
Shift towards Green and Circular Economy	In the new green and circular economy paradigm, organizations are driving the digitalization of sustainability practices and seeking a digitalized green world. The aim is to promote sustainable development by minimizing environmental impact and resource depletion while fostering economic growth.	(Pagoropoulos et al., 2017; Pieroni et al., 2019; Schögggl et al., 2020)
Digitalization of Sustainability	The rise of innovative digital technologies sustainability challenges. These technologies facilitate the convergence of sustainability and digitalization, allowing for more effective and efficient solutions to environmental, social, and economic issues.	(Brenner & Hartl, 2021; George et al., 2021; Hatanaka et al., 2021)
Green Digital Value	Green digital value is created and captured through the utilization of new processes enabled by novel digital technologies, which drive sustainable digital transformation.	(Ghobakhloo, 2020; Goralski & Tan, 2020; Müller & Voigt, 2018)
Global Digital Ecosystems	The race toward global digital transformation in the post-COVID-19 era is providing a conducive environment for ABI technologies to create sustainable business models.	(Datta & Nwankpa, 2021; Katz & Callorda, 2018; Nair & Paulose, 2014)

## Discussion

The expansion of ABI technologies offers organizations and countries new ways to capitalize on green growth opportunities afforded by Industry 4.0 (Ibarra et al., 2018; Weking et al., 2020; Yang & Gu, 2021). At the industry level, bigdata has applications in sustainable supply chain practices and efficient manufacturing, contributing to sustainable development and the United Nations' SDGs. (Bag et al., 2020; S. Wang et al., 2018). At the country level, the incorporation of big data as a policy tool for addressing sustainability-related challenges is observed (Balogun et al., 2020; De Gennaro et al., 2016).

IoT enhances productivity and efficiency, sustainable supply chain management practices, and energy conservation, leading to sustainability enhancement (Manavalan & Jayakrishna, 2019; Tao et al., 2016). As an emerging technology, IoT will play an essential role in intelligent and sustainable cities (Feroz et al., 2021) because of its ability to generate massive amounts of data by ubiquitously deployed sensor devices (Pimpinella et al., 2019). As a critical component of ICT infrastructure, IoT has the potential to enhance environmental sustainability in intelligent, sustainable cities (Bibri, 2018) e.g., in this study (Khan, 2018) the author proposed algorithms for managing security versus energy consumption in an IoT network in the context of smart cities. In short, IoT can be applied in sustainable and green smart cities by minimizing energy consumption and enhancing cleaner production (Sodhro et al., 2019).

AI technology can support the sustainable development of wastewater treatment through water reuse, reduce pollutants, conserve energy consumption, and curb carbon emissions, thus enhancing sustainability and generating economic benefits (Huang & Fan, 1993; G. D. Sharma et al., 2020; Zhao et al., 2020). By addressing critical environmental issues, AI is contributing significantly to achieving the sustainable development goals of the United Nations, which strives for sustainable societies (Bali Swain & Yang-Wallentin, 2020; Saxena et al., 2021; Vinuesa et al., 2020). For other more significant threats to global sustainability, AI and machine learning can prove helpful in building systems and creating tools for assessing climate change and global warming (Biesbroek et al., 2020; Huntingford et al., 2019). Besides the environmental benefits, the business arena is also changing. With the emergence of AI-based robotics in the circular economy, business practices are increasingly being digitalized for waste management to decrease harm to the environment (Sarc et al., 2019). AI has enabled new business models in clean water and efficient energy management (Goralski & Tan, 2020). All these developments show that greener businesses are emerging where sustainability is at the center of value creation.

## Conclusion

ABI technologies are vital in addressing sustainability and economic challenges in the new paradigm shift of the alliance between digital transformation and sustainability. Through qualitative meta-synthesis (QMS) and case study research (CSR) design, this study reviewed existing literature and examined case studies in Finland, Germany, and South Korea. The findings underscore the significant impact of ABI technologies on sustainable development, leading to new green business models that simultaneously enhance value creation and sustainability objectives. The study's conceptual framework for novel sustainable business models contributes to advancing the theoretical foundations of sustainable development. By elucidating the interplay between ABI technologies and sustainable innovation, this research provides valuable insights for organizations seeking to leverage digital tools for sustainability goals. However, there are limitations. Our study sample of only 3 case countries can be expanded into a more significant sample for a more accurate generalization of findings from this study. In the future, researchers can employ qualitative and quantitative methods to understand the inner organizational mechanism of sustainable innovation and the role of ABI technologies.

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