Big Data Analytics and Supply Chain Operations: Trends, Gaps and Future Research Directions

Wanigasekara Y.[1] and Herath H.M.R.P.[2]

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ABSTRACT

Purpose: Big Data Analytics has emerged as a transformative force in addressing the complexities of modern Supply Chain Operations. Despite its growing significance, scholarly attention on this knowledge intersection has remained marginal with noticeable scarcity of systematic literature reviews. The purpose of this study is to understand existing knowledge and explore the areas to be evolved in in the intersection of Big Data Analytics (BDA) and Supply Chain Operations (SCO).

Design/methodology/approach: This study presents comprehensive systematic review of meticulously selected fifty-two articles published from 2016 to 2024 whereas article selection was executed as per the PRISMA guidelines. We conducted multifaceted descriptive, bibliometric and content analysis with two research objectives (1) to understand current state of the knowledge and (2) to propose future research landscape in this domain.

Findings: This comprehensive analysis revealed the increasing trend of scholarly attention; whereas noticeable gaps persist, including imbalances of contextual focus, methodological bias, inadequate industrial focus, limited theoretical foundations, and focus on key terms. Through rigorous content analysis, we clustered existing research gaps under eight themes exploring the necessity of future inquiries.

Originality: This study contributes to the knowledge domain by setting five clearly defined potential directions for future researchers with starting points. It advances the academic discourse by exploring current state of knowledge and unveiling marginally explored dimensions in BDA applications in SCO.

Implications: Findings offer valuable understandings for researchers and practitioners seeking to enhance SCO through BDA. Ultimately, current study explores the role of Big Data Analytics in contemporary Supply Chain Operations.

Keywords:

Supply Chain Operations, Big Data Analytics, Systematic Review, Bibliometric Analysis, Content Analysis

Introduction

The "proximity to market" is no longer a valid consideration for market-related decision-making in a contemporary global market where each corner of the world has integrated through complex supply chain (SC) networks that expand beyond traditional SCOs. Therefore, all producers are supplying their goods and services to the world market whereas all customers are purchasing from the world market. The dynamic interest of modern customers and globalization pushes all SC actors to be more agile, responsive,

[1]Faculty of Graduate Studies, SLIIT Business School, Sri Lanka
[2]Department of Information Management, SLILT Business School, Sri Lanka

and flexible than ever before to remain in the modern market (Pyun and Rha, 2021; Amentae and Gebresenbet, 2021; Stroumpoulis and Kopanaki, 2022). Further, the modern market operations have introduced unprecedented complexity to modern SCOs whereas disruption in one node can ripple the entire supply network (Marinagi et al, 2023). Therefore, SCOs have become more critical and complex than ever before since market competitiveness has shifted from nodes to entire supply chains perspective. According to Xu and Pero (2023), traditional SCs are struggling to compete with modern SCOs whereas rapid adoption of BDA is essential and timely needed to remain in the contemporary market.

Existing literature explored BDA as a transformative force to overcome this complexity of modern SCs (Kamble et al, 2020; Xu et al., 2021; Centobelli et al, 2022; Riggs et al., 2023; Al-Khatib, 2023; Chatterjee et al., 2023; Albqowr et al, 2024). The scholarly interest in this field of knowledge has been excessively expanded from the year 2019 (Figure 1) whereas the global situation created by COVID-19 has set up the ground for a substantial increase in digital solutions for SCOs (Kamble et al, 2023). With that ignition, many studies have been conducted and published to explore the relationship between BDA and SCO (Del Giudice et al., 2021; Riggs et al., 2023; Al-Khatib, 2023; Ahmadzadeh et al., 2023; Chatterjee et al., 2023; Lutfi et al., 2023; Albqowr et al., 2024). Even though many studies have been conducted in this knowledge domain, researchers have highlighted the necessity of further studies to understand different aspects of the relationship between BDA and SCO (Alsolbi et al., 2023; Xu et al., 2023; Zamani et al., 2023; Oesterreich et al., 2022; Patrucco et al., 2023).

This study aimed to have a holistic approach encompassing two objectives. The first objective is to "conduct a comprehensive review on existing knowledge domain of BDA and SCO" to have a comprehensive understanding of the subject domain and explore existing research gaps. Then, the second objective is to "suggest potential research areas to evolve" as our second objective.

The current study is a landscape of comprehensive descriptive, bibliometric and content analysis where it designed to explore saturated and unsaturated areas within the domain of BDA and SCO. In this broader spectrum of knowledge, we understood the necessity of a holistic approach for BDA in SCO operations. The extensive literature survey of the current study has led to an exploration of the existing landscape of the research domain, emerging research trends, and future research potentials in BDA and SCO. The rest of the study was designed to review the literature and explore the methodology of current work in the second and third sections whereas descriptive, bibliometric, and content analysis were conducted in section four with different analytical tools. Then, the comprehensive discussion was conducted in section five followed by a conclusion in section six, which includes findings and limitations encountered.

Literature Review

This is designed to provide comprehensive definitions and a critical understanding of key terms of the current study of BDA and SCO. We noted that different scholars have given diverse definitions and understandings for such terms.

Big Data and Big Data Analytics

Big Data (BD) being a popular area of research, many scholars have defined and evolved the domain with wider contribution. BD has differentiated from "Data" due to its nature of complexity and the inability of traditional systems and human beings to maintain and analyse that exhausted amount of data (Albqowr et al. 2024). Initially, BD consisted of three characteristics volume, variety, and velocity (Holmlund et al., 2020; Xu et al., 2021; Acciarini et al., 2023; Cadden et al., 2023). The "Volume" refers to the huge amount of data generated at each stage of a process along with its technological capabilities (Jabbar et al., 2020; Acciarini et al., 2023; Cadden et al., 2023) whereas such data can be structured, semi-structured or unstructured (Xu et al., 2021; Riggs et al., 2023). The process-wide data generation drives the characteristic of "Variety" which refers to the diversity of data generation (Jabbar et al., 2020; Acciarini et al., 2023; Cadden et al., 2023). The "Velocity" denotes the speed at which data generation and analysis can be processed (Jabbar et al., 2020; Xu et al., 2021; Cadden et al., 2023). According to Acciarini et al., (2023), scholars have explored the forth and fifth characteristics of "Veracity" (refers to BD uncertainty) and "Value" (refers to the possibility of value generation through BD).

