Chapter 1:

Characteristics and trends in big data for service operations management research: A blend of descriptive statistics and bibliometric analysis

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Abstract The field of service operations management has a plethora of research opportunities to capitalise on, which are nowadays heightened by the presence of big data. In this research, we review and analyse the current state-of-the-art of the literature on big data for service operations management. To this aim, we use the Scopus database and the VOSviewer visualisation software for bibliometric analysis to highlight developments in research and application. Our analysis reveals patterns in scientific outputs and serves as a guide for global research trends in big data for service operations management. Some exciting directions for the future include research on building big data-driven analytical models which are deployable in the Cloud, as well as more interdisciplinary research that integrates traditional modes of enquiry with for example, behavioural approaches, with a blend of analytical and empirical methods.

Key words: analytics, big data, operations management, services, bibliometrics.

1 Introduction

Operations management is a fundamental organisational function involved in the management of activities to produce and deliver products and services (Bag *et al.*, 2020). Services have long been the dominant sector of industrialised nations; nevertheless, the field of operations management has been traditionally associated with manufacturing and supply chains rather than with services (Karmarkar & Apte, 2007). And while it is true that *service operations management* (SOM) has struggled to find its fit as a distinct discipline in the literature, it is fair to say that the number of studies on the topic have increased substantially over the years. For example, a recent review study by Roth and Rosenzweig (2020) concluded that, in their sample, service-oriented papers represented 58% of the publications, with the healthcare and retail sectors at the forefront. Today, big data have been accelerating this shift in research. All in all, the presence of big data has been 'pushing' organisations to review their practices and identify opportunities that would allow them to embrace data-driven decision-making processes to a greater extent.

Although there is no unique definition of big data (Charles & Emrouznejad, 2018; Charles & Gherman, 2018), it is commonly accepted that big data are "datasets that are too large for traditional data-processing systems and that therefore require new technologies" (Provost & Fawcett, 2013). In the literature, it is common to refer to the four dimensions of big data defined by Laney (2001): volume, velocity, variety, and veracity, which are indicative of the computational complexities and technical requirements associated with big data. Coupled with ethical challenges (Charles, Tavana, & Gherman, 2015), analysing big data confronts the researchers with many difficulties (Bizer *et al.*, 2012). Charles and Gherman (2013) underlined that in order to create value and competitive advantage, big data should be further considered in view of the dimensions of context, connectedness, and complexity. The growth of big data has created opportunities for pursuing new avenues of research in SOM. In particular, big data analytics may support improved policy- and decision-making and drive organisational performance.

It is vital to both comprehensively and quantitatively evaluate the development trend in research on big data for SOM, which can help not only practitioners and managers, but also academics interested in making informed decisions in their future research endeavours. Bibliometric analysis, which has been widely used across different fields, is a feasible means that can quantitatively and qualitatively assess trends in research fields over time. It can be used to systematically identify, organise, and analyse the main elements of a research topic (Mourao & Vítor, 2020; Wong *et al.*, 2020), as well as to clearly determine the development trends of a particular research field (Albort-Morant *et al.*, 2017).

After decades of research developments in SOM, there is currently a growing interest in exploring the potential that big data pose for this field. This is supported not only by the increasing availability of data, but also by the methodological advances in a number of fields. Therefore, this research investigates the characteristics and trends of studies integrating big data and SOM through a bibliometric analysis

so as to facilitate a comprehensive understanding of the state-of-the-art of current research directions and progress in the field.

2 Methods and Materials

Bibliometric analysis is a valuable research technique that can help in discovering the global research trends on a topic or field from multiple angles, providing an overview of future lines of research (Liu, Zhang, & Hong, 2011). By bibliometric analysis, this paper reveals the characteristics and trends in studies integrating big data with SOM in view of publication outputs and major journals, subject categories, geographic and institutional distribution of publications, and keywords analysis.

The bibliometric analysis was conducted based on the Scopus database, which is the abstract and citation database of Elsevier. Although there are other databases available, Scopus was deemed to be one of the best choices in view of the fact that it is characterised by consistent citation metrics and precision in locating authors and institutions. Relevant data on big data for SOM research were downloaded on 13 March 2021 via the concurrent search for the keywords “big data”, “operations management”, and “service”. These keywords were searched in the title, abstract, and keyword lists of each publication. Finally, only publications in English were selected for further analysis. The search criteria along with the Boolean expression was as follows: TITLE-ABS-KEY ("big data" "operations management" "service") AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013)) AND (LIMIT-TO (LANGUAGE , "English")).

