Proposals for Addressing Research Gaps at the Intersection of Data Analytics and Supply Chain Management

Chibuzor Udokwu, Patrick Brandtner, Farzaneh Darbanian, and Taha Falatouri
University of Applied Sciences Upper Austria, Steyr, Austria
Email: {chibuzor.udokwu, patrick.brandtner, farzaneh.darbanian, taha.falatouri}@fh-steyr.at

***Abstract*—Data Analytics (DA) plays an important role in improving and optimizing the processes in a Supply Chain (SC) network. Due to a huge amount of data generated in the various SC processes, the role of DA in Supply Chain Management (SCM) is becoming increasingly evident. Organizations have already invested heavily in applying various DA technologies to their SC networks. Several reviews have been conducted in different domains of SCM indicating applications and limitations of DA in SCM. As the research domain of DA applications in SCM matures, it is necessary to identify and address the research gaps that exist at the intersection of these domains. The paper qualitatively examines recent review papers in the domain of DA in SCM to identify and outline prominent ways that DA is currently applied in SCM, what potential future opportunities stated and what challenges affecting DA application in SCM are existing. Prominent use cases of DA in SCM include i) forecasting demand, ii) product development, iii) logistics route planning and iv) lean SC development. However, there is no prominent, unique future application list of DA in SCM since the findings vary across the papers. Prominent challenges affecting DA in SCM include i) lack of collaboration, ii) data sharing problems, iii) risks associated with BD management and iv) lack of skilled experts. Lastly, this article provides two conceptual ideas for addressing these prominent DA challenges in SCM: first, a framework for data analytics enabling collaboration in SCM by using transparent data questions and second, a blockchain-based data management approach in SC networks.**

***Index Terms*—data analytics, supply chain management, SCM challenges, SCM research gaps, data analytics research gaps**

I. Introduction

Several opportunities and potentials exist for applying data analytics in a SCM value network [1]. This is because SCM represents a complex business collaboration of several players/parties, performing different organizational functions for the achievement of specific goals in the network. As a result, SCM activities and processes result in the generation of huge datasets scattered across various silos of data storage in different organizations [2]. Such datasets have been explored using DA techniques in various ways to improve the general performance of the SCM network, improve sustainability and improve the resilience of the network towards disruptions [3]. Thus, the benefits and use of DA to optimize organizational processes cannot be overstated.

Research [4] shows that organizations have continued to steadily increase their investments in DA related technologies in SCM. As the application of data analytics in SCM matures, and investment increases, the need to systematically identify opportunities for applying DA in SCM as well as its limitations arises. Application barriers and limitations affect the use of DA in organizations and inhibit the full exploitation of the potential that DA provides in SCM. Application opportunities consist of already running, current applications and of planned respectively future application sicarios. Limitations consists of the problems and barriers mitigating the current and future application of data analytics in SCM. The paper [5] shows that the full potential of DA has not been properly explored in SCM due to several technical and organisational issues. By clearly identifying the current opportunities for DA use in SCM, organizations can easily identify DA solutions to focus their resources and investments on. Also, by identifying the issues affecting the use of DA applications in organizations, researchers can identify gaps that will guide their future research directions.

A study [5] performed thematic analyses in understanding Big Data (BD) applications in SCM to unravel challenges affecting the adoption in practice. The study further provided a conceptual framework to advance the use of DA in SCM by proposing solutions to address the identified challenges. However, the study [5] only reviewed articles between 2008 to 2016. The findings from this review article can be considered as outdated. As a result, challenges identified, and proposed research directions may not represent the current state of the art in DA adoption in SCM. A recent study [6] reviewed articles to identify applications and research opportunities for predictive DA in SCM. Although the study only focused on predictive analytics and does not provide any systematic framework or approach to systematically address the challenges of DA in SCM, the aggregation of such similar and recent articles can quickly provide the current state of the art of DA

Manuscript received January 17, 2022; revised June 10, 2022.

doi: 10.12720/jait.13.4.338-346

applications in SCM. Thus, analyzing recent review articles provides the potential for identifying current applications and challenges of DA in SCM.

