Big Data and Sustainability Innovation

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BIG DATA AND SUSTAINABILITY INNOVATION

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INTRODUCTION

This chapter presents the connection between big data and sustainability innovation. Understanding the connection between these two recent prominent topics is important because today, the need for sustainable innovation is increasing along with various global challenges faced both in terms of the natural environment and the social environment (Adams et al., 2016; Harsanto & Permana, 2021). Companies' innovations frequently have unanticipated consequences that degrade the environment on land, sea, and air. It also frequently harms the social environment, as evidenced by the growing economic divide between rich and poor.

This creates a sense of urgency for businesses to be able to innovate sustainably. Meanwhile, in terms of technology, the development of information communication technology is progressing rapidly, marked by, among others, big data and big data analytics, which help process large amounts of information and assist decision making, including decisions relating to innovation. These two major issues that are currently emerging, sustainability innovation and big data, which are the focus of this chapter. This chapter aims to better understand the link between big data and sustainability innovation. This achieved by exploring keywords form the scientific articles analyzed using bibliometric technique. This understanding is important because in the era of digitalization, companies need to rethinking about the ways they do business. Among the ways of doing business that business actors are starting to realize is the importance of achieving not only economic value but also social and environmental performance (Adams et al., 2016). Digital technologies such as big data regarded as a vital component to help companies achieve not only economic returns but also social and environmental benefits (Schneider, 2019). This chapter could be useful as a resource for academic and practical studies to maximize the use of big data to innovate sustainably and to serve as the foundation for future development.

BACKGROUND

Big data utilization has increased rapidly in recent years. Big data, which means huge volumes of data, when utilized carefully can help facilitate the organization in optimizing various business functions. For example, the use of big data can increase agility, which means the company's ability to effectively identify and respond to situations in its environment at speed (Ghasemaghaei et al., 2017). Sivarajah et al., (2017) suggested that big data can provide insight to enhance the decision-making process. these positive impacts can ultimately improve the company's performance, especially financial performance. Recent studies have found that increased profitability and reduced costs can be achieved with the effective use of big data (Dana et al., 2022; Love et al., 2020; Müller et al., 2018; Silva et al., 2019). Müller et al. (2018) using panel data spanning 6 years involving more than 800 companies found that the increase in company productivity as a result of big data and analytics implementation was in the range of 3-7 percent. In a wider perspective, the use of big data also provides benefits for non-commercial usage such as education, smart city, or heritage management (Harsanto, 2021; Ozer et al., 2022; Wang, 2022; D. Zhang et al., 2022).

The focus of previous studies investigating the relationship between big data and operational or financial aspects of a company has prompted the question, how big data is related to non-operational or non-financial performance such as social or environmental aspects of the organization. As performance is determined by various traditional factors such as leadership or culture or other factors, it is interesting to find out the latest issues regarding the relationship between big data and performance, especially innovation performance (Azis et al., 2017; Harsanto et al., 2020; Widianto & Harsanto, 2017). This question is important because of the concern of various stakeholders towards business organizations to be able to provide economic benefits but more than that, it can also provide benefits to the environment and society (Nunan & Di Domenico, 2017). In this context, big data utilization is also no exception to this concern.

More specifically, the focus of this study is the sustainability of innovation as a specific form of innovation (Hansen & Große-Dunker, 2013; Harsanto et al., 2018; Harsanto & Permana, 2019). In general, sustainability innovation can be in the form of eco or social innovation (Gumbira & Harsanto, 2019; Hansen & Große-Dunker, 2013). A study from Calic & Ghasemaghaei (2021) shows that innovation is a mediator between big data and social performance. Although it does not directly discuss sustainability innovation, the study implies that there is a possible connection between the two. In a broader view, it is interesting to know the discussion about big data and its relation to sustainability innovation. The purpose of this paper is to explore this phenomenon and become the basis for further exploration.

This study contributes to the literature by providing an overview of big data connectedness and sustainability innovation which is still rarely studied in the literature. Previous studies have focused more on the technical aspects of big data or the relationship between big data and the company's financial performance.