3 Results

The concurrent search for the keywords “big data”, “operations management”, and “service” search yielded 57 document results on 13 March 2021, all published between 2013-2020. In Section 3.1, we proceed to analyse these document results by means of summary statistics. Subsequently, in Section 3.2, we continue with a bibliometric analysis of the same material, while in Section 3.3, we focus on exploring the themes of the journal research articles only.

3.1 Descriptive summary statistics of published material

In this section, we provide an overall analysis of the 57 document results by means of various visualisations. Figure 1 shows evolution of the number of publications in big data for SOM. Several observations are worth mentioning. First, all 57 documents have been published after the year 2013, which means that at least in the Scopus database, there were no publications that integrated the three keywords together before this year. Second, we can observe an increased interest in the topic in recent years, with a peak in the year 2018 (16 publications).

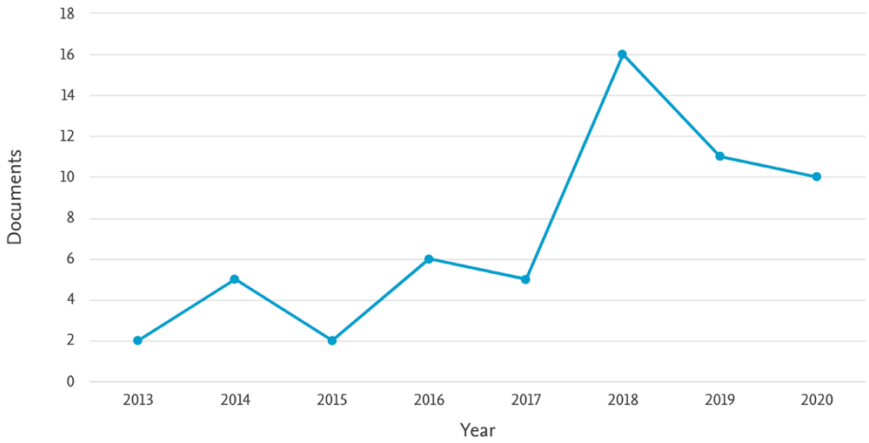

Figure 1. Annual scientific production. (Source: Scopus 2021).

Figure 2 shows the number of documents per year by source, with a comparison of the document counts for the top four sources. The journals that have published most of the material on big data for SOM are Production and Operations Management (4 publications), Annals of Operations Research (2 publications), International Journal of Operations and Production Management (2 publications), and International Journal of Systems Assurance Engineering and Management (2 documents).

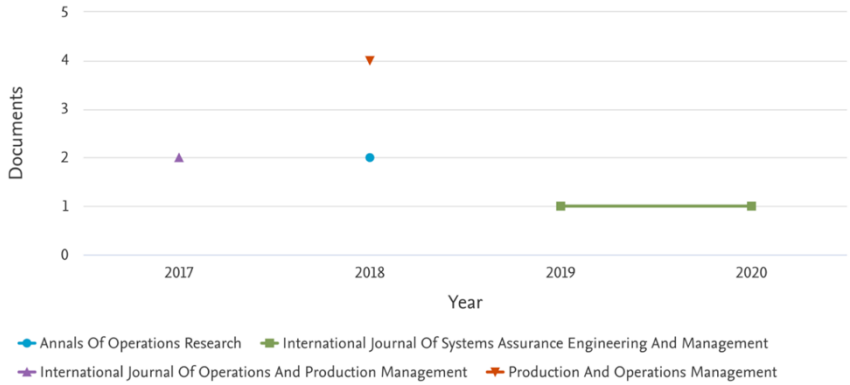

Figure 2. Documents per year by source. (Source: Scopus 2021).

Figure 3 presents the documents by affiliation, comparing the document counts for the first 15 affiliations. Affiliation-wise, there are five institutions that lead the ranking with most document counts (2 publications each), namely Hong Kong Polytechnic University, University of Leeds, Pohang University of Science and Technology, Ulsan National Institute of Science and Technology, and Leeds University Business School. These institutions represent a mixture of countries (China, United Kingdom, and South Korea). All remaining institutions each have one publication.