BDA is used to obtain meaningful patterns and insights from BD through advanced analyzing techniques to support informed decision-making (Jabbar et al., 2020; Holmlund et al., 2020; Xu et al., 2021; Riggs et al., 2023). As explored by Xu et al., (2021), BDA can be classified as Descriptive analysis (to understand what is happening), Predictive analysis (to understand what will happen), and Prescriptive analysis (to understand what should happen) whereas Holmlund et al., (2020) revealed Inquisitive analysis which can be utilized to understand causes, relationships, and reasons for observed pattern and trends.

Role of BDA in SCO

BDA has become a stimulant in modern SC whereas that augmented BDA contribution has attracted many researchers to this domain over the last few years. Many scholars have revealed the positive impact of BDA on SCO in general (Centobelli et al, 2022; Stroumpoulis and Kopanaki, 2022; Chatterjee et al., 2023) and on specific operations (Xu et al., 2021; Dennehy et al., 2021; Al-Khatib, 2023) and different industries (Margaritis et al., 2022; Kamble et al., 2020). It is evident in the existing literature that BDA has created competitive edges for SC partners (Cadden et al., 2023; Mikalef et al., 2020; Talwar et al., 2021) through wider spectrum of SC planning (He et al., 2020; Xu et al., 2021), visibility (Kamble et al., 2020), agility (Dubey et al., 2019) and resilience (Zamani et al., 2023).

Xu et al., (2021) underscored three different roles of BDA in SC as Supportive Facilitator, Source of Empowerment, and Game-changer. Meanwhile, scholars have heavily investigated the role of BDA in sustainable aspects of SCO and explored the positive and strong influence (Mageto, 2021; Rejeb et al., 2022). Notably, BDA has also been identified along with its evolving role as a robust resolution for challenging humanitarian SCOs (Gupta et al., 2019; Dennehy et al., 2021) and Circular Economy Practices (Kamble et al., 2021; Del Giudice et al., 2021).

Methodology

To understand the current state of knowledge, we conducted a systematic and comprehensive literature survey in November 2024 using precise keywords to explore the scope of existing knowledge alignment with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al, 2021). The keywords utilized for retrieving are "BDA" (Big Data Analytics), "SCO" (Supply Chain Operations), and "SC" (Supply Chain). Other than the keyword searches, we developed a search strategy to explore more publications as "BDA" OR "Big Data Analytics" AND "SCO" OR "Supply Chain Operation*" OR "SC" OR "Supply Chain" where the same was modified according to databases

Table 1
Inclusion and Exclusion Criteria

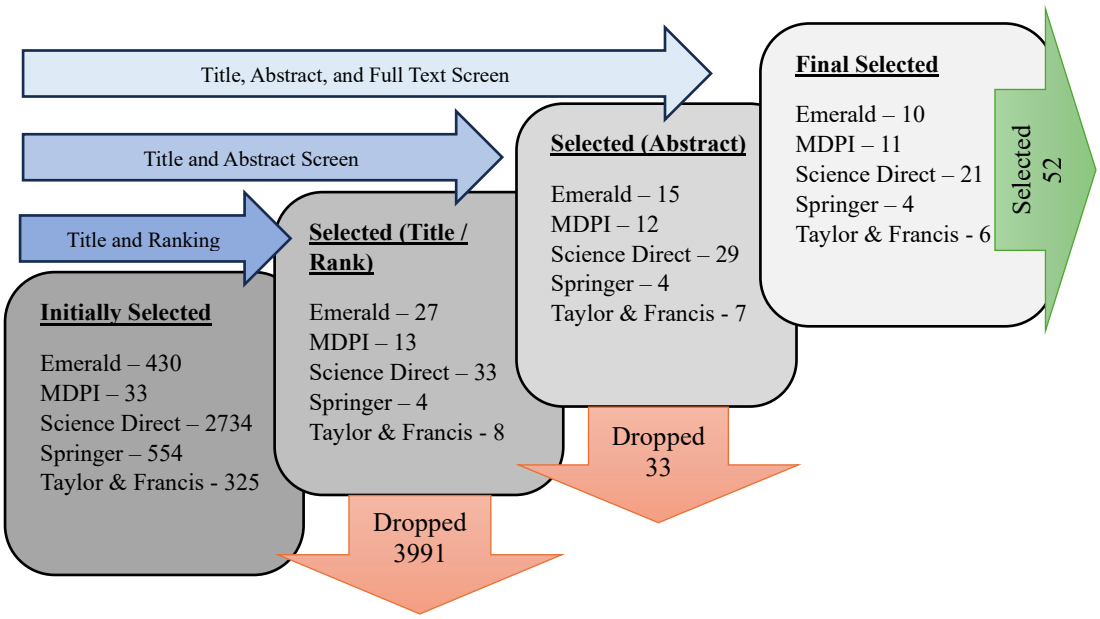
Include	Publications from 2014 to 2024
	Journal Articles
	Scimago Journal Ranking
	Articles in English Language
	Open Access
Exclude	Article which not directly link to BDA and SCO
	Book Chapters, Conference Papers, Blogs, Theses
	Duplicated Works
	None Indexed Papers

Through the PRISMA approach, we selected 52 most related, high-ranked, and recently published papers from different databases of Emerald, MDPI, Science Direct, Springer and Taylor & Francis since scholars have emphasized the importance of selecting articles from a wider range of databases (Pyun and Rha, 2021; Rejeb et al., 2022; Zamani et al., 2023; Jahani et al., 2023). We rigorously adhered to an extensive selection process of papers whereas points specified in Table 1 were applied as Inclusion and Exclusion criteria.

By using selected Keywords and Search Strategies, we initially shortlisted 4076 papers through different databases. Then, the PRISMA approach was employed to select the final set of papers for analysis along with the Inclusion and Exclusion criteria in Table 1. To

select the most reliable source of knowledge, we screened the selected papers with Scimago Journal Ranking Index whereas only high-ranked papers were selected for further consideration. The Title, Duplication, and Ranking screen excluded many papers from the scope of the current study and resulted only 85 highly related and top-ranked articles for Abstract and Full-Text screening. We selected only mostly relevant 52 papers to scrutinize the current state of the knowledge and identify existing knowledge gaps. Figure 1 shows the process of screening.