METHOD

The approach used is a systematic search on the Web of Science database to then analyzed using bibliometric tecnhique. The keywords used are a combination of “big data” AND “sustainability innovation” in the topic, covering title, abstract, and keywords. The selection of keywords is carried out in a straightforward manner on two concepts that are the center of attention in this paper, namely big data and sustainability innovation. Indeed, there are several other synonyms of sustainability innovation that can be involved such as eco-innovation or social innovation and the like. However, these keywords are not used because these concepts are a subset of sustainability innovation and in this paper, we focus on the generic concept of sustainability innovation. The search results gave 386 documents. After a systematic search, the next two main steps were taken. First, capture descriptive statistics provided by WoS to find out various attributes of the obtained document. Second, exporting metadata in the form of plain text files for keyword occurrence analysis to determine the relationship between various concepts discussed in these two fields (Harsanto, 2020b; van Eck & Waltman, 2014). Further, the metadata is exported to MS Excel format to facilitate analysis and reading, especially the title, abstract, and other important information of the article. The step-by-step process is shown in Figure 1.

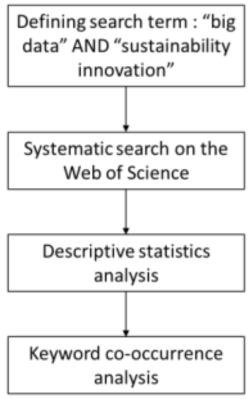

Figure 1. Step-by-step analysis process
Source: Authors' elaboration, 2021

The VOSViewer software is used to perform co-occurrence analysis on the keywords in documents (van Eck & Waltman, 2020). When performing co-occurrence analysis, VOSViewer's default setting is used, which is the occurrence of a minimum of 5 keywords. In principle, a cluster of concepts formed from co-occurrence analysis works by discover concepts that appear together in the analyzed documents. Concepts belonging to the same cluster mean that they have a strong link because they frequently appear together in the analyzed documents (IBM, 2022). The keywords used are from both the author and WoS and calculated using a full counting technique, which means that all keywords are given the same weight. The outcome of this analysis is the clustering of keywords based on their level of connection, as well as detailed frequency data for each keyword, which is analyzed using the content analysis principle to determine the most frequently used keywords in each cluster (Harsanto, 2020a).

RESULTS AND DISCUSSION

The following is a presentation of the results as well as a discussion of the results of the analysis of the publications included in the review. The sections presented include publication attributes such as publication year, document types, Web of Sciences categories, authors' affiliation, journal, research areas, countries of authors, and research areas. Subsequently, an analysis of the concepts represented by the keywords used in various publications is presented.

Publication year

The trend of publication by year seems to increase from year to year. Publications began to appear in the 2000s, although in small numbers with a relatively flat trend from year to year. The publication seems to have started to increase in 2014 with an increasing trend starting from around 10 articles per year then doubled to around 20 articles per year, to reach around 90 articles per year in 2021.

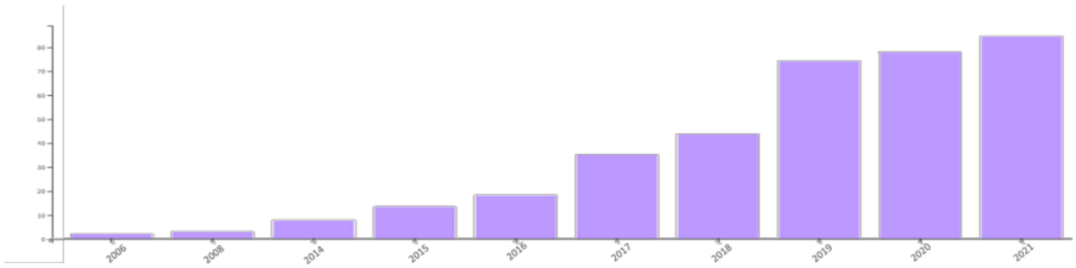

Figure 2. Publication year
Source: Web of Science, 2021

The trend, as shown in Figure 2, is in line with the development of SOI, which began to emerge in the 2000s and then increased after 2010. On a cumulative percentage basis, more than three-quarters of the total publications analyzed were published in the last four years. In 2021 there were 89 publications (23.01%), in 2020 there were 82 articles (21.24%), in 2019, there were 78 articles (20.21%), and in 2018 there were 46 articles (11.92%).

Document types

There are various types of documents included in this review. Most of the articles were 257 documents (66.58%), followed by conference proceedings with 70 documents (18.14%) and review articles with 50 documents (12.95%). Next, there were 25 early access documents (6.48%), book chapters 14 documents (3.63%), and editorial materials 10 documents (2.59%). This indicates there are quite a number of publications related to big data on sustainability innovation, and most of them are peer-reviewed journal articles. Peer review is the highest level in terms of the stringency of the review process to maintain and ensure the quality of publications.