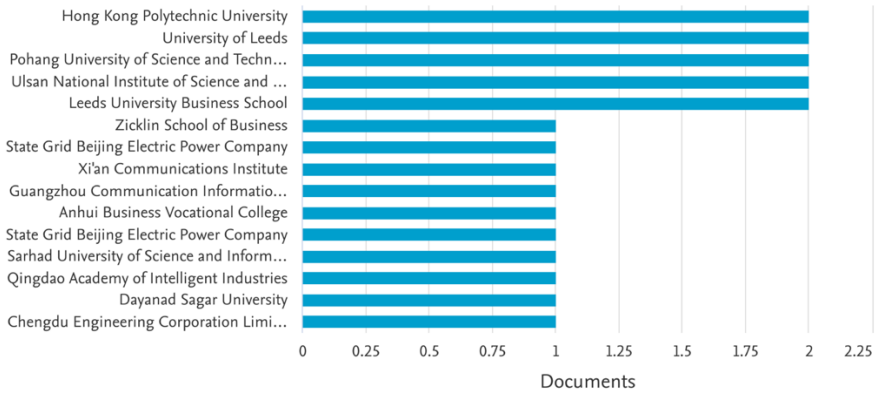

Figure 3. Documents by affiliation. (Source: Scopus 2021).

Figure 4 visually depicts the countries with the highest number of publications, comparing the document counts for 15 countries/territories. The countries of origin for the 57 documents were determined by considering the country of the corresponding author. It can be easily observed that China and the United States share the first place, with 16 publications each. As a matter of fact, a notable observation is that China and the United States together account for more than half (*i.e.*, 56.14%)

of the total number of publications. The United Kingdom occupies the third place with 4 publications, followed by India, Japan, South Korea, and Taiwan, each with 3 publications. All remaining countries each have one publication, while there are also 8 documents for which the corresponding author information is not available.

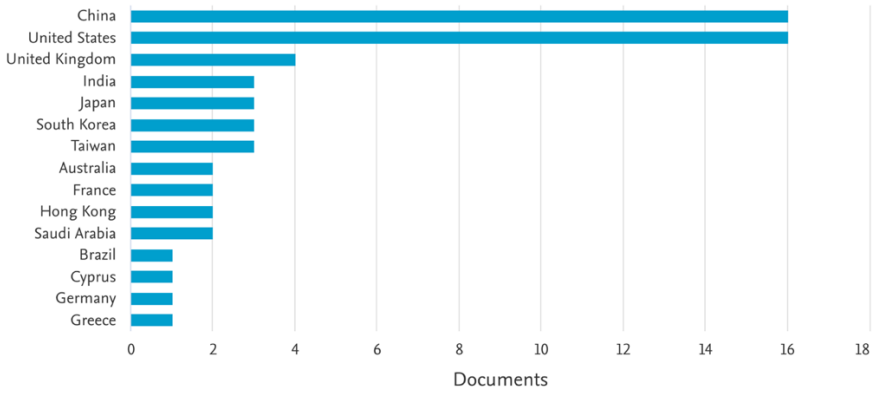

Figure 4. Documents by country or territory. (Source: Scopus 2021).

Table 1 depicts the number of documents by publication type, while Figure 5 shows the same visually. In this sense, we can note that the literature is dominated by articles (22 documents, which constitute 38.6% of the publications), followed closely by conference papers (21 documents, representing 36.8% of the publications). Therefore, journal articles and conference papers are the most frequent publication types in the literature. The third place is occupied by conference reviews with 8 documents, which account for 14% of the publications. Lastly, there are 3 book chapters, 2 reviews, and 1 editorial, which represent 5.3%, 3.5%, and 1.8% of the publications, respectively.