The main research question is how to address the main challenges affecting the use of DA in SCM. To address this concern, it is necessary to first understand the opportunities for the application of DA in SCM, identify the issues limiting its usage and subsequently proposing a potential solution to address these mitigating issues. Thus, the sub research questions for this paper are outlined as follows.

1) What are the current and future applications and usage of DA in SCM?
2) What are the issues mitigating the applications of DA in SCM?
3) What are potential solutions to addressing the issues limiting the application of DA in SCM?

By addressing these research questions, it is possible to address the research gaps that exist in the DA-SCM domain systematically. Identifying the current and future applications of DA in SCM also involves finding the most important applications of DA in SCM. The same applies to challenges affecting the use of DA in SCM. As a result, answering the second question helps in understanding the main problems. Hence, the suggested proposals and research directions focus on solving the major problems experienced when applying DA solutions in SCM processes.

The rest of the paper is organized as follows. Section II outlines the method used to systematically identify the applications of DA in SCM and possible issues mitigating such applications by analyzing relevant literature. Section III presents the results of the analyses, thus answering the first and second research questions for this paper. Section IV presents the proposal(s) for addressing the prominent issues affecting the full exploitation of DA applications in SCM, thus, addressing the research gaps that exist in the domain.

II. Method

This section presents the method used (shown in Fig. 1) in collecting and analyzing data and presenting the results of this paper.

A. Data Collection

The data collection method applied in this paper involves the following steps: keywords search, selection of relevant articles and filtering of articles.

1) Keyword search

Two keywords are used in finding the relevant review articles for this paper. They are ‘data analytics in the supply chain’ and ‘data analytics in logistics’. The terms *supply chain* and *logistics* are often used interchangeably [7], therefore, we used both keywords in our search. The selected database for performing the search is Scopus and Web of Science. These two sources are popular indexing databases for scientific articles [8]. To collect only recent review articles outlining the current state of the art in the domain, the search is limited to articles published between 2020 to 2021.

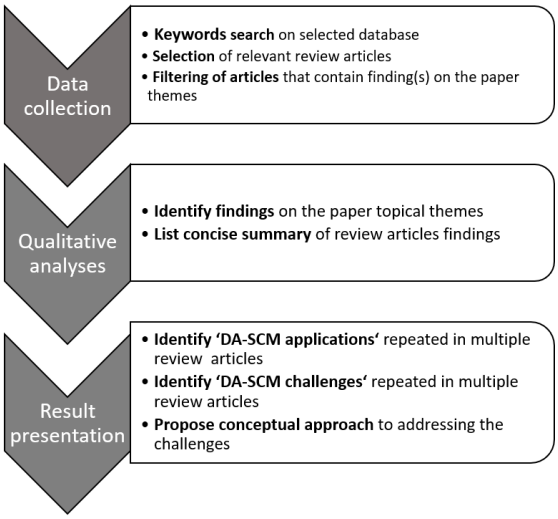

Figure 1. Research method.

This keyword-based search in the selected databases within the limited timeframe resulted in 68 published articles.

2) Selection of relevant articles

The focus of this paper is to understand the applications and challenges of DA in SCM by analyzing review articles. The review articles analyzed are articles that performed literature reviews or expert reviews. Thus, the selected articles for this paper are published articles that reviewed data from expert interviews (or questionnaires) or literature. By applying this article selection criterion and by eliminating repeated articles, a total of 16 articles was selected.

3) Filtering of articles

This paper seeks to identify the current applications of DA in SCM, future application of DA in SCM and challenges of DA in SCM in recent review articles. As a result, these three objectives form the themes for filtering relevant review articles. The final selected articles are the ones that contain clear findings in at least one of the themes of this paper. After filtering, the articles that provide findings on the themes of this paper, 10 articles were finally selected for the qualitative analyses.