Research Areas

From the perspective of the research area, there is an interdisciplinary nuance in the publications included in the review. Two research areas are equally dominant, namely environmental sciences ecology and other science technology topics, each with 118 documents or 30.57%. The next three research areas that are also widely studied are business economics with 87 documents (22.54%), engineering 74 documents (19.17%), and computer science 57 documents (14.77%). This is understandable because big data is an area that is closer with fields of science such as computer science, engineering, and technology; while sustainability innovation is more concerned with fields of science such as business economics and environmental science. The intersection of these domains of knowledge is interesting, and it can provide valuable insights into the future of big data for sustainable innovation.

Affiliations

The affiliations of the authors are shown in Figure 3. The main affiliations of the authors of the publications included in the review were mainly from Europe, China, and America. From Europe, the largest contributors were the Norwegian University of Science Technology NTNU with 9 documents (2.33%), followed by the University of London with 8 documents (2.07%), the University of Naples Federico II with 5 documents (1.29%) and the University of Salento (1.29%).

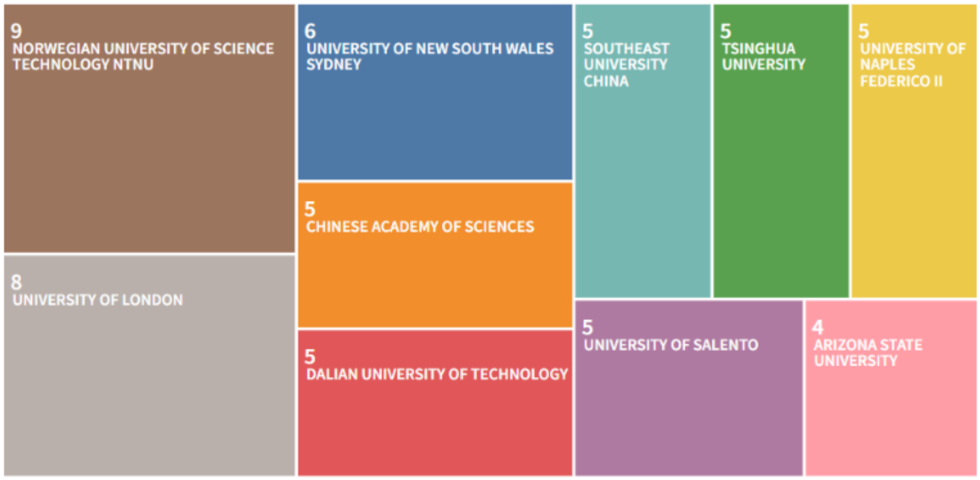

Figure 3. Author affiliations
Source: Web of Science, 2021

In China, the largest contributors were the Chinese Academy of Sciences, Dalian University of Technology, Southeast University China, and Tsinghua University, each with 5 documents (1.29% each). From America, the highest contributor was Arizona State University with 4 documents (1.04%). Apart from these affiliates, many other affiliates contributed 4 documents or less, including from universities in Latin America such as Universidade De Sao Paulo (1.04%), or universities in the Middle East such as Abu Dhabi University (0.77%). These results indicate that the topic has attracted the interest of researchers from various parts of the world, although it is currently predominantly studied by researchers with affiliations in Europe, China, and America.

Publication title

The outlets for the publication of documents included in the review are in quite many different titles. Considering that the most types of documents included in this review journal articles, so most publication titles are also in the form of journals. The journal that contains the most articles on this topic is Sustainability with 65 documents (16.84%), followed by the Journal of Cleaner Production with 17 articles (4.40%) and Technological Forecasting and Social Change with 9 articles (2.33%).

Outside the journal, there are several other titles, such as a book entitled Big Data Science and Analytics for Smart Sustainable Urbanism which contains 4 documents (1.04%) or proceedings such as Procedia Manufacturing with 3 documents (0.77%). The variety of publication titles, both in terms of titles and fields of science, shows the multidisciplinary nature of big data and sustainability innovation and attracts the attention of researchers from different disciplines.

Funding agencies

The Web of Science also records data on funding agencies. Funding agencies that sponsored the most documents were the National Natural Science Foundation of China (NSFC) with 34 articles (8.81%), followed by the European Commission with 11 articles (2.85%), and Coordenacao De Aperfeicoamento De Pesjual De Nivel Superior Capes, Brazil with 8 articles (2.07%).