Figure 1
Article Selection and Screening Process
Source: Developed by Author



Upon selection of 52 papers, we carried out a comprehensive analysis under three main sub-sections. Primarily, descriptive analysis was conducted to categorize selected articles under different criteria whereas bibliometric analysis, as the second sub-section, was conducted to understand considerably researched and marginally explored areas of the subject domain. Finally, we conducted content analysis to cluster future research directions under selected themes. The descriptive and bibliometric analysis was executed with a quantitative approach which exposed the trend in this widespread subject domain of BDA and SCO. Through the content analysis, we delve into the deep of existing literature to have a clear and concise understanding of the subject domain with a qualitative approach. To execute this multifaceted analysis, we utilized Microsoft Excel and VOSviewer as analyzing and representation tools.

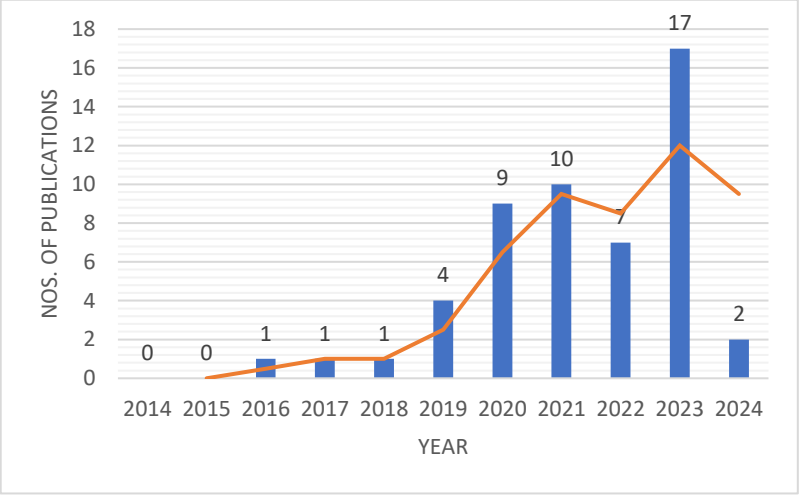
Analysis and Results

As discussed in the methodology section, selected articles analyzed under three sub-sections of Descriptive Analysis, Bibliometric Analysis, and Content Analysis under this section.

Descriptive Analysis

Under the descriptive analysis, we categorized selected articles depending on the years of publications, journal, geographical distribution of authors, contextual focus, research method, and industrial focus. We utilized Graphs, Charts, and Tables for pictorial representation of analysis facilitating a nuance understanding of the current state of knowledge.

Figure 1
Article count from 2014 – 2024
Source: Developed by Author



At first, we executed an analysis of years of publications to understand the trend of scholarly contribution to the knowledge yearly. Figure 2 shows the clear trajectory of publication density from 2014 to 2024. In the beginning, from 2014 to 2018, it reflects the nascent stage of academic exploration towards this research area. Overall, Figure 2 shows an evolving trend generally where researchers' interest in this field of knowledge has significantly increased from the year 2020 with a pronounced spike in the year 2023. We disregarded the lower value reported in 2024 since the literature survey of the current study was conducted during November 2024 and incomplete data for a particular year. Further, Rejeb et al. (2022) and Margaritis et al. (2022) have also identified this increased scholarly attention over the past few years towards this domain whereas the current study explores the continuation of that interest.

Then, we analyzed how these selected articles have been distributed among Journals to identify leading and marginal focused areas of knowledge in general view. Table 2 shows

the frequency distribution of selected articles among the different journals. The majority of papers (11) belong to the journal "Sustainability" whereas nearly 20 percent of the selected papers have focused on sustainable aspects of BDA and SCO. Following the Sustainability aspects, Production, Manufacturing, and Operations related journals are also leading in the front whereas Technology and Marketing related journals have also acquired a sufficient number of articles according to Table 2. The analysis conducted by Rejeb et al., (2022) has also explored that sustainability, production, and manufacturing-related journals are dominating in literature in this domain.

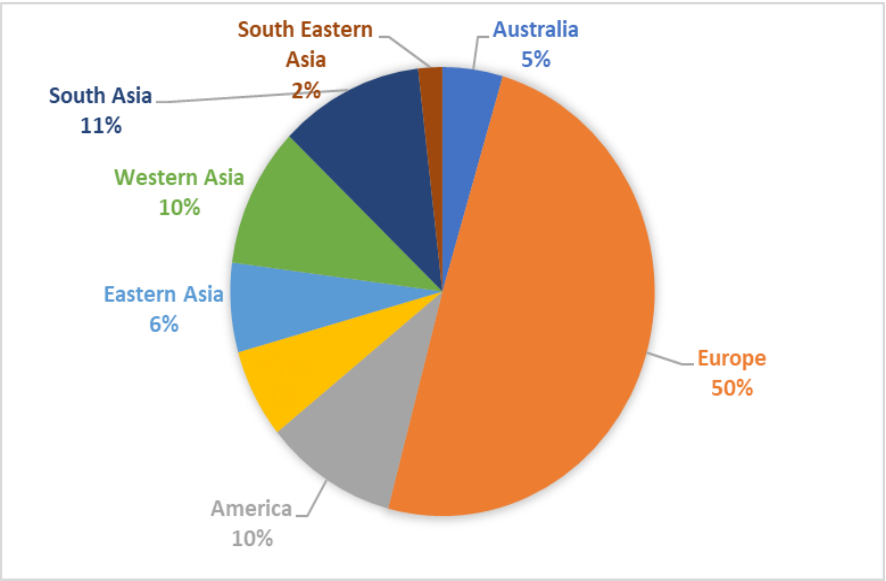
Table 2
Distribution of Articles among Journals

Journal	Nos. of Articles
Sustainability	11
Technological Forecasting & Social Change	4
Journal of Business Research	4
International Journal of Production Research	4
Annals of Operations Research	3
International Journal of Physical Distribution & Logistics	3
Information & Management	2
Technovation	2
Journal of Retailing and Consumer Services	2
Industrial Marketing Management	1
Artificial Intelligence Review	1
Decision Support Systems	1
European Journal of Innovation Management	1
Food Chemistry	1
Heliyon	1
Information Systems Management	1
International Journal of Logistics Research and Applications	1
International Journal of Operations & Production Management	1
International Journal of Production Economics	1
International Journal of Research in Marketing	1
Journal of Engineering, Design and Technology	1
Journal of Management Science and Engineering	1
Journal of Manufacturing Technology Management	1
The International Journal of Logistics Management	1
Transportation Research Part E	1
VINE Journal of Information and Knowledge Management Systems	1

Next, we analysed the geographical locations of contributed authors to understand the spread of research interest over the world. The pictorial representation in Figure 3 shows

that the majority of authors (50%) are from European countries and authors from the United Kingdom, France, and Italy have heavily contributed to this field of knowledge. Following the European interest, American and South Asian region authors have also contributed to existing knowledge in considerable magnitude. Even though a considerable amount of contribution from the South Asian Region has been highlighted in Figure 3, the majority of authors are from India and have conducted their research along with authors from other countries by focusing global context.