Table 1
Documents by publication type (Source: Scopus 2021)

Document type	**No. of Documents**
Article	22
Conference Paper	21
Conference Review	8
Book Chapter	3
Review	2
Editorial	1
TOTAL	57

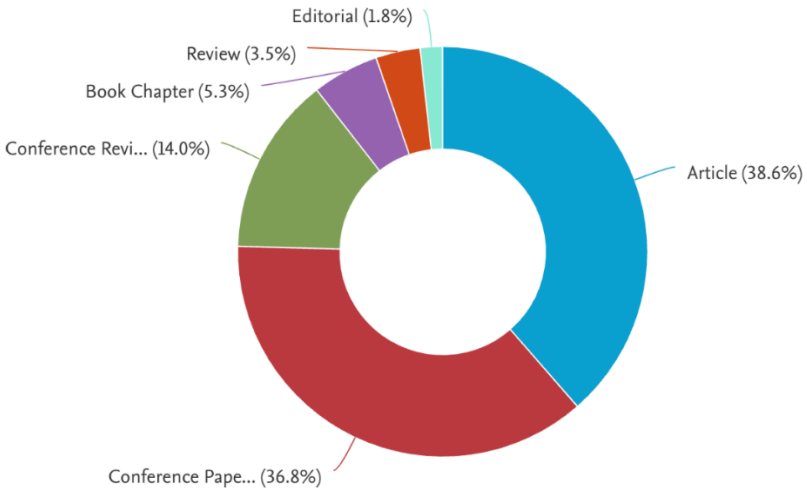

Figure 5. Documents by publication type. (Source: Scopus 2021).

Finally, an analysis of the published documents by subject area (Table 2 and Figure 6) indicates that the area of "engineering" has received the most interest, with 29 documents or 23.2% of the publications. This is followed closely followed by the areas of "business, management, and accounting", with 25 documents or 20.0% of the publications. We then have "computer science" (with 21 documents or 16.8% of the publications) and "decision sciences" (with 19 documents or 14.2% of the publications).

Table 2
Documents by subject area (Source: Scopus 2021).

Subject area	**No. of Documents**
Engineering	29
Business, Management, and Accounting	25
Computer Science	21
Decision Sciences	19
Social Sciences	8
Mathematics	6
Energy	5
Economics, Econometrics, and Finance	3
Earth and Planetary Sciences	2
Environmental Science	2
Physics and Astronomy	2
Biochemistry, Genetics, and Molecular Biology	1

Chemistry	1
Medicine	1

Note. A publication can be classified under more than one subject area.

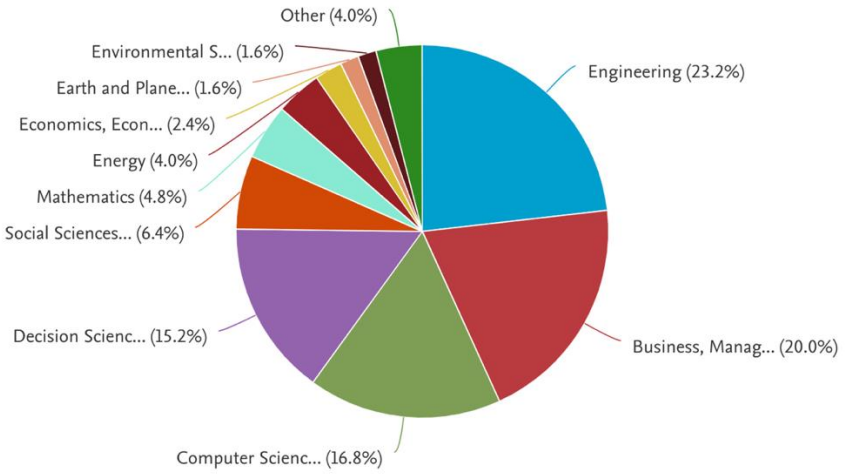

Figure 6. Documents by subject area. (Source: Scopus 2021).

3.2 Bibliometric analysis of published material

Using the VOSviewer software, we have created co-authorship and keyword co-occurrence maps based on bibliographic data. The co-authorship analysis (Figure 7) considered two as the minimum number of documents of a country; of the 25 countries identified, 11 met the threshold, although the largest set of connected items consisted of 8 countries. The keyword co-occurrence analysis (Figure 8) has been performed using all the keywords as the unit of analysis, with minimum number of occurrences as three, and with full counting as the counting method.

Figure 7 reveals the network map of international cooperation among major countries (with the greatest total link strength) participating in research on big data for SOM. The colours indicate the clusters to which the countries are attributed according to the strength of their relationships, while the size of the circles is indicative of the number of publications held by each country. We can observe that there are 3 clusters in the figure. The first cluster (red colour) is dominated by the United States, and includes a mix of Eastern and Western countries, namely Taiwan and South Korea (in Asia), and France (in Europe). The second cluster (blue colour) is headed equally by Hong Kong and Japan. Lastly, the third cluster (green colour) is led by China, but also includes Australia.