In addition, other funders from various parts of the world have also funded these studies. For example, UK Research Innovation (UKRI) with 6 articles (1.55%), Ministry of Education Culture Sports Science and Technology (MEXT) with 4 articles (1.04%), National Institutes of Health (NIH) the USA with 2 articles (0.52%). The diversity of funders indicates enthusiasm for developing big data, including developing sustainable innovations.

Index

Considering that the Web of Science database consists of various specific indexes, as shown in Figure 4, the composition of the documents is based on the index. The largest index is the Social Sciences Citation Index (SSCI) with 202 documents (52.33%), followed by the Science Citation Index Expanded (SCI-Expanded) with 181 documents (46.89%) and the Emerging Sources Citation Index (ESCI) with 53 documents (13.73%).

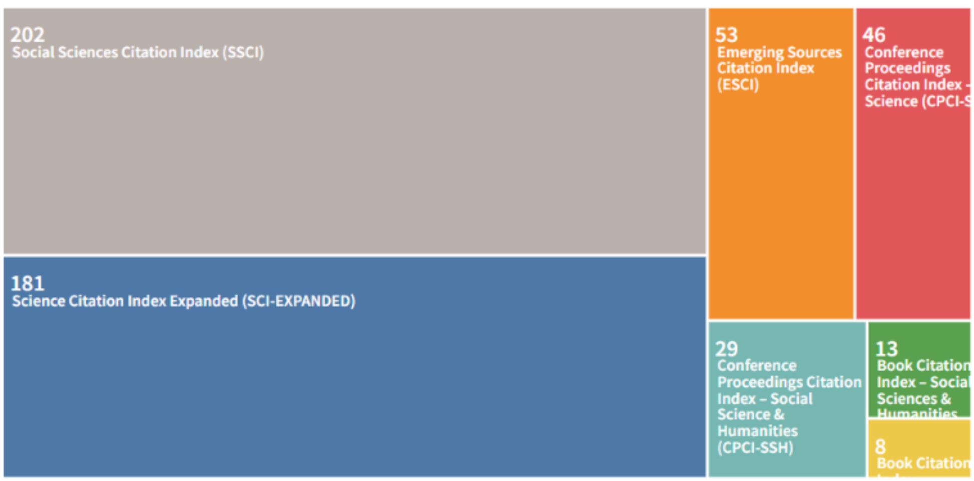

Figure 4. WoS Index
Source: Web of Science, 2021

Subsequently, it was followed by a conference and book citation index, namely the Conference Proceedings Citation Index – Science (CPCI-S) with 46 documents (11.92%), Conference Proceedings Citation Index – Social Science & Humanities (CPCI-SSH) with 29 documents. (7.51%), Book Citation Index – Social Sciences & Humanities (BKCI-SSH) with 13 documents (3.37%) and Book Citation Index – Science (BKCI-S) with 8 documents (2.07%). There are two things to be learned here. First, the majority of the documents are in the main indexation, which includes journals; specifically, the first three indexes are SSCI, SCI-Expanded, and ESCI. Second, the two most dominant indexes are a combination of indexes containing journals in the field of social sciences (SSCI) and journals more in the field of science and technology (SCI-Expanded).

Clusters of concepts

The clusters of concepts are accomplished by analyzing the co-occurrence keywords from the documents included in the review. Co-occurrence analysis is performed by analyzing document metadata using VOSViewer software and analyzing all keywords in WoS from both the author and the database. As a default in the software, 116 keywords with co-occurrence of at least 5 times were obtained from a list of 2182 keywords. The analysis yielded the results of six concept clusters (Figure 5).