B. Qualitative Analyses

For each of the selected articles, the results that show ‘current application of DA in SCM’, ‘future application of DA in SCM’, and ‘challenges of DA in SCM’ are identified. The findings are then reduced into a concise summary that is then presented as a list of findings for each literature source. With such an analyses approach, repeated findings in multiple review articles can easily be identified.

C. Result Presentation

The objective of this paper is to show the prominent current and future applications of DA in SCM, identify the main challenges of DA applications in SCM and propose conceptual ideas to address these challenges. Therefore, the prominent applications of DA in SCM are identified by selecting findings from review papers that are repeated in multiple papers. The same applies to the

themes 'future application of DA in SCM' and 'challenges of DA in SCM'. Research proposals are then made to address the main challenges affecting the use of DA in SCM.

III. Results

This section presents the qualitative results of recent articles that reviewed related literature on DA applications in SCM. Table I shows the result presentation of the analyzed articles. The first column states the selected articles analyzed, the second column shows the current applications of DA in SCM, the third column presents the expected future applications and potential use of DA in SCM, the fourth column summarizes the possible limitations that affect the use of DA in SCM, and the last column indicates the domain in which the selected articles reviewed their relevant literature. Each of the selected review articles is explored in detail to identify and summarize the contributions towards the three themes that guide the qualitative analyses conducted in this paper. The summarized findings are then presented in a list for each of the columns- *current applications, future applications and challenges*.

The articles focused on the general application of DA in SC and SCM Information Systems [3], [9], the applications of Big Data Analytics (BDA) in SC [10]-[14], predictive BDA in SC and logistics [6], [15] and the applications of Social Media Data Analytics (SMDA) in SC [16]. This shows that most of the review articles are focused on the use and applications of BDA in SCM. Although three phases/types of data analytics drive business planning and insights generations such as descriptive, predictive and prescriptive analytics [17], the recent review articles only captured predictive data analytics. This could imply that the SCM domain is not currently mature enough for applying the last phase of data analytics which is prescriptive data analytics. Thus, prescriptive analytics can already be considered as a potential future application of DA in the SCM domain.

TABLE I. Applications and Challenges of DA in SCM

Art.	Current applications	Future applications	Challenges	Domain
[3]	• improve the *performance* of SCM processes • improve the *resilience* of SCM towards potential disruptions that may occur in the network • improve the *sustainability* of the network with respect to using 'green' inputs and outputs in the network	-	-	DA in SCM
[10]	• *optimizing* logistic and SCM processes • Personnel requirements calculation • Improving forecasts for better *demand planning*	• *Connected demand*-driven SC • *Real-time visibility* of SCM network • *Predicting behaviour* of complex SC • Improving SC and *logistics planning* • Evaluating *new business models* based on customer needs • Identifying opportunities for *cross-selling*	• *lack of clear strategy* for big data application • Cases are *analysed in silos* • *security and legal issues* with the use of data • lack of clarity with regards to *data ownership* • limited involvement of *employees* • Lack of *skilled experts* in managing big data • lack of full *interoperability and sharing data* between partners in the network due to trust issues	BDA in SCM
[11]	• *Optimizing* business operations by analysing customer behaviour • Application in customers *product personalization* • Optimizing vehicle routing • *prediction of epidemic/disruptions* to enable logistics planning • provides verifiable information for solving complex governance problems	-	• better *prediction of customer needs* • better *risk assessment* for SCM networks • improve *traceability in SCM* networks • improvement of techniques for *coping with volatility in demand* and cost fluctuations • A need for proper *data sharing and collaboration* among organizations in a given SCM network	BDA in SCM
[6]	• Combination of predictive algorithms and simulation models provides *prescriptive capabilities* in dealing with future scenarios	• The use of IOT in dealing with problems associated with *data collections in reverse logistics* • Direct *integration of physical items* in the supply chain with computer systems	• Very few research conducted in the area of *predictive analytics and reverse logistics* • Problems with *predicting the rate of return goods* in reverse logistics which generally affect the efficiency of the network.	Predictive BDA in SCM
[15]	-	-	• Collecting and *integrating high velocity* changing large *datasets* • Poor *quality of data* • Difficulty in *analysing and interpreting data* • Challenges that are experienced in implementing *data protection policie* • Need for *homogenous and interoperable* data format with an SC network • *Unknown costs associated* with handling data (such as security, data privacy legal issues), therefore, benefit trade-off is difficult to calculate.	Predictive DA in logistics