Figure 7. Co-authorship network of countries.

Figure 8 shows that a total of 20 most common keywords have been identified. Keywords are labelled with coloured frames, whose size is positively correlated with the occurrence of the keyword in the document. Moreover, these keywords are grouped into five clusters that seem to assume a prominent role vis-à-vis "computational paradigms" (three items, yellow cluster), "big data for quality control and electric utilities" (four items, blue cluster), "information services and operations management" (five items, red cluster), "data analytics for SOM" (four items, purple cluster), and "big data analytics, internet of things, and smart city" (four items, green cluster).

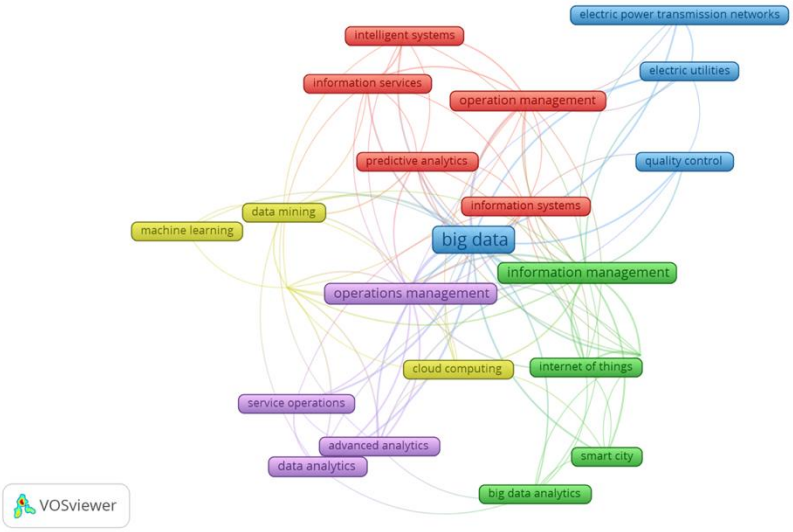

Figure 8. Network map showing the relations between various topics in the literature on big data for SOM (57 documents).

3.3 Bibliometric analysis of journal articles

In this section, we have proceeded to analyse only the journal articles on big data for SOM. Such decision was guided by both literature and practical considerations. First, conference papers generally do not provide enough information on the research conducted, as we encounter in full papers, being normally written with the aim of presenting preliminary results (Mubin, Arsalan, & Al Mahmud, 2018). Book chapters, conference reviews, and reviews, also, do different work than journal articles, as do editorials; hence, these were also excluded from further analysis. This screening led to the consideration of 22 research articles for further processing, constituting 38.6% of the publications (Figure 5).

Figure 8 shows the increasing number of journal articles in the field of big data for SOM in recent years, Figure 9 positions the United States as the country with most of the journal articles publications, and Figure 10 illustrates that the area of "business, management, and accounting" accounts for most of the journal article publications (27.7%), followed by "engineering" (21.3%), and "decision sciences" (19.1%).

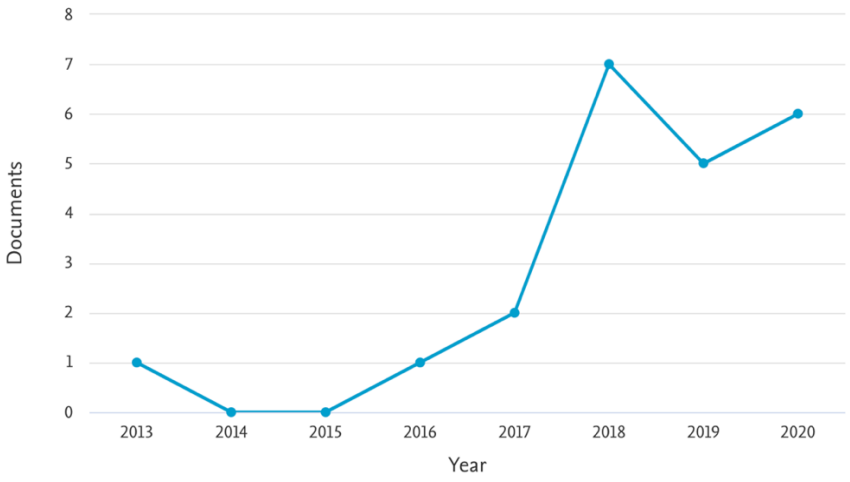

Figure 8. Annual scientific production of studies on big data for SOM. (Source: Scopus 2021).