Figure 3
Geographical Distribution of Contributed Authors
Source: Developed by Author



Then, the contextual focus of selected studies was analyzed to understand upon which empirical data the current knowledge has evolved. According to Figure 4, we observed that 57 percent of selected articles have focused on the Global perspective. By confirming the evident data through Figure 3, the second largest contextual attention of authors has been recorded towards the European region where it represents 25 percent of total articles. Further, it revealed that contextual focus for other geographical regions is very marginal level with 18 percent from all selected papers.

In order to have an exact conclusion about the empirical base of existing knowledge, we conducted further analysis on research methods and types of selected papers since only empirical research imports and boosts practical concerns of existing knowledge. Table 3 shows the summary of research methods of selected papers.

Figure 4
Contextual Focus of Existing Knowledge
Source: Developed by Author

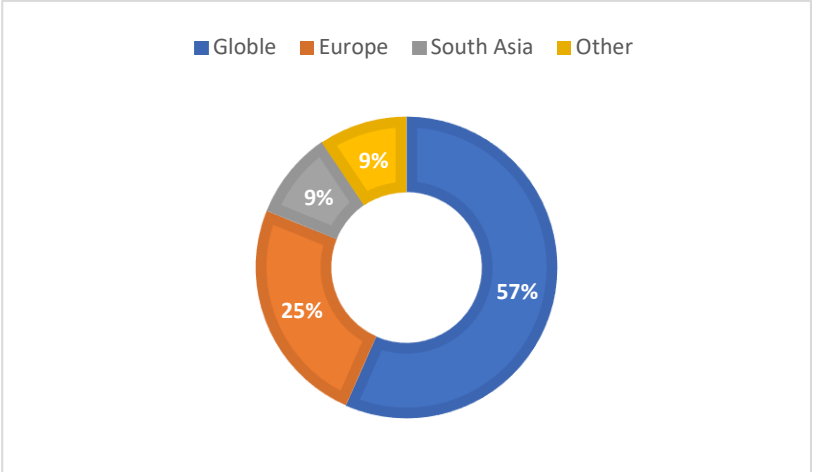


Table 3
Categorization of Articles on Method

Research Method	Article Count	%
SLR	32	62%
Mixed	3	6%
Qualitative	5	10%
Quantitative	12	22%

As shown in Table 3, 62 percent of selected articles can be categorized as SLR articles which explore new knowledge by scrutinizing existing scholarly publications. Since, SLR articles are purely depending on already existing knowledge, such articles do not bring changing practical concerns to the theoretical framework. Only 10 percent of research has been conducted under qualitative research methodology whereas only 22 percent and 6 percent of research have been conducted with quantitative and mixed approaches respectively. The qualitative approach explores new contextual details, narrative descriptions, and experiences by adding different descriptive insights to understand the rapidly growing BDA and SCO fields. Further, Table 3, explores that both qualitative and data-driven statistical approaches are still very limited in this knowledge field where it is evident that this area of knowledge needs to be enriched with more empirical research Jha et al. (2020); Xu et al., (2021); Talwar et al. (2021); Del Giudice et al. (2021); Kamble et al. (2021). Moreover, it reveals that scholars interested in this field of knowledge are still more focused on SLR approaches to delve deep into understanding on subject domain rather than studying empirical evidences. Moreover, when scrutinizing Figure 4 and Table 3 together it can be concluded that empirical studies in both qualitative and quantitative approaches are very limited within the existing knowledge and the majority of research works executed from a global perspective are SLR articles which may not exactly explore the practical changing behavior of the domain in different geographical areas.

Then we analyzed the industrial attraction of existing knowledge to understand highly and marginally focused industries by researchers and the popularity of BDA within SCO of particular industries. Table 4 shows industry wise distribution of selected articles whereas 71 percent of articles have not focused on any specific industry and researched common factors pertaining to BDA on SCO. However, existing literature is evident that industries like Agriculture, Automobile, Humanitarian logistics, Pharmaceutical, and Retail have attracted the marginal interest of scholars in BDA and SCO aspects.

Table 4
Industrial focus of selected articles

Industry Focus	Nos. of Articles	%
Agriculture	7	13%
Automobile	2	4%
Humanitarian	2	4%
Pharmaceutical	1	2%
Retail	2	4%
Small and Medium Enterprises	1	2%
Cross-Industry	37	71%

Theoretical Foundation

Table 5:
Theoretical Affiliation of Existing Knowledge

Theory / Model / Framework	**Definition**	**Articles**
Resource Based View (RBV)	Suggests that the competitive advantages of the organization depend on the internal strategic resources and capabilities.	Barbosa et al. (2017); Kamble and Gunasekaran (2019); Gupta, Altay, and Luo (2019); Mikalef et al. (2019); Mikalef et al. (2020); Stroumpoulis and Kopanaki (2022); Al-Khatib (2023); Chatterjee et al. (2023); Lutfi et al. (2023)
Dynamic Capability View (DCV)	Ability of organizational resources to adapt with changing environmental conditions	Barbosa et al. (2017); Dubey et al. (2019); Mikalef et al. (2020); Cetindamar, Shdifat, and Erfani (2021); Talwar et al. (2021); Cadden et al. (2023); Chatterjee et al. (2023)