[9]	• The use of data analytics to increase the *competitiveness and efficiency* of organizations • *ERP* systems are used in *providing structured data* useful for data analytics	• Use of cross-functional analytics to increase *SC transparency, flexibility & agility* • Integration of SC *planning decision-making* with the results of data analytics • Moving towards *real-time analytics* and incorporating prescriptive analytics	• Limited research on the potential use of *BD on SC planning & execution* • System *interoperability and data heterogeneity* problems • The problem of identifying the specific type of *data and suitable model* for a given SC function	DA in SCM IS
[12]	• Application in processes that are *less internally focused* within an SC • Application in processes that require *external contact points* such as delivery, return, sourcing & planning processes	-	• There is a lack of *collaboration among stakeholders* in the task of extracting and *sharing business data* through BDA • *Lack of skill* and mastering analytic techniques with that has a lot of data challenges	BDA in SCM
[13]	• Improving *Forecasting* • Enabling SC *System Integration* • *Human Capital* related analyses • enhance decision making in reverse logistics • improve remanufacturing to eliminate waste	-	-	BDA in SCM
[16]	• Used in *integrating and building relationships* by directly connecting organizations to suppliers and customers • Enables *knowledge sharing* to improve the operational efficiency of SCM • Used *in forecasting and developing new products* by organizations • Useful source of *information during disruptive events* in an SC network	• Integration of *focused group survey* to confirm or negate the *SM data analytics* result • explore *deeper integration and relationship building* on several levels of the SC network • Explore SM to further identify the factors that influence *new product d evelopment* in organizations	-	SMDA in SCM
[14]	• Improve a firm's *performance* • Enable *lean SCM* & *waste* elimination • Achieve a *resilient and agile SC*	-	-	BDA in SCM

A. Current Applications of DA in SCM

Table I shows, on a high level, that current applications of DA in SCM generally aim to optimize the efficiency of the SC network by improving the performance, resilience, sustainability, agility of SCM processes and logistic operations. SCM and logistic operations which have the most potential for application of DA are less internally focused processes that require external contact points such as delivery, return, source and plan processes [6]. Furthermore, organizations that adopt various enterprise IS such as ERP systems for managing their different SCM processes have an advantage because of the possibility of generating clean structured data which is a useful input for DA.

On a detailed level, the prominent current use of DA in SCM include forecasting demand, product development, logistics route planning and development of lean SC network. The prominent applications of DA in SCM are identified by selecting findings that are repeated in multiple review literature analyzed.

1) Forecasting demand

The findings of the studies [10], [13], [16] show that DA is currently and actively used in SCM for forecasting product sales to better plan the replenishment of products. While historical sales data is commonly used for predicting future demand, the study shows that data from Social Media (SM) are also used in forecasting the demand for certain products.

2) Product development

The studies [11], [16] show that DA in SCM is applied in the customization of existing products and the development of entirely new products. BD has been applied in product customization by personalizing products for retail customers [4]. SMDA is currently applied in developing entirely new products by organizations based on trends generated by customers in the SM.

3) Logistics route planning

Logistic plan scheduling is an important application of DA in SCM for optimizing routes to enable timely delivery of products [10], [11], [12], [16]. While the studies [10]-[12] generally show that BD is commonly applied in logistics route planning, the study [16] shows that SM is a useful source of information during disruptive and epidemic events for better planning of product delivery.