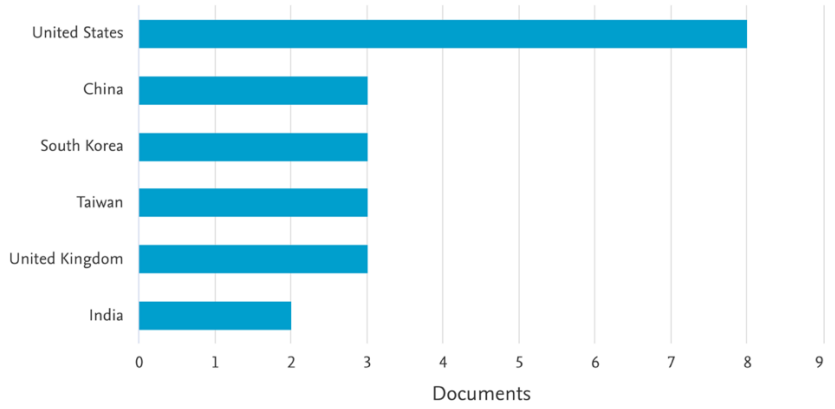

Figure 9. Studies on big data for SOM by country or territory. (Source: Scopus 2021).

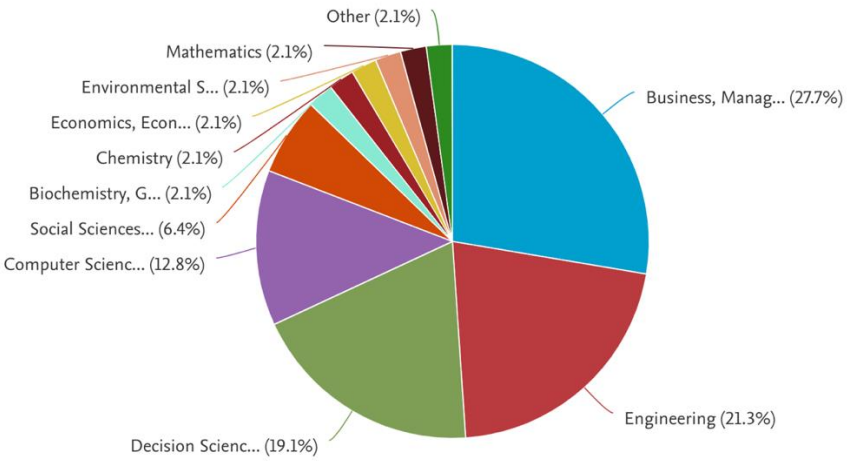

Figure 10. Studies on big data for SOM by subject area. (Source: Scopus 2021).

A brief bibliometric analysis of the 22 journal articles composing the final sample of studies integrating big data with SOM identified a variety of keywords as the most common keywords (whose co-occurrence is at least two times) (Figure 11). These keywords were further classified by the software into four clusters that seem to assume a prominent role vis-à-vis "big data analytics in supply chain management" (four items, red cluster), "information systems and SOM" (three items, blue cluster), "internet of things and smart city" (four items, green cluster), and "computational paradigms" (two items, yellow cluster). Below, we present briefly the pool

of 22 journal articles identified, which are arranged in chronological order, starting from the most recent one.