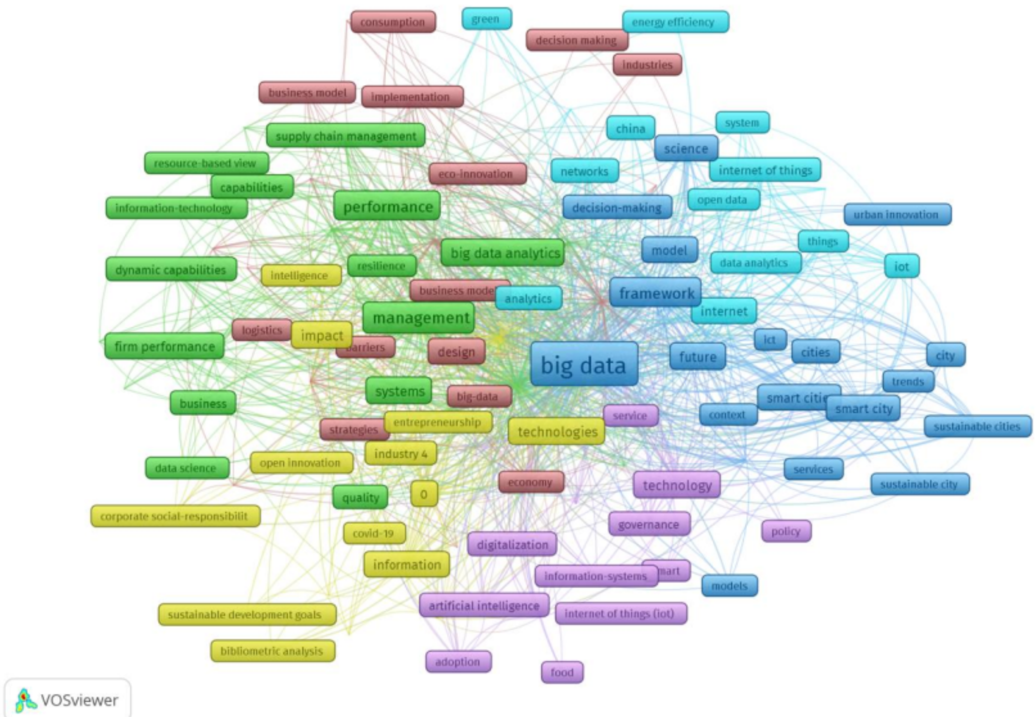

Figure 5. Cluster of Concepts
Source: Authors' elaboration based on Web of Science, 2021, generated by VOSViewer

Cluster 1: Circular Economy and Sustainable Development

The first cluster discusses several topics related to sustainable development, circular economy, design, business model innovation, knowledge, and other topics (Table 1). The discussion of big data for sustainability innovation certainly cannot be separated from the keyword sustainable development, which includes a discussion of the implications of industry 4.0 on sustainability and ecosystem support for digital sustainability development (Bonilla et al., 2018; Stuermer et al., 2017). The concept of digital sustainability development is related to the circular economy which is concerned with reducing the consumption of natural resources and protecting the environment, which involves various domains, including technology management (Centobelli et al., 2020). To be able to support the circular economy requires a good design of digital solutions (Bibri & Krogstie, 2017; Kumar et al., 2020).

Table 1. The first cluster of concepts and examples of references

Keywords	Occurrences	Example of references
sustainable development	40	(Bonilla et al., 2018), (Stuermer et al., 2017)
circular economy	19	(Centobelli et al., 2020); (Konietzko et al., 2020)
design	17	(Kumar et al., 2020); (Bibri & Krogstie, 2017)
business model innovation	14	(Visconti & Morea, 2019); (Minatogawa et al., 2020)
knowledge	10	(Klerkx et al., 2019); (Di Vaio et al., 2020)
business models; economy; implementation; barriers; smes; eco-innovation; indicators; perspective; creation; business model; consumption; big-data; decision making; evolution; firm; industries; logistics; product; strategies; supply chains; sustainable business model;	Less than 10 each	(Hidalgo-Carvajal et al., 2021); (Onu & Mbohwa, 2021; Zigiene et al., 2019); (Cui et al., 2019); (Cetin et al., 2021)

Source: Web of Science, 2021

The data on the first cluster concept shows that that one of the most essential aspects to achieving sustainability is business model innovation to facilitate a smooth day-to-day operation. Using case studies on sustainable fashion e-commerce enterprises, Minatogawa et al. (2020) propose that big data may be utilized to develop creative and customer-driven business models. In order to create a long-term company plan, you'll need a lot of expertise. In order to construct a more sustainable society, were exploring the development of artificial intelligence and machine learning for the development of sustainable business models by understanding consumer production and consumption patterns.

Furthermore, the implementation of big data for sustainable innovation will almost certainly face challenges, especially for small-scale businesses (Hidalgo-Carvajal et al., 2021; Onu & Mbohwa, 2021). Onu & Mbohwa explore various opportunities and barriers from implementing industry 4.0 for SMEs in manufacturing to improve operational performance and sustainability, especially for business organizations in Africa. To deal with these various opportunities and barriers, careful decision-making and strategies are needed. Decision-making, for example, can be assisted by the DEMATEL method to convert expert opinions into more measurable and quantifiable data so that they can provide better outcomes (Cui et al., 2019).