4) Lean SC development

The studies show that DA is applied in developing various lean SCM approaches [13], [14]. The main goal of lean SCM is to reduce or eliminate waste and components. Waste generated during various processes of the SCM can be reduced with better demand forecasting [14] or by reusing waster in manufacturing new products [13].

B. Future Applications of DA in SCM

The results for future applications of DA in SCM are not consistent across the review literature articles

analyzed. This could be due to the subjectivity of the researchers in interpreting their results. Still, the review articles [6], [9], [10], [16] provide the basis for discussions on the future application of DA in SCM.

As already mentioned in the initial part of this section, prescriptive data analyses provide a potential future application of DA in SCM since current research in this domain focuses mostly on predictive DA. To further establish this, the article [9] suggested real-time data analytics incorporating prescriptive DA as a possible future application of DA in SCM. The review article [9] also proposes cross-functional DA to increase transparency, flexibility and agility in the SCM network. Cross-functional implies that organizations in a given SCM network collaborate more closely in performing DA for specific or shared functions in the network. The paper also suggests further integration of DA results in planning processes in the organization.

With respect to SMDA, the finding from the review article [16] show that the potential future of DA in SCM is a deeper exploration of SM data to identify the main factors that affect new product development in organizations. Furthermore, the findings from the same article suggest that complete reliance on SM data for the development of new products or business models may not produce the intended results. Thus, integrating focus group surveys to either confirm or negate the findings from SM data is another potential future application of DA in SCM.

The review article [6] suggests more integration of the Internet of Things (IoT) in SCM processes for efficient data collection to improve the performance of closed-loop supply chains. The article [10] identified the following as future DA applications in SCM: connected demand & identification of cross-selling opportunities with BD, analyzing new business models by analyzing customer needs. Others are increasing the visibility and predicting the behaviour of complex SC networks.

C. Issues Limiting DA Applications in SCM

Lack of collaboration, data sharing problems between organizations in an SCM network, lack of skilled experts in managing, analyzing and interpreting results, managing risk associated with BD data such as security, privacy and legal issues are the consistent findings repeated in multiple reviews papers [1], [9], [10], [11], [15]. These, therefore, represent the prominent challenges affecting the application of DA in SCM.

1) Lack of collaboration

A huge amount of data is generated in different processes in any given SC network. However, due to multiple players and organizations in a network, the data generated are stored in silos in various organizational data management infrastructures. Organizations currently perform data analytics based on data available in their organizations [10], [11], thus, are not able to optimally use the BD generated in their value network. Since organizations work in silos in performing their respective data analyses, they do not see the need to collaborate and fully take advantage of the large datasets generated in the SC network.

2) Data sharing problems

Organizations develop their specific infrastructures for data management which are not homogenous (or standardized) with other organizations in their SC network, as a result, data are stored in different formats [9], [15]. Because of this, it is nearly impossible to exchange data in real-time between organizations in the SC network. Thus, even when organizations in any given SC network demonstrate a willingness to collaborate & optimize the use of data generated in a network, interoperability problems between the technologies for data management and formats of stored data limit such potential collaboration.

3) Risks associated with BD management

Security, privacy and legal issues are the common risks associated with collecting, storing and analyzing internal and external data of a SC network [10], [11], [15]. These risks have potential costs that affect the performance of organizations in the network. BD may contain sensitive information which could be misused when attackers exploit information systems storing the data. Also, sensitive data in BD could be shared with other organizations in a SC network. Without any access control, such data could be misused by organizations it is shared with. Also, BD in an SCM network may contain private customer information. As a result, the processing of such data could result in legal issues. Identifying and anonymizing sensitive information that is contained in BD is a tedious task that results in additional data processing costs to the organizations.

4) Lack of skilled experts

Skilled experts that can properly collect, analyze and interpret data in SCM are currently lacking [10], [12], [15]. A skilled expert in DA in the SCM domain is expected to have a deep understanding of SC processes and a technical understanding of DA techniques and tools. Traditionally, SCM is largely a management domain, while DA is a software science domain. As a result, finding experts that are grounded in these two areas can be a difficult task.