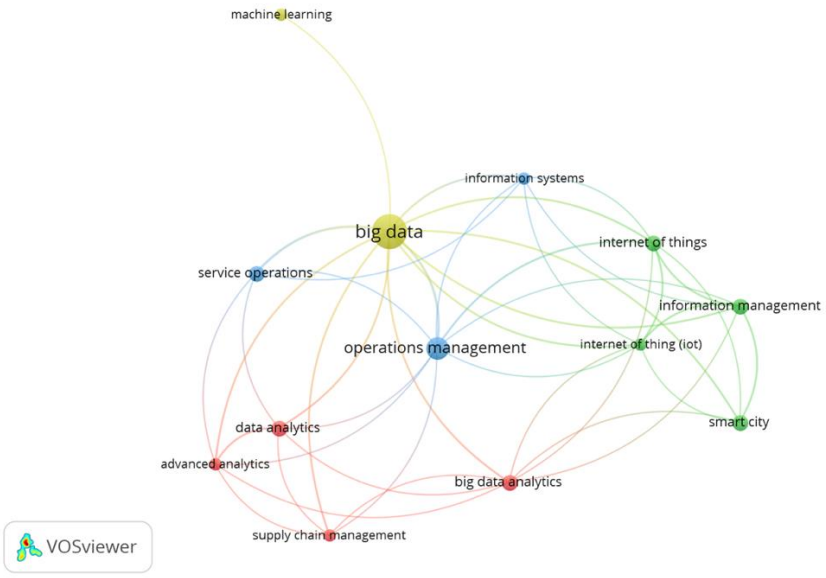

Figure 11. Network map showing the relations between various topics in the journal article literature on big data for SOM (22 documents).

Ruan *et al.* (2020) presented an IoT-based e-business model of intelligent vegetable greenhouses with details of the basic process and key nodes of the e-business model. The authors recognised key operation issues including big-data-driven pricing, planting structure and time optimisation, water and fertilizer integrated control, plant light supplement, and order-driven picking and packing. Kumar, Singh, & Singh (2020) proposed a reliable, more accurate and efficient model based on the statistical analysis of the sensor-based data for occupancy detection. The paper also proposed one online and adaptive model-based online sequential extreme learning machine to perform occupancy detection on real-time data when complete data are not available, and learning is done with recent data points coming in the form of streams. Wang (2020) focused on deployment and optimisation of wireless network node deployment and optimisation in smart cities. In this sense, aiming at problems such as poor network security connectivity, weak node attack resistance, and large storage overhead in the existing key management schemes, the author designed a three-phase key pre-distribution mechanism and direct sharing of the key management scheme based on node group deployment, via an adaptive particle swarm optimisation algorithm. Bag *et al.* (2020) used the dynamic capability theory as a foundation for evaluating the role of big data analytics capability as an operational excellence approach in improving sustainable supply chain performance. The au-

thors surveyed mining executives in South Africa and analysed the data using Partial Least Squares Structural Equation Modelling (PLS-SEM). The paper contributes to identifying two pathways that managers can use to improve sustainable supply chain outcomes in the mining industry, based on big data analytics capabilities. Roth and Rosenzweig (2020) provided an examination of the rise of empirical operations management research in Manufacturing & Service Operations Management. The authors advocated for a tighter integration of analytical and empirical operations management knowledge in order to address the challenges and opportunities of the 21st century. Tamás and Koltai (2020) aimed to review the relevant literature related to the development, improvement and application of learning curves in the age of big data, and to demonstrate the possible insight which its application can provide in manufacturing and service operations decision-making.

Datta and Goyak (2019) presented an efficient method for reliability evaluation of stochastic flow networks that can pass various demands simultaneously from multiple source nodes to multiple destination nodes. March and Scudder (2019) viewed the IoT through the lens of predictive maintenance and analysed optimal preventive maintenance policies in an environment where equipment is subject to a deterioration, which shifts it from its initial, fully-productive state, having a specified, age-dependent failure rate to a less-productive or deteriorated state, having a different, presumably higher, age-dependent failure rate. Lim *et al*. (2019) developed an original, specific framework for a company's use of customer-related data to advance its services and create customer value. Building upon four action research projects, the proposed customer process management framework suggests steps a service provider can take when providing information to its customers to improve their processes and create more value-in-use by using data related to their processes. Albergaria and Chuaopetta Jabbour (2019) aimed to provide an original exploration of the challenges of information and operations management in the sharing economy, by focusing on the classic example of a shared service represented by library operations. The paper addresses the organisational use of big data analytics capabilities, with the main goal of helping organisations make better business decisions, in terms of information and operations management issues. Carnerud and Bäckström (2019) aimed to identify and depict the key areas around which research on quality has centred during the past 37 years and to explore longitudinal patterns in the identified key areas. The study identified seven central topics around which research on quality has centred during the time period analysed: Service Quality & Customer Satisfaction; Process design & Control; ISO Certification & Standards; TQM - Implementation, Performance & Culture; QM - Practices & Performance; Reliability, Costs, Failure & Problems and Excellence - BEMs, Quality Awards & Excellence in Higher Education.