Technology-Organization-Environment (TOE) framework	Explains the influence of the technological, the organizational, and the environmental context on the process of technology innovation adoptions by the firms	Kamble and Gunasekaran (2019); Xu et al., (2021); Lutfi et al. (2023)
Supply Chain Operations Reference (SCOR) Model	A model that explains the core five processes of SCO, Plan, Source, Make, Deliver, and Return.	Kamble and Gunasekaran (2019); Kamble et al. (2020)

The analysis of the theoretical landscape was executed to explore the highly utilized theories in the subject domain of BDA on SCO. According to Table 5, we found that Resource Based View (RBV) and Dynamic Capability View (DCV) are dominant and foundational theories in this knowledge span. The theory of RBV posits that organizations can profitably sustain in the long term with competitive edges when such organization owns strategic resources (Mikalef et al., 2020; Al-Khatib, 2023; Chatterjee et al., 2023). DCV posit that companies owns resources that can be flexible with the changing environment especially with technological aspects can sustain long term (Dubey et al., 2019; Mikalef et al., 2020; Cadden et al., 2023). When RBV highlights the availability of strategic resources within an organization to BDA applications, DCV emphasizes the importance of adaptability and reconfiguration of existing capabilities, particularly in digital transformation and data-driven decision-making, to adaptation (Mikalef et al., 2020; Chatterjee et al., 2023). Further, RBV and DCV underscore the concerns on resources availability and flexibility whereas it does not accommodate the holistic nature of BDA necessities integrated with modern SCO.

Even though RBV and DCV are dominating theories of the subject domain, researchers have laid the marginal theoretical foundation for BDA on SCO with a wide range of other theories, models and frameworks. Technology-Organization-Environment (TOE) framework (Kamble and Gunasekaran, 2019; Xu et al., 2021; Lutfi et al. 2023) and Supply Chain Operations Reference (SCOR) Model (Kamble and Gunasekaran, 2019; Kamble et al., 2020) can be identified as potential theoretical foundations for future studies. Many scholars have highlighted the importance of technological, organizational, and environmental factors for BDA adoption and the necessity of further studies on those aspects (He et al., 2020; Pyun and Rha, 2021; Xu and Pero, 2023; Jain et al., 2024). Further, scholars have underscored the inevitability of different theoretical groundings to expand the domain (Dubey et al., 2019; Gupta, Altay, and Luo, 2019).

Bibliometric Analysis

With the view of understanding the intellectual structure and the trends of the subject domain, we conducted bibliometric analysis. In this section, we analyzed the occurrence, connections, and density of keywords by utilizing different analyzing tools such as word cloud, network visualization, and density visualization.

Word Cloud Analysis

To broaden the understanding of the current state of knowledge, we conducted bibliometric analysis by grouping similar kinds of keywords. The word cloud analysis in Figure 5 reveals that the terms "Big Data" and "Supply Chain" have repeatedly and extensively appeared as keywords of selected articles which shows that scholarly attention is still mainly focused on studying key terms of this knowledge domain. The marginal concern and limited appearance of other related terms are evident that existing knowledge has not been saturated and spread sufficiently towards the different aspects of SCO.

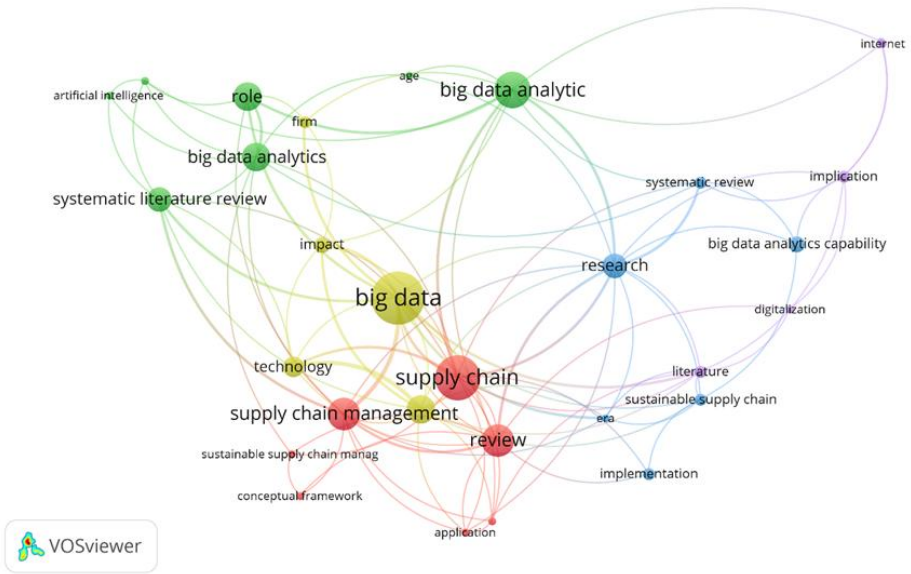
Figure 5
Word Cloud of Keywords
Source: Developed by Author

The terms such as "Capabilities" and "Analytics" related to Big Data have also appeared at a considerable rate whereas the appearance of other related terms such as "Adoption" and "Development" are limited and have not attracted sufficient scholarly attraction. Along with the Supply Chain, terms like "Management", "Sustainability" and "Performances" have been connected in the existing literature to focus on specific areas. Further, Figure 5 shows that the term "SLR" is also repeatedly used as a keyword of selected articles where it re-confirms the weight of SLR articles within the existing literature.

Network Analysis

Next, we analyzed and mapped the relationship of keywords using VOSviewer. According to the VOSviewer visualization structure, the size of the node visualizes the appearance frequency of the theme whereas line thickness shows the strength of the relationship. According to Figure 6, “Big Data”, “Supply Chain” and “Big Data Analytics” appeared as main nodes with strong of relationship whereas it shows that scholarly focus is still remain on general association of BDA and SCO. Further, the term "role" has also appeared as a main node with a strong relationship to both nodes of BDA and it reveals that scholars have focused more on understanding the role of BDA in SCO where it shows the novelty of the research domain. Moreover, terms like “Systematic Literature Review” and “Review" also appeared as significant nodes of the keyword network of selected articles with significant relationship to the main nodes of BDA and SCO where the same re-confirmed that the majority of studies in the current knowledge of BDA and SCO domain are SLR studies. The network evident that the primary focus of current knowledge has centered only on leveraging BDA in SCO in a general view.