IV. Addressing Prominent Challenges of DA in SCM

This part of the paper presents conceptual proposals to address the main challenges of DA applications in SCM as identified in Section III.C. The focus is on the first two identified issues such as *lack of collaboration* and *data sharing problems*.

For the problem of *risks associated with BD management*, a lot of studies have been conducted to apply BD in managing risks in organizations [18]-[20]. However, a systematic approach to address the security, privacy and legal risks associated with the use of BD in organizations is still lacking. The current approach in dealing with privacy issues in BD is to use different data anonymization techniques [21]. Data anonymization is a tedious and expensive process. Therefore, it is necessary to develop a systematic approach for identifying personal data in various BD sources in SCM processes.

Developing such an approach is out of the current scope of this paper, hence, considered as future work.

The problem associated with *limited skilled data analytics experts* in the SCM domain is organizational and can be addressed with additional training. On the practical aspect, organizations can employ skilled data analysts with limited experience in the SCM domain. However, structured training on the concepts of SCM is required for such experts to be grounded in the SCM domain and concepts. From a research and academic perspective, more structured courses that are rooted in computer science - Data Analytics - background and economics & management – SCM - background, are needed to develop future analysts for the domain. SCM operations represent complex processes with several organizational interactions. As a result, only skilled data analysts with the required background can develop custom data analytics models to address the complex issues experienced within different types of SC respectively value networks.

Two different research proposals are made to address the collaboration and data sharing problems experienced within a SC network. The first is a framework for DA in SCM that encourages collaboration between organizations in the network. The second is a blockchain framework for data management in SCM that enables efficient data sharing between organizations. These proposals are presented in the following section.

A. A Framework for Data Analytics that Enables Collaborations in SC Networks

The goal of the DA framework for SCM proposed in this paper is to enable collaboration between organizations in any given SC network by providing a complete picture of the processes and motivate organizations to share data. Organizations are unwilling to share data because the benefits of sharing data with other organizations are not clear, thus, their data analytics is limited to the data they generated and stored within the organization.

The proposed DA framework for SCM comprises four main steps: identification of organizational types within a value network, generation of data questions for the given value network, mapping of data questions to organization types within the SC network and identification of data sources for specific data questions in the network.

1) Identification of organizational types within a value network

There are various standard organization types or domains that are within any given value network. The organization types within an SC based on the functions they perform include manufacturers, vendors, logistic transporters, distributors, retailers [22]. Organizations that perform similar functions will tend to have similar objectives in any given SC network.

2) Generation of data questions for the given value network

The study [3] provides a comprehensive list of data questions relevant to analyzing the performance, resilience and sustainability of SC networks. Such questions provide an overview of business needs for organizations in each SC network. Organizations that perform similar roles in a value network will share similar objectives. As a result, a specific group of data questions can be mapped to organizations based on the functions they perform in the SC.

3) Mapping of data questions to organization types within the SC network

Specific data analytics questions can be mapped to specific organization types in the value network. For instance, questions about the early and late delivery of certain products can be mapped to organizations that perform logistic functions and the organizations ordering the products within the SC network. Another example is that data questions about customer satisfaction can be mapped to organizations at the end of the chain of a given network since such organizations directly interact with the consumers and / or customers. As a result, organizations having similar business goals linked to specific data questions can collaborate, share data and perform analytics to address the common challenges they face.

4) Identification of data sources for specific data questions in the network

Specific data questions are linked to different datasets that reside in organizations within a value network. It is therefore necessary to identify the locations for datasets linked to any given data questions. As such, a specific collaboration setup can be established between organizations to address data questions that apply to their business objectives in the network.

