Internet of things towards environmental performance: a scientometrics and future research avenues

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Abstract. The emerging contribution of the Internet of Things and technology in promoting sustainability and environmental protection is substantial. However, the empirical literature that studies the linkage between the three constructs is far from well-mapped. Accordingly, this study aims to map the literature associated with the Internet of Things and technology in establishing environmental performance by analyzing 1294 articles that underwent rigorous peer review on the Scopus and WOS databases. The finding demonstrated that there were six significant clusters to guide future research. The resulting visual trend is a guide for international collaboration between researchers in diverse academic fields, resulting in more enhanced research in terms of quality and quantity. Further implications are discussed in the paper.

1 Introduction

Information communication technology provides an impetus to establish performance and competitiveness in the age of knowledge. Consequently, integrating knowledge, technology, and the Internet of Things is a resource that enhances an organization's dynamic capabilities to achieve competitiveness [1–3]. However, from a different aspect, every business entity is encouraged to be sensitive to the environment [4] which is materialized by developing pro-environmental strategies and implementing concrete steps for environmental preservation [5,6]. Business performance must also be complemented with environmental responsibility [7] by recognizing internal and external aspects [8], [9]. The existing literature highlights that establishing environmental performance is determined by various drivers, which to date have yet to be comprehensively mapped [4,6]. For this purpose, it is imperative to map the literature that shows a trend for future research projections by noting several critical points as the urgency of this study.

First, the Internet of Things is imperative in promoting adaptation to future possibilities [1]. It prompts each organization to develop its strategic flexibility [10] to remain dynamic in response to dynamic due to turbulence [11,12]. The capability to grasp internet features is consistent with a technological adaptation that can be utilized to elevate organizational performance [13] advance circular economy practices [2] and predict future risks more precisely [1].

Second, the role of technology is acknowledged as an essential driver in building environmental performance. In constructing environmental strategies, technology assists in promoting the transformation of renewable energy for natural resource curtailment [14], the transformation of green innovation adoption [15] and upgrading clean technology for environmental management [16].

Third, owing to the urgency of environmental protection globally, stakeholders are pressing business entities to pursue environmentally oriented behaviors and perspectives [17–20]. Consequently, virtually every industry today endeavors to design environmentally friendly procedures and devise pro-environmental strategies [21,22]. Therefore, the trend of environmental research will foster cross-sectoral collaboration to produce an excellent quality of collaboration.

Further, corresponding to the emerging characteristics, research on the Internet of Things, technology, and environmental performance remain fragmented and investigated in diverse dimensions [23,24]. Although IoT and technology are the underpinnings of building environmental performance, studies on these three constructs are scarce [2,3], despite IoT and technology offering innovative solutions and advancing sustainability [23,24]. Consequently, understanding the interlinkages between IoT and technology is paramount in bridging an organization's transformation to sustainability [2,25] The existing literature has centered on the drivers and barriers to the Internet of Things and technology in multiple industries. However, the literature on the Internet of Things and technology as environmental performance triggers remains understudied. Therefore, this article maps out key research topics at the intersection of the Internet of

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Things, technology, and environmental performance. Further, bibliographic merging is applied to identify the principal lines of research within a broad range of literature and recommend topics for future research.

2 Methodology

2.1 Research protocols

We elaborated the research protocols into four principal steps. First, we identified the keywords "Internet of Things," "technology," and "environmental performance." Second, data organized as a research information system (*RIS) was collected and imported into Mendeley. Third, we retrieved 1200 valid data from Scopus and WOS databases for further analysis. Fourth, by performing multiple selections, including scope, keywords, and alignment, we obtained 518 suitable articles to be processed to achieve the study's objectives. This study identified the three keywords between June and August 2023.

Considering that all business entities were engaged in environmental sustainability, the topic of environmental performance experienced a significant increase [6], [7], [26].

2.2 Data analysis

VOS Viewer 1.6.20 was utilized to process the data. This tool was employed to determine relevant titles, abstracts, and keywords [27]. Moreover, publication maps, country maps, keyword maps, citations, and journal maps were adequately recognized [28]. VOS Viewer was implemented for data mining, database, and article grouping [29].

3 Results

3.1 Descriptive analysis

Further, we conducted analyses of the keywords "Internet of Things," "technology," and "environmental performance." When examining the publication trends comprising 104 review articles and 414 research articles, we retrieved 518 articles since 2014 with 1 article, which was later described in this paper as 2015 (1), 2016 (7), 2017 (12), 2018 (24), 2019 (37), 2020 (81), 2021 (81), 2022 (125), 2023 (145), 2024 (4). Figure 1 depict the trend from ten years.