Focusing on the area of after-sales service, Boone *et al.* (2018) developed a framework that seeks to define service parts performance goals for the purpose of outlining where scholars and practitioners can further examine where, how, and why big data applications can be employed to enhance service parts management performance. To objectively evaluate emergency physicians across facilities, Foster *et al*. (2018) leveraged big data from an emergency physician management network and

proposed data-driven metrics using a large-scale database. The proposed indices benchmark physicians from the perspectives of revenue potential, patient volume, patient complexity, and patient experience by controlling for exogenous factors at the facility level. As the authors acknowledge, the proposed framework can also be adapted to non-medical professional settings such as value chains, where employees often provide services in various profit- and cost-centres. Silva *et al*. (2018) proposed a big data analytics-embedded experimental architecture for smart cities. The mentioned architecture facilitates the exploitation of urban big data in planning, designing, and maintaining smart cities, as well as it shows how big data analytics can be used to manage and process voluminous urban big data to enhance the quality of urban services. Cohen (2018) discussed how the tremendous volume of available data collected by firms has been transforming the service industry, with particular focus on services in the sectors of finance/banking, transportation and hospitality, and online platforms (subscription services, online advertising, and online dating). Kuo, Lin, and Lee (2018) applied big data mining and machine learning analysis techniques and used the Waikato Environment for Knowledge Analysis (WEKA) as a tool to discuss the convenience stores energy consumption performance in Taiwan. Shmueli and Yahv (2018) introduced the use of Classification and Regression Trees for automated detection of potential Simpson's paradoxes in data with few or many potential confounding variables, and even with large samples (big data). The authors illustrate the approach via several real applications in e-governance and healthcare. Kim, Lim, and Kim (2018) proposed an approach to analysing and utilizing vehicle operations management (VOM)-related data for designing VOM services. The feasibility and effectiveness of the proposed approach is demonstrated by means of a case study on the design of an eco-driving service.

By adopting an exploratory approach to the secondary research which examines vendors' offerings, Matthias *et al.* (2017) focused on the application and exploitation of big data to create competitive advantage. To this aim, the authors presented a framework of application areas, and how these help the understanding of targeting and scoping specific areas for sustainable improvement. Mehmood *et al.* (2017) aimed to advance knowledge of the transformative potential of big data on city-based transport models. In this sense, the authors developed a Markov-based model with several scenarios to explore a theoretical framework focused on matching the transport demands (of people and freight mobility) with city transport service provision using big data. Li *et al*. (2016) developed and applied a framework to case examples that demonstrate how smart cities are redefining the characteristics of operations models around their scalability, analytical output, and connectivity. The paper contributes to our understanding of how smart cities can potentially transform operational models and sets out a research agenda for operations management in smart cities in the digital economy. Lastly, Huang and Rust (2013) discussed the characteristics of information technology associated with consumer centricity.

4 Conclusions

In this chapter, we have aimed to review the literature on big data for SOM via an exploration of the Scopus database and by means of using the VOSviewer visualisation software for bibliometric analysis in order to highlight the research trends in the field. From a practical perspective, our analysis reveals patterns in scientific outputs and serves as a guide for global research trends in big data for SOM.

Overall, the findings reveal an increased interest in studies in the fields of urban planning and smart city decision management empowered by real-time data processing using IoT, big data analytics, and cloud computing technologies. Other research strands include big data for quality control, electric utilities, information services and information systems. Additionally, there is continued interest in exploring big data analytics to predict and mitigate the effect of supply chain risks and disruptions, which have been shown that can severely disrupt operations and supply chains. As Hazen *et al.* (2014) stated, it is important for organisations to improve the quality of the analytical outputs of their decision-making processes by means of paying attention to the quality of the big data on which they base their decisions.

The review of the studies included in this research has further shown that there is an increased interest towards studying computational paradigms in the field of big data for SOM. Although great progress has been made so far, nonetheless, much more research is needed; in particular, more research is necessary to build big data-driven analytical models which are not only explainable and interpretable (Hansun *et al*., 2020), but also deployable in the Cloud. Furthermore, there is a need for more interdisciplinary research that integrates traditional modes of enquiry in (service) operations management with, for example, behavioural approaches, with a blend of analytical and empirical methods.

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