Figure 6
Key Words co-occurrence network
Source: Developed by Author



Network Density Analysis

With the view of having a deep understanding of the density of keywords appearing in the selected articles, we conducted a density visualization analysis through VOSviewer and Figure 7 depicts the result of the analysis. The visualization shows the density of terms by the color whereas darkness shows the level of concentration on those terms in the subject domain. According to Figure 7, terms like "Big Data”, “Big Data Analytics”,

"Supply Chain Management", "Technology" and "Review" are highly concentrated areas whereas researches have excessively centered towards highlighted terms. However, scholarly attention on other light color areas is marginal and can be identified as emerging areas. Further, some key and popular terms in modern SCO such as collaboration, responsiveness, agility, integration, etc. have not been visualized in Figure 7 due to limited literature attention toward those areas.

Figure 7: Density visualization of keywords
Source: Developed by Author

Content Analysis

Under the content analysis, we thoroughly scrutinize the limitations and future research directions of each selected article of the current study under eight themes. Table 6 shows the summarized tabulation of explored future research directions under selected Themes.

According to Mikalef et al., (2020) and Centobelli et al, (2022), BD has transformed SCO into an integrated network by facilitating a wider range of benefits including enhanced decision-making, improved customer satisfaction, and competitive advantages. Nonetheless, only limited organizations have adopted BDA practices and more than 80 percent of adoption efforts have become a failure (Younis and Wuni, 2023; Lutfi et al., 2023). While underpinning these empirical existences, we selected "BDA adoption and implementation" as our "Theme 1" to analyze the frequency of future research calls under this subdomain.

Through the descriptive analysis, we revealed that the majority of selected articles have not focused on a particular industry where the association of BDA and SCO has been analyzed with a common lens (Table 4). However, it is apparent that industrial-specific factors need to be studied to understand BDA adaptability and role in a particular industry and many scholars have highlighted while calling future research in different

industries (Kamble and Gunasekaran, 2019; Maheshwari, Gautam, and Jaggi, 2020; Talwar et al., 2021). By noticing that, we have set our “Theme 2” as “Expansion to other industries”.

According to Figure 3 and Figure 4, existing literature centered on the limited countries and geographical areas. Upon identifying that gap, we reviewed selected articles to comprehend scholars' views on this aspect. Further, we noticed that Rejeb et al. (2022) have explored the same finding whereas many researchers have highlighted “Contextual Focus (Geographical)" (Theme 3) as a vital area of future research (Dubey et al., 2019; Mageto, 2021; Chatterjee et al., 2023; Brewis et al., 2023). Especially, many researchers have emphasized the significance of contextual focus on the developing countries that are operating far behind the BDA adaptation (Mageto, 2021; Pyun and Rha, 2021; Amentae and Gebresenbet, 2021; Talwar et al., 2021; Rejeb et al., 2022; Lutfi et al., 2023).

In order to bring changing practical existences to the knowledge domain, conducting empirical studies is much more significant where many scholars have explored the same through their studies (Xu et al., 2021; Del Giudice et al., 2021; Centobelli et al., 2022; Jain et al., 2024; Albqowr et al., 2024). According to Table 3, it is further confirmed that scholars' growing interest in SLR studies has created a huge research gap empirically. With the above-explored stance, we set our “Theme 4” as “Empirical Focus”.

Similarly, current literature highlighted the necessity of a wider range of holistic approaches to optimize the operation of BDA in SCO (Ahmadzadeh et al. 2023; Amentae and Gebresenbet 2021; Margaritis et al., 2022). Many scholars have explored the future research directions to incorporate Governance and Regulatory Frameworks (Rejeb et al. 2022; Hassoun et al., 2023; Jain et al., 2024) and Organizational Factors (Huynh et al., 2023; Lutfi et al., 2023). We established “Human and organizational related factors” and “Governance and regulatory framework” as “Theme 5” and “Theme 6” respectively.

The uneven and severally skewed methodological biases towards SLR studies explored through Table 3 encouraged us to delve into selected papers to synthesize the necessities of future studies. The review explored that same gap has been determined by many researchers and called future studies in different research approaches and methodologies (Mikalef et al., 2019; Maheshwari, Gautam, and Jaggi, 2020; Jha et al., 2020; Kamble et al., 2021; Lutfi et al., 2023). During the extensive review, we noted that many scholars have suggested to conduct more qualitative studies (Chalmeta and Santos-deLeón, 2020; Stroumpoulis and Kopanaki, 2022; Patrucco et al., 2023; Albqowr et al., 2024) to explore different unexplored factors in the domain of BDA and SCO. With this understanding, we determined “Theme 7” and “Theme 8” as “Imbalance in Current Research Approaches” and “Necessity of qualitative approach” respectively.

As indicated in Table 6, the existing literature underscores a strong need for further empirical investigations, while simultaneously highlighting a notable imbalance in prevailing research approaches (19; 13). Additionally, twelve studies emphasize the

importance of incorporating contextual considerations in future research. Furthermore, eleven and twelve studies, respectively, stress the necessity of adopting qualitative research approaches and increasing industry-specific investigations. Beyond methodological concerns, several scholars have consistently called for greater attention to human and organizational factors (13), as well as to issues related to BDA adoption (7)

Table 6
Categorization of future research directions

	Theme	Supporting Articles	Frequency
1.	BDA adoption and implementation	Barbosa et al. (2017); Kamble et al. (2020); Mikalef et al. (2020); Xu et al. (2021); Xu and Pero (2023); Younis and Wuni (2023); Hassoun et al. (2023)	7
2.	Expansion to other industries	Kamble and Gunasekaran (2019); Dubey et al. (2019); Maheshwari, Gautam, and Jaggi (2020); Kamble et al. (2021); Talwar et al. (2021); Centobelli et al. (2022); Al-Khatib (2023); Acciarini et al. (2023); Cadden et al. (2023); Jain et al. (2024)	10
3.	Contextual Focus (Geographical)	Gupta, Altay, and Luo (2019); Dubey et al. (2019); Mikalef et al. (2020); Jha et al. (2020); Del Giudice et al. (2021); Mageto (2021); Dennehy et al. (2021); Xu and Pero (2023); Chatterjee et al. (2023); Brewis et al. (2023); Lutfi et al. (2023); Patrucco et al. (2023)	12
4.	Empirical Focus	Xie et al. (2016); Kamble and Gunasekaran (2019); Mikalef et al. (2019); Jha et al. (2020); Xu et al., (2021); Talwar et al. (2021); Del Giudice et al. (2021); Kamble et al. (2021); Cetindamar, Shdifat, and Erfani (2021); Mageto (2021); Rejeb et al. (2022); Centobelli et al, (2022); Stroumpoulis and Kopanaki (2022); Abdalla et al. (2022); Govindan et al. (2022); Patrucco et al. (2023); Alsolbi et al. (2023); Jain et al. (2024); Albqowr et al. (2024);	19
5.	Human and organizational-related factors	Mikalef et al. (2019); Holmlund et al. (2020); Xu et al. (2021); Dennehy et al. (2021); Rejeb et al. (2022); Margaritis et al. (2022); Oesterreich et al. (2022); Xu and Pero (2023); Al-Khatib (2023); Cadden et al. (2023); Lutfi et al. (2023); Zamani et al. (2023)	13
6.	Governance and regulatory framework	Dekimpe (2020); He et al. (2020); Pyun and Rha (2021); Oesterreich et al. (2022); Zamani et al. (2023); Jain et al. (2024)	6