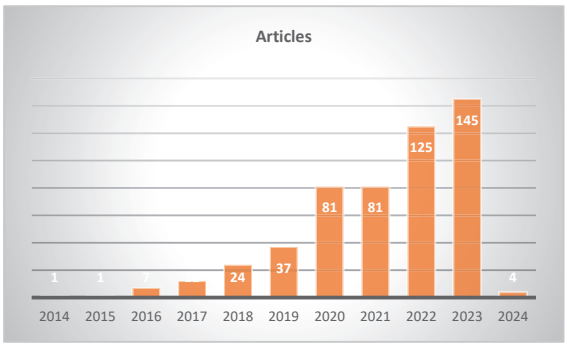

Fig. 1. Amount of related articles

Subsequently, we organized the journal venues of interest for publications adhering to these three keywords (see Figure 2). The generated results were Journal of Cleaner Production (179 articles), Technological Forecasting and Social Change (51), International Journal of Production Economics (34), Computers & Industrial Engineering (28), Sustainable Production and Consumption (28), Resources, Conservation, and Recycling (23), Renewable and Sustainable Energy Reviews (20), Journal of Environmental Management (18), Building and Environment (17), Computers in Industry (15), Automation in Construction (14), Industrial Marketing Management (13), Journal of Building Engineering (13), Energy and Buildings (12), Applied Energy (12), International Journal of Information Management (11), Environmental Impact Assessment Review (11), Energy (10), Science of the Environment (9), Sustainable Cities and Communities, Heliyon, and Resource Policy.

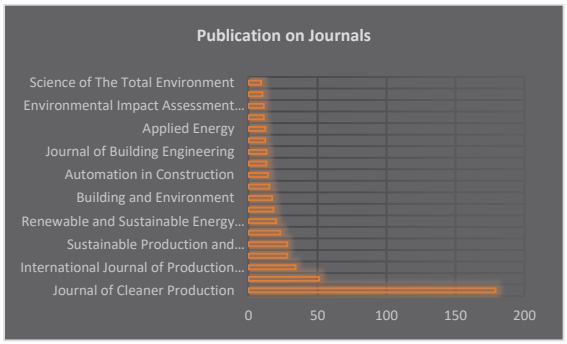

Fig. 2. Publication on journals

In terms of research areas, the trend of environmental performance is a prominent topic in virtually all research areas. It demonstrates that environmental protection concerns are evident in many business entities. The articles were significantly contributed by the fields of Energy (302 articles), Environmental Science (297), Engineering (173), Decision Sciences (142), Business, Management and Accounting (88), Social Sciences (63), Psychology (51), Economics, Econometrics and Finance (34), Chemical Engineering (28). Figure 3 revealed the subject areas and research trend.

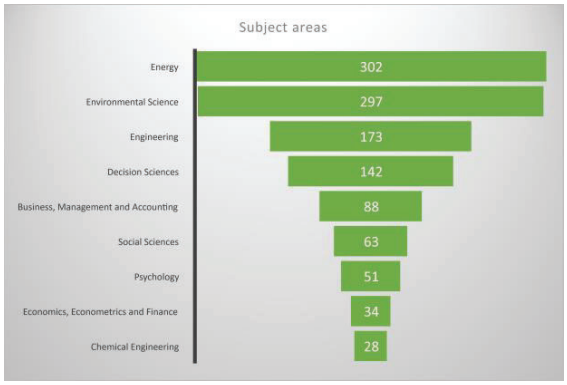

Fig. 3. Research in related areas

3.2 Bibliographic analysis

We utilized a bibliometric approach to reveal the research themes in this study (Figure 4).

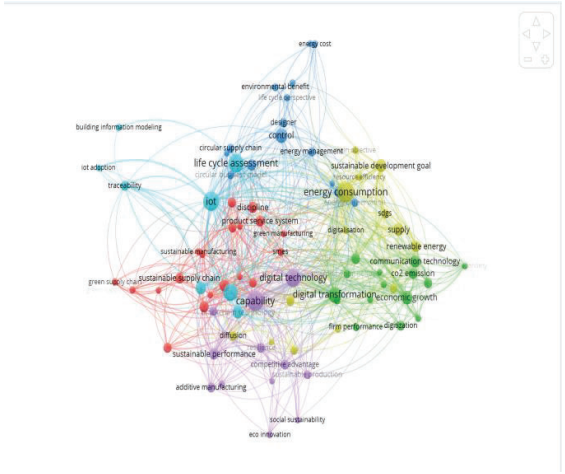

Fig. 4. Network visualization

The network results demonstrated six clusters as follows:

3.2.1 Big data analytic and circular economy

In the first cluster, big data analytics was an instrumental trigger in constructing environmental preservation initiatives, including circular economy practices [29,30] green supply chain [31,32] and green manufacturing [20], [33]. Further, there was also an interlinkage between big data analytics and sustainability practice and performance [34,35]. Moreover, stakeholder theory was the anchorage theory for framing this construct [36,37].

3.2.2 Digital technology

Implementing digital technology influenced the actualization of organizations in promoting pro-environment awareness [19], [21]. Digital transformation stimulated green innovation in accomplishing business performance [32], [38]. The reinforcement in technology was estimated to have a positive influence on achieving production efficiency in the natural environment [39].