Cluster 2: Innovation and Management

In the second cluster, the most prominent keywords are innovation and management (Table 2). There are quite a number of documents that publish research from previous researchers regarding the relationship between sustainability innovation and business performance mediated by big data. El-Kassar & Singh (2019), as an example, using a sample of respondents from the Middle East, North Africa and Gulf Cooperation Countries, examines the effect of green innovation on firm performance by considering the influence of big data in the relationship. Similar research was also conducted by Song et al. (2019). Both El-Kassar & Singh (2019) and Song et al. (2019) are the most cited documents in WoS with 162 and 102 citations, respectively. Several researchers investigated similar phenomena in specific sectors such as agriculture (Rose & Chilvers, 2018) or healthcare (Papa et al., 2020).

Table 2. The second cluster of concepts and examples of references

Keywords	Occurrences	Example of references
innovation	117	(El-Kassar & Singh, 2019); (Song et al., 2019); (Rose & Chilvers, 2018); (Papa et al., 2020); (Mora et al., 2019)
management	58	(Belaud et al., 2014); (Schuelke-Leech et al., 2015); (Brenner, 2018)
performance	39	(Bag et al., 2020)
big data analytics	35	(Raut et al., 2021)
systems	26	(Waibel et al., 2018)
industry 4.0	25	(Bonilla et al., 2018)
strategy	22	(Nan & Tanriverdi, 2017)
firm performance	17	(Erkmen et al., 2020)
capabilities	13	(El Hilali et al., 2020)
supply chain management	13	(Bui et al., 2021)
predictive analytics	12	(Adjekum et al., 2017)
business	10	(Strandhagen et al., 2017)
dynamic capabilities	10	(Ramadan et al., 2020)
quality	10	(Shivajee et al., 2019)
supply chain	10	(Mehmood et al., 2017)
Integration; competitive advantage; resource-based view; data science; environmental performance; financial performance; information-technology; resilience	Less than 10 each	(Munodawafa & Johl, 2019); (Ali et al., 2020); (Kabongo, 2019); (Carayannis et al., 2017)

Source: Web of Science, 2021

The relevance of innovation management is demonstrated by the data on the third cluster concept. This cluster particularly mentions different types of capabilities. As an example, dynamic capabilities and technological capabilities such as the ability to implement big data analytics (Raut et al., 2021); as well as various vital decisions in operations management such as supply chain management and quality management (Bui et al., 2021; Shivajee et al., 2019; Usman et al., 2021). These capabilities are expected to produce a good firm performance (Ali et al., 2020; Kabongo, 2019) and provide a competitive advantage and resilience in the long term (Carayannis et al., 2017; Munodawafa & Johl, 2019).

Cluster 3: Big Data and Business Model Innovation

The third cluster discusses one of the main concepts that are the focus of this chapter, namely big data, as well as other important concepts such as d business model innovation (Table 3). A prominent document that uses the keyword big data is Wu et al. (2016), cited 166x in WoS, which suggested that big data is one of the most powerful drivers to support innovation, especially innovations related to green challenges and revolutions.

Table 3. The third cluster of concepts and examples of references

Keywords	Occurrences	Example of references
big data	184	(Wu et al., 2016), (Lim et al., 2018), (Singh & El-Kassar, 2019), (Song et al., 2019), (Pappas et al., 2018)

Keywords	Occurrences	Example of references
framework	45	(Avdiushchenko, 2018)
challenges	39	(Islam et al., 2015)
future	30	(Lajoie-O'Malley et al., 2020)
smart city	21	(Yigitcanlar et al., 2020)
model	19	(Konietzko et al., 2020)
science	18	(Horowitz et al., 2017)
smart cities	17	(de Souza et al., 2019)
cities	13	(Cowley & Caprotti, 2019)
opportunities	13	(Stahel, 2008)
decision-making	11	(Xia et al., 2017)
city	10	(Mehmood et al., 2017)
context; ict; sustainable cities; service; trends; machine learning; models; smart sustainable cities; sustainable city; urban innovation	Less than 10 each	(Bibri & Krogstie, 2017); (Goncalves et al., 2021); (Zheng et al., 2020)

Source: Web of Science, 2021

These challenges are faced by various organizational forms, both business organizations and non-business organizations, including cities which also face challenges to innovate and at the same time be sustainable and can become smart cities (Lim et al., 2018). In enterprises, big data plays an important role along the supply chain and inevitably faces various technological challenges (Singh & El-Kassar, 2019; Song et al., 2019). The development of big data in sustainability innovation is important in line with the digital transformation that is taking place as well as a path to a more sustainable society (Pappas et al., 2018).