7.	Imbalance in Current Research Approaches	Mikalef et al. (2019); Maheshwari, Gautam, and Jaggi (2020); Jabbar et al. (2020); Chalmeta and Santos-deLeón (2020); Jha et al. (2020); Kamble et al. (2021); Del Giudice et al. (2021); Stroumpoulis and Kopanaki (2022); Rejeb et al. (2022); Al-Khatib (2023); Chatterjee et al. (2023); Brewis et al. (2023); Lutfi et al. (2023)	13
8.	Necessity of qualitative approach	Xie et al. (2016); Kamble and Gunasekaran (2019); Dubey et al. (2019); Chalmeta and Santos-deLeón (2020); Del Giudice et al. (2021); Stroumpoulis and Kopanaki (2022); Al-Khatib (2023); Patrucco et al. (2023); Xu et al. (2023); Alsolbi et al. (2023); Albqowr et al. (2024)	11

Discussion

We organized this section to facilitate a comprehensive discussion by integrating the findings of current study with existing literature in the domain. Through this section, we connected our findings with the Research Objectives of the study.

Our review revealed a significant increase in scholarly attention on the BDA and SCO domain after the year 2020. Pyun and Rha (2021 argue that the COVID-19 pandemic significantly accelerated scholarly and practical attention toward digital technologies. The analysis on journals of selected articles revealed that journals related to sustainability have facilitated more than 20 percent of publications whereas Production, Manufacturing, Operations, Technology, and Marketing related journals have contributed marginally. It is evident that subject domain of BDA and SCO considerably less exposed in many world-leading journals related to this subject domain.

Despite the growing global interconnectedness and widespread benefits of digitalized SCOs, contributions to knowledge development in this domain are not equally shared across regions. The analysis shows that the majority of European scholars have contributed to the current knowledge whereas American, Western Asian, and South Asian authors have contributed considerably but marginal when compared with Europeans. The knowledge contribution from other regions is negligible where it reveals that existing knowledge has been developed centered to the European region where that knowledge may not provide a lens to understand BDA on SCO in developing region perspectives. Moreover, the analysis on geographical focus explored that the majority of studies have been conducted with a contextual focus on the European market. By confirming the findings of the current study, many scholars have called for more studies with different geographical focus (Dennehy et al., 2021; Xu and Pero, 2023; Chatterjee et al., 2023; Brewis et al., 2023; Lutfi et al., 2023; Patrucco et al., 2023).

We observed methodological bias towards SLR research during our analysis where it is doubtful up to what extent those studies convey practical aspects to the knowledge domain. As highlighted by Baryannis et al. (2018), Cetindamar, Shdifat, and Erfani (2021) and Mageto (2021), the incorporation of dynamic practical concerns into existing knowledge and validation of existing theories, models, and frameworks is essential to integrate different contextual aspects to the subject domain of BDA and SCO. Moreover, the analysis displayed the limited empirical approaches from researchers even though such approaches are sensible with dynamic environmental changes. Out of the empirical approaches, mixed and qualitative research have reported very limited existences whereas literature has emphasized the timely necessity of such approaches (Stroumpoulis and Kopanaki, 2022; Al-Khatib, 2023; Patrucco et al., 2023; Xu et al., 2023; Alsolbi et al., 2023; Albqowr et al., 2024). According to current analysis, it is evident that this domain is still in the developing stage where scholars need nuance understanding on knowledge domain and key terms before having empirical approaches (Abdalla et al., 2022; Huynh et al., 2023).

Even though many scholars explored the necessity of expanding the scholarly attention to different industrial aspects in the BDA and SCO domain, the analysis evident that studies with cross-industry focus are significantly dominating. As highlighted by Centobelli et al. (2022); Al-Khatib (2023); Acciarini et al. (2023); Cadden et al. (2023) and Jain et al. (2024), further investigation into the applicability, adoption, and related aspects of BDA across diverse industrial contexts is essential for advancing the existing body of knowledge.

The analysis showed that RBV and DCV are the foundational and prominent theories within the subject domain. However, both dominant theories are based on a single organizational perspective where the applicability of the supply chain view which is far beyond the single organization concern is doubtful. Further, many researchers highlighted the necessity of incorporating Technological (Talwar et al., 2021; Dubey et al., 2019), Organizational (Dubey et al., 2019; Cadden et al., 2023) and Environmental (Hassoun et al., 2023; Jain et al., 2024) factors for BDA adoption in SCO where it explores the necessity of wider approaches beyond the resource availability and flexibility of a particular organization. Therefore, RBV and DCV theories cannot fully accommodate this foundational requirement of the domain. It encourages other marginally utilized theoretical approaches such as TOE and SCOR as potential foundations.