3.2.3 Energy consumption

Resource allocation with practical calculation enabled the realization of the circular economy business model [6], [29]. Adequate energy consumption fostered efficient utilization of resources while simultaneously saving costs and elevating financial performance [4]. Regarding the environment, cost efficiency and enhanced financial performance prompted organizations to allocate a substantial budget to environmental protection and corporate social responsibility activities [40,41].

3.2.4 Internet of Things (IoT)

The Internet of Things was a significant driver in technology adoption for future endeavors. This reinforcement strengthened the organization's dynamic capability to perform environmental preservation programs, notably circular economy practices [2,3]. The Internet of Things had forced organizations to formulate a series of flexible strategies to overcome challenges and disruptions in the future [42,43].

3.2.5 Dynamic capabilities

Adopting open strategy and open innovation motivated organizations to transform their business model into a circular economy business model [43]. This business model transformation mandated organizations to enhance their dynamic capabilities by leveraging resources [44,45]. These dynamic capabilities elevated the organization's agility framework [45], enhancing innovation and competitiveness [46]. Moreover, dynamic capabilities promoted circular economy practices that impacted organizational resilience [47].

3.2.6 Blockchain technology

Technology adoption spurred fundamental changes and mechanisms in routine organizational activities comprising supply chains and operations [48,49]. Besides, blockchain technology enabled knowledge-sharing, promoting stakeholder trust [50]. Further, technology also fueled innovation sustainably. Regarding environmental performance, technology contributed to environmental preservation [51]. Technology also emphasized clean technology [16], [23].

Subsequently, we verified the history of these three topics in the past three years. The findings revealed that in 2020, the research topics were energy consumption, control, renewable energy, communication technology, CO2 emission, diffusion, energy cost, and control (Figure 5). Then, in early 2021, research topics focused on resource efficiency, digital transformation, life cycle assessment, sustainable supply chain management, capability, and the Internet of Things. In 2022, research

topics dwelled on digital technology, green supply chain, traceability, blockchain technology, digital transformation, and SMEs. Accordingly, viewing the trends in the last three years, it can be inferred that technology was an imperative driver in fostering environmental awareness in building sustainable business performance [34,35], [52,53]. Figure 5 illustrates the research trend in the last three years.

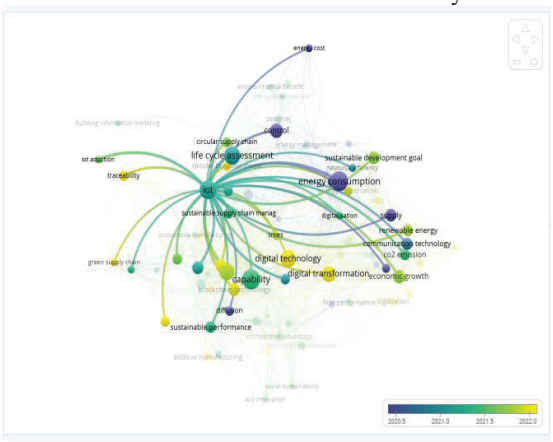

Fig. 5. Overlay visualization

Ultimately, we performed an analysis of the density visualization (Figure 6) to determine the primary concentration of research topics for the future. There were three main topics: the Internet of Things, economic growth, and energy consumption. It was followed by fainter colors, which depicted digital technology, sustainable supply chain, sustainable performance, product service system, and circular supply chain. Meanwhile, the faintest areas comprised building information modeling, information communication technology adoption, energy cost, social sustainability, and green supply chain management.

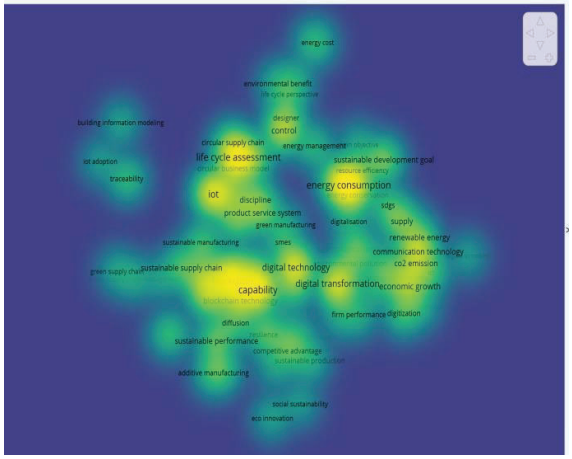

Fig. 6. Density visualization

4 Conclusions

We conclude that the Internet of Things and technology are fundamental to establishing environmental performance in this transition model. Digital technology, sustainable performance, energy consumption, and the Internet of Things are the prime triggers in achieving environmental performance.

The fundamental dimensions of the Internet of Things and technology can be materialized in technological transformation, which can serve as the framework for implementing these two constructs to achieve environmental performance. Further, it is crucial to mitigate barriers, including unsupported systems in technological transformation, high costs, limited resources, and resistance to technology. Accordingly, organizations that explore the internet and technology will achieve a long-term strategic plan and generate environmental legitimacy.

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