There are considerable documents that discuss smart and sustainable cities in this cluster. For example, analysis of best practices from various parts of the world from Songdo to San Francisco (Yigitcanlar et al., 2019). In developing smart and sustainable cities, de Souza et al. (2019) found that the use of data mining and machine learning plays an important role, especially through smarter mobility. Mehmood et al. (2017) developing a model with multiple scenarios regarding the transformation of urban transportation to become smarter through the use of big data.

Cluster 4: Sustainability and Impact

Sustainability and impact are two prominent keywords in the fourth cluster (Table 4). This indicates the importance of big data to have a real impact in realizing a more innovative and sustainable economy. The following keywords appear more than ten times in the analyzed documents: technologies, information, industry, and industry 4 (4.0), followed by corporate social responsibility, education, entrepreneurship, and open innovation.

Table 4. The fourth cluster of concepts and examples of references

Keywords	Occurrences	Example of references
sustainability	70	(Bebbington & Unerman, 2018); (Wu et al., 2016); (Bonilla et al., 2018)
impact	30	(Bianchini et al., 2019)

Keywords	Occurrences	Example of references
technologies	27	(Gossling, 2021)
information	21	(Olszewski et al., 2018)
industry	13	(Santos et al., 2017)
industry 4	13	(Bai et al., 2020)
corporate social-responsibility; sustainable development goals; bibliometric analysis; intelligence; tourism; covid-19; education; entrepreneurship; open innovation	Less than 10 each	(Gurzawska, 2020); (Fiorentino et al., 2020); (Cappa et al., 2020); (Dooley, 2021); (Pizzi et al., 2020)

Source: Web of Science, 2021

Considering that this chapter discusses the role of big data for sustainability innovation, it is not surprising that it became one of the central topics. Sustainability requires the role of various stakeholders from practitioners, policymakers, academics, and society in general (Bebbington & Unerman, 2018). This multi-stakeholder involvement is because the challenges in optimizing big data to have a significant impact on sustainability are very high (Bonilla et al., 2018). These challenges include challenges from the point of view of the natural environment and social environment (Wu et al., 2016). Education and effort to encourage citizen participation are critical in promoting effective multi-stakeholder engagement (Dooley, 2021; Pizzi et al., 2020).

Among the techniques proposed by the author to overcome various barriers is using a new visualization tool or gamification. New visualization is considered effective in overcoming various barriers to be more sustainable (Bianchini et al., 2019). Gamification, for example, can be applied as a form of sustainability innovation in urban transportation (Olszewski et al., 2018). These techniques, when combined with big data, have the potential to drive Industry 4.0 strategies in a variety of industries (Bai et al., 2020; Gossling, 2021; Santos et al., 2017). Specific sectors studied, for example, are tourism (Gossling, 2021), air navigation service (Fiorentino et al., 2020), cultural heritage (Cappa et al., 2020), education (Pizzi et al., 2020).

Cluster 5: Technology

The fifth cluster is almost entirely concerned with technology. Artificial intelligence (AI), digitalization, precision agriculture, and the internet of things (IoT) are among the most popular technology-related keywords (Table 5). Technology, particularly IoT and big data, is crucial to organizational performance. (El-Kassar & Singh, 2019).

Table 5. The fifth cluster of concepts and examples of references

Keywords	Occurrences	Example of references
technology	27	(El-Kassar & Singh, 2019); (Tachizawa et al., 2015); (Chalvatzis et al., 2019)
artificial intelligence	13	(Dadi et al., 2021)
digitalization	11	(Felsberger & Reiner, 2020)
governance	11	(Brennan et al., 2019)
precision agriculture	10	(Rose & Chilvers, 2018)

Keywords	Occurrences	Example of references
Adoption; digital transformation; sharing economy; business; intelligence; policy; food; information-systems; services; smart; internet of things (iot)	Less than 10 each	(Belli et al., 2020); (Hayat et al., 2020); (Ding, 2018)

Source: Web of Science, 2021

The technology mentioned in this cluster that is used relatively frequently is artificial intelligence (AI). Previous researchers examined the application of AI and related technology in agri-food (Dadi et al., 2021), textile (Hayat et al., 2020), pharmaceutical (Ding, 2018), built environment (Tachizawa et al., 2015), or resource allocation for the power generation (Chalvatzis et al., 2019). These technology applications are part of digital transformation and digitization, which are in high demand today (Felsberger & Reiner, 2020).