B. A Blockchain-Based Approach for Data Management in SC Network

The study [23] analyzed various applications of blockchain technologies in organizations and identified information interoperability as one of the main reasons for blockchain adoption in organizations. Blockchain is a distributed ledger that replicates stored data for all the parties / organizations in a given network. Decentralized consensus establishes the rule for adding new data to the ledger such that information and data stored is consistent across the storage system of all the parties in the network [23]. A smart contract is a computer program that runs on blockchain specifying and enforcing a set of business conditions contained within it. Thus, we apply blockchain concepts in proposing a framework for addressing data-sharing problems in SC networks.

We propose an approach to data management in a SC network to enable real-time data access between organizations in a given value network that involves the use of the public cloud for storing SC data, an Application Programming Interface (API) to manage access to data by external organizations and a smart contract that contains rules specifying data access.

1) Public cloud for SC data storage

Public cloud data storage is a type of service that allows storing and accessing data over the public internet. The concept of the public cloud is presented in detail in [24]. The main purpose of adopting the public cloud is

that it allows to access data across several organizations. However, to ensure information security, data generated in a SC can be encrypted and stored in the cloud. This ensures that such data is only available to organizations with the necessary key to decrypt the data.

2) API for data access control

Each organization in the network maintains an API that manages access to the generated SC data by external organizations. The API also contains the key to decrypt the stored data and make it available to the requesting conditions provided they meet the requirements to access the data.

3) A smart contract specifying data access requirements

A smart contract deployed on blockchain contains conditions for accessing a particular organization's data by external organizations in an SC network. The API deployed by the organization that owns the data reads the smart contract to determine if an external party requesting access to data meets the conditions for accessing the data. The data access requirements can contain the identification for external organizations granted access to data, the particular data access granted as well as the duration and type of access granted. These listed data access criteria that can be specified in a smart contract are further explained below.

Identification: With a public key infrastructure that exists in blockchain networks, organizations collaborating on a given value network can be identified by their public key. Public keys are unique identification issued in blockchain networks. As a result, access to a given dataset stored in the public cloud can be granted to specific public keys that exist within a given blockchain network.

Data type: It is also necessary to specify the particular data or set of data to which access is granted for specific organizations. This ensures that external organizations do not have unlimited access to another organization's SC data stored in the public cloud.

Access duration: this requirement specifies the duration an external organization is granted access to a particular data. This ensures that external organizations do not have perpetual access to the data. Access to data can be limited within the timeframe the collaboration still exists in the SC network.

Access type: this specifies what the external organizations can do with the accessed data within the public cloud. For instance, access may be limited to read-only for one organization. For another organization, write-access could be granted on data.

V. Discussion and Conclusion

The discussion from this paper compares the results of this paper with similar studies. The study [5] reviewed related articles about a decade ago and provided concise findings on the current challenges of BDA applications in organizations. Half of the articles that provided inputs for the qualitative analyses performed in this paper reviewed articles published within the BDA domain. Thus, comparing our findings with the study [5] shows how the problems affecting BDA adoption in organizations have changed in about a decade.

The comparisons are presented based on thematic findings of the paper [5] and our current paper. Under the theme organizational challenges of BDA, two results which are also repeated in our major findings include lack of resources & skilled experts, and privacy & security concerns. These are similar to our findings on the lack of skilled experts and risks associated with processing of BD such as potential security, privacy and legal issues. Under technical challenges, one finding that is repeated in our work is the data quality problem. The issue about data quality was discussed in [5] as a problem that resulted out of a lack of standardization in systems that produce SC processes data. In our paper, the results show that the lack of standardization and homogeneity of information systems in SCM processes have resulted in data sharing problems. Thus, the identified three problems represent issues that have mitigated DA applications in SCM since the inception of BDA adoption in organizations.

To conclude this study, we provide a general summary of the research conducted in this paper and provide answers to the research questions that guided this study. The main objective of this study is to present research proposals to address the gaps that exist in DA applications in SCM. To achieve this, it is necessary to identify the current and future applications of DA in SCM, and their challenges of DA applications in SCM. A qualitative assessment of recent review literature was conducted to identify the DA applications in SCM and their challenges. Research proposals are then made to address the prominent DA problems in SCM that are repeated in multiple reviewed papers.