We observed through the keyword analysis and network analysis that the knowledge domain is still centered on the general understanding of BDA and SCO. As per the content analysis conducted in Table 6, scholars have called for future studies with a specific focus on different contexts (Mageto, 2021; Dennehy et al., 2021; Xu and Pero, 2023; Chatterjee et al., 2023; Brewis et al., 2023; Lutfi et al., 2023) and different industries (Acciarini et al., 2023; Cadden et al., 2023; Jain et al., 2024) to study under explored areas. Furthermore, several scholars have emphasized the need for alternative methodological approaches to

mitigate the prevailing bias toward systematic literature reviews. Specifically, qualitative approaches such as in-depth interviews, multiple case studies, and grounded theory have been recommended to capture contextual and organizational dynamics. In addition, mixed-methods designs, longitudinal studies, and industry-specific empirical investigations have been proposed to enhance methodological rigor and contextual relevance (Al-Khatib, 2023; Chatterjee et al., 2023; Brewis et al., 2023; Lutfi et al., 2023).

We determined through the bibliometric analysis that the majority of key areas of the BDA and SCO domain such as collaboration, agility, responsiveness, resilience, visibility, integration, traceability, and many other areas are limitedly explored and studied. Further, BDA adoption has not surfaced sufficiently in some regions whereas current analysis shows restricted geographical expansion.

Upon the understanding of the current analysis, we unveiled eight potential areas for future researchers to evolve in this knowledge domain.

Direction 1: Empirical Studies to link practical changes to the subject domain

The analysis is evident that this subject domain is heavily boosted by SLR studies by refining already explored knowledge whereas such studies unable to accommodate and incorporate dynamic changes to existing knowledge. Many scholars have found the same gap over the years and called for more empirical studies (Abdalla et al., 2022; Govindan et al., 2022; Patrucco et al., 2023; Alsolbi et al., 2023; Jain et al., 2024; Albqowr et al., 2024). Xu and Pero (2023) have given strong starting point with well-structured framework of resource orchestration process in BDA adoption for empirical studies whereas Centobelli et al, (2022) suggested a novel framework for integrating strategic, operational and technological levels for BDA implementation in SCO.

Direction 2: Identify and explore challenges and opportunities for developing countries for BDA adoption.

We observed that BDA adoption has been centered to most developed countries with the existing literature evidences (Rejeb et al., 2022; Lutfi et al., 2023) whereas many developing countries are far behind in the adaptation process. Centobelli et al. (2022) proposed a novel framework for BD adoption by combining all managerial levels with the common lens. Further, scholars mentioned in Table 6 explored the significance of incorporating Human and organizational-related factors and Governance and regulatory framework for BDA adoption in SCOs. With this understanding, we set a clear research gap in developing a scalable framework of BDA adoption with special attention to developing countries for future researchers.

Direction 3: BDA's role on different areas of SCO

The bibliometric analysis reveals that the existing body of literature remains limited with respect to several critical SCO dimensions, including agility, collaboration, traceability, visibility, integration, and responsiveness. Prior studies have similarly acknowledged these gaps and emphasized the need for further scholarly inquiry into specific aspects of SCO (Xu et al., 2021; Dennehy et al., 2021). However, despite these calls for future research, the aforementioned dimensions have not been explicitly conceptualized or systematically examined within the SCO framework. This omission suggests that the scholarly understanding of these constructs in relation to SCO is still at a nascent stage, underscoring significant opportunities for theoretical refinement and empirical investigation.

Direction 4: Exploration of different industries

Through the current analysis, we observed that scholarly attention has heavily focused on cross-industry perspectives with marginal attention on different industries. In the light of this literature base, we also propose to have more industry-focused studies as underscored in reviewed many studies (Talwar et al., 2021; Centobelli et al., 2022; Al-Khatib, 2023; Acciarini et al., 2023).

Direction 5: Expanding methodological approaches

SLR remained as dominant methodological approach in the domain of BDA and SCO whereas more than 62 percent of reviewed articles of the current study were categorized under the same methodology. Existing literature called different methodological approaches to explore this growing domain of DBA and SCO from different perspectives (Chalmeta and Santos-deLeón, 2020; Jha et al., 2020; Kamble et al., 2021; Del Giudice et al., 2021; Stroumpoulis and Kopanaki, 2022; Rejeb et al., 2022). Further, the necessity of qualitative studies has been extensively emphasized by many scholars to strengthen this domain with rich insights on human factors, cultural factors, and regulatory factors beyond the measurable data to have nuance understanding (Alsolbi et al., 2023; Albqowr et al., 2024).

Conclusion

The current study has been designed to extensively review the intersection of BDA and SCO domains. By employing the PRISMA approach, we selected 52 highly relevant and recently published articles to review. Then, we utilized descriptive, bibliometric, and content analysis approaches to explore current trends in literature and uncover gaps to direct future studies in the subject domain. The analysis revealed the newest and growing nature of the domain within academic society and scholarly skewness towards developed countries. Further, we underscored the methodological bias towards SLR studies which evidenced the novelty of this domain within the academic community. Moreover, the

analysis emphasized marginal industrial and contextual focus in existing literature. Meanwhile, bibliometric analysis explored that limited keywords have repeatedly appeared with high density disregarding other highly relevant terms in SCO.

Then, we underpinned eight extensively explored future research directions through a rigorous content analysis where scholars have called future studies focused on BDA adoption and implementation, wider range of industrial and context concerns, with empirical focus, human and organizational factors, governance and regulatory factors with different methodological approaches. By understanding the current trends and gaps of knowledge domain, we proposed five highly influential future research directions to boost this intersection of BDA and SCO. Further, we highlighted the necessity of diverse data sources, methodological approaches, and real-world case studies for a comprehensive and actionable understanding of the domain.

Finally, we acknowledged several limitations during the current work. First, we reviewed only 52 high-ranked journal articles which may potentially exclude some influential industry reports, conference proceedings, articles in different languages, and low-ranked articles with a wider range of perspectives. Second, we executed some limited analysis where more extensive different analytical approaches may uncover some unexplored trends, patterns, and future research gaps. Third, the SLR approach lacks primary data and direct interaction may not explore the real-world phenomenon in the current analysis. Lastly, the rapidly growing nature of the domain may outdate some findings within a limited period while highlighting the necessity of continuous updates of the knowledge domain of BDA and SCO.

Author Details

Wanigasekara Y., Faculty of Graduate Studies, SLIIT Business School, Sri Lanka, ORCID: 0009-0008-4629-4303, mp24750356@my.sliit.lk

Herath H.M.R.P., Department of Information Management, SLIIT Business School, Sri Lanka, ORCID: 0000-0001-8057-0553 renuka.h@sliit.lk

Corresponding Author: mp24750356@my.sliit.lk

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