Cluster 6: Internet of Things (IoT)

The sixth cluster contains the most important internet and internet of things keywords (Table 6). This is not surprising given that the discussion of big data is always accompanied by the internet that allows companies and other entities to obtain large volumes of data at previously unimaginable speeds. Another term that appears is analytics, which is almost always used in conjunction with big data because big data without analytics produces no insightful information for the decision-making process.

Table 6. The sixth cluster of concepts and examples of references

Keywords	Occurrences	Example of references
internet	22	(Latif et al., 2017); (Villegas-Ch et al., 2020)
internet of things	16	(Makori, 2017)
analytics	15	(Adjekum et al., 2017)
iot	14	(Belli et al., 2020)
networks	14	(Turkina & Oreshkin, 2021)
china	11	(N. Zhang & Chen, 2017)
data analytics; green; system; things; energy; energy efficiency; environmental sustainability; open data	Less than 10 each	(Nozari et al., 2021), (Cui et al., 2019), (Corrales-Garay et al., 2020)

Source: Web of Science, 2021

Specific topics found in documents about big data and sustainability innovation include the use of 5G technology (Latif et al., 2017), IoT dan blockchain (Villegas-Ch et al., 2020), and IoT in academic and library settings (Makori, 2017). Precision medicine was researched in the health sector (Adjekum et al., 2017), while data analytics in supply chain management was researched in the FMCG industry to optimize decision making and company productivity (Nozari et al., 2021). Aside from productivity, data analytics plays a role in green efficiency (Cui et al., 2019). Tseng & Hsu (2019) conducted an interesting study on the role of IoT in increasing family interaction. In the field of entrepreneurship, while Turkina & Oreshkin (2021) investigated co-inventor networks, and (Corrales-Garay et al., 2020) researched the importance of open data for entrepreneurship.

FUTURE RESEARCH DIRECTIONS

Progression work on the study in this chapter is a more specific analysis on specific business sectors because the present study is carried out on various business sectors. Analysis of specific business sectors is expected to provide a more in-depth understanding of big data and sustainability innovation in that sector. Future research can also compare the implementation and impact of big data for the development of sustainability innovation before, during, and after the pandemic Covid-19. This is due to the fact that the Covid-19 pandemic is an extraordinary event that is very likely to change how organizations use big data for the development of sustainability innovation. In terms of the literature review, additional research can be conducted by restricting the search and analysis to documents of the journal article type only, accompanied by an assessment of the journal's quality, to obtain sharper insights based on peer-reviewed documents of the highest level of quality and impact. In the future, the quality of search process can also be improved by manually filtering relevance, wherever possible, improvement in pre-processing and using document quality proxies based on the title source qualities.

CONCLUSION

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The present chapter aims to understand the development of big data for sustainable innovation in the academic literature. This chapter shows that the development of big data studies for sustainability innovation has developed in the last 10 years by involving various research areas such as environmental science, science technology, business economics, engineering and computer science. The authors on this topic come from all over the world, especially Europe, China, and America, with major outlets such as Sustainability, Journal of Cleaner Production, and Technological Forecasting and Social Change. This chapter has identified six keywords cluster where sustainable development and circular economy are the prominent keywords in the first cluster, innovation and management in the second cluster, big data and framework in the third cluster, sustainability and impact in the fourth cluster, technology and artificial intelligence in the fifth cluster, and internet and internet of things in the sixth cluster. Of the six clusters, the nuances of big data seem to be strong in the third, fifth, and sixth clusters; while the nuances of sustainability innovation are strong in the first, second, and fourth clusters.

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KEY TERMS AND DEFINITIONS

Co-occurrence analysis: an examination of the frequency of occurrence and the strength of the link between specific keywords

Eco-innovation: innovation aimed not only for profit but also for providing ecological benefits

Innovation Management: activities of planning, implementing, and controlling innovation within the organization

Internet of things: physical objects linked together and exchanging data via the internet network

Social innovation: innovation aimed not only for profit but also for providing social benefits

Sustainability innovation: type of innovation that is a combination of eco-innovation and social innovation, in which the innovation is not only profitable but also provides ecological and/or social benefits

Web of Science: one of the major multidisciplinary academic databases by Clarivate (formerly Clarivate Analytics, formerly Thomson Reuters)

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