The first research question of this study is what are the current and future applications and usage of data analytics in SCM? This is answered by the four prominent use of DA in SCM identified in this study: forecasting demand, product development, logistics route planning and lean SC development. However, there is no prominent future application of DA in SCM since the findings vary across the papers. For the second research question of what are the issues mitigating the applications of data analytics in SCM it was found that the prominent challenges affecting the use of DA in SCM include lack of collaboration, data sharing problems, risks associated with BD management and lack of skilled experts. For the last question of what are the potential solutions to addressing the issues limiting the application of data analytics in SCM two main proposals were presented to address the absence of collaboration and data sharing problems that exist in SCM. The first is a proposed framework for data analytics that enables collaborations in the SC network by using data questions to present a general overview of the SC network. The second proposal is a blockchain data management approach for organizations in the SC network. The proposed solution enables the real-time availability of data to several organizations by storing SCM processes data in a public cloud and using requirements information stored on the blockchain to maintain access control on the data.

CONFLICT OF INTEREST

We hereby declare that this work was carried out with any conflict of interest.

AUTHOR CONTRIBUTIONS

C. Udokwu is the lead author and participated in data collection, qualitative analyses and paper documentation. P. Brandtner participated in qualitative analyses of collected data and paper documentation. F. Darbanian participated in data collection and qualitative analyses. T Falatouri participated in data collection and qualitative analyses. All authors had approved the final version.

ACKNOWLEDGMENT

This research was funded by the Government of Upper Austria as part of the Excellence Network Logistics – Logistikum.RETAIL.

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Chibuzor Udokwu has bachelor's degree in computer engineering from the University of Benin Nigeria and obtained his master's degree in software science from University of Technology, Estonia. He is on the path to obtaining his PhD degree in the field of Software Engineering.

He is currently a research associate in department of Logistics at the university of applied science, Upper Austria. His research interest focuses applying technological concepts in improving organizational processes. His area of research includes data analytics and predictive modelling, complex system designs and blockchain related software engineering.

Patrick Brandtner obtained his bachelor's degree in E-Business and a master's degree in supply chain management at the University of Applied Sciences Upper Austria, he started his career as Research Associate and Research Project Manager at the Department for Digital Business at the University of Applied Sciences Upper Austria. In 2017, he finished and successfully defended his PhD-Thesis, which he wrote at the Department for Business Informatics at Dublin City University.

He is currently a Professor for Data Driven Management at the Department of Logistics at Upper Austria University of Applied Sciences. His research interests include Predictive Analytics and Data-Driven Decision Making in Supply Chain Management and Digital Innovation Management in Value Networks. He has led several research

projects with a total volume of over € 5 Mio. and has published his research in international outlets in the domains of information systems, logistics and supply chain management, innovation management, and design science research.

Farzaneh Darbanian got her bachelor's degree in industrial engineering and continued her academic path in the field of logistics and supply chain engineering focusing on sustainable optimization.
She is a research associate in the department of logistics in University of Applied Sciences Upper Austria. Before Starting her research career in 2019, Farzaneh had several years of experience in the department of planning and development as a data analyst in a conglomerate industry related to retail and manufacturing in Iran. Her research interest and personal qualities are descriptive analytics, diagnostics analytics and data preparation, exploration, and visualization.

Taha Falatouri has a master's degree in Information System Management and continuing his academic path to a Ph.D. in Industrial Engineering.
He is a research associate at the University of Applied Sciences Upper Austria. He has 9 years of experience in the banking, manufacturing, and retail sector. He started his research career in Austria in 2019. Taha has a good background in quantitative analytics and Operational research supporting with Machine learning techniques, Python and R programming languages and SQL skill. His current tasks in the research team are interpreting the business question to data questions and applying machine learning techniques to solve them. His research interest and personal qualities are quantitative analysis, predictive analytics, Text mining, and Statistics.