A landscape of Big data analytics in Supply chain planning: completing the puzzle and vision to the future

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Abstract: Despite the boom of research interest at the intersection of big data and supply chain domain, little research effort has been directed to investigate big data analytics (BDA) for the planning processes of supply chains. This paper aims to draw the landscape of current knowledge regarding the use of BDA in supply chain planning (SCP) and to provide a vision for future research. Based on a systematic literature review of 51 peer-reviewed papers published between 2013 and February 2019, we organized the literature according to the SCP process with the "supply chain planning matrix", and studied the managerial issues related to BDA adoption in SCP. Results highlight that extant literature is dominant by the use of BDA in demand planning and production planning and scheduling, while other planning activities are relatively under-investigated. Most of the studies are restricted to the investigation of BDA in a single planning phase, where the supply chain perspective is weak. Finally, we suggest that empirical studies are in need to bridge academic and practitioner studies on the theme.

Keywords: Big data, Big data analytics, Supply chain planning, Supply chain, Literature review

1. Introduction

Big data has huge potential in improving business performance and create new business value (Brinch, 2018). It is believed to have the revolutionary power in transforming supply chain design and management (Waller and Fawcett, 2013). The concept *big data* can be defined as the high-volume, variety and velocity datasets that exceed the handling capability of traditional data management systems (Addo-Tenkorang and Helo, 2016; Mishra et al., 2018; Tiwari et al., 2018); while *big data analytics* (BDA) refers to the application of advanced analytics to these datasets in extracting trends, meaningful patterns and insights to inform decisions (Arunachalam et al., 2018; Wang et al., 2016).

Significant enthusiasm was demonstrated in the practitioners' community to the application of BDA in the supply chain context. Surveys to top managers highlighted its relevance, value, as well as the potential fields of application (Accenture, 2014; O'Marah et al., 2014). Meanwhile, it is also apparent the flourish of research interest in academy. In the last few years, many high-ranking journals have published special issues and sections to investigate the utilization of big data in the supply chain domain. However, despite the evident commitment, extant literature reviews have mainly tackled BDA application in supply chain management from the generic term, where the planning process was only a collateral finding (e.g. Wang et al., (2016), Tiwari et al., (2018), Nguyen et al., (2018)) regardless of the high importance and applicability of BDA in the planning activities (Brinch et al., 2018). This has led to the lack of an overall picture on how BDA could support supply chain planning (i.e. SCP), in which the primary goal is to match supply and demand, optimizing and preparing the supply chains for upcoming events (Stadtler and Kilger, 2005).

Therefore, this paper aims to provide a systematic review on the state-of-art of BDA applied to SCP processes, synthesizing the scattered contributions and insights to draw the landscape on *how BDA will reshape the processes of supply chain planning*. In particular, two research questions (RQ) were proposed in line with this objective to identify and map the relevant academic publications on BDA in SCP processes and provide an elaborated research agenda for future studies:

- *RQ1: what are the core contributions related to BDA in SCP?*
- *RQ2: what SCP processes are influenced by BDA, and how they are affected?*

The remainder of the paper is as follows. Firstly, section 2 introduces the reference framework, the SCP matrix, which is used for paper classification. Secondly, section 3 explains the review methodology and provide an overview of the selected papers. Then, we presented the findings from the review, and discussed the findings to identify future research directions in section 4 and 5. Finally, the paper is concluded with its contributions and limitations.

2. Supply chain planning matrix

The *supply chain planning matrix* (*SCP matrix*) (Stadtler and Kilger, 2005) is a framework representing the common hierarchical architecture of tasks and activities involved in organizing supply chain decisional processes. Supply chain actors from up- and down-stream interact with each other at the boundary processes. The unique focus of each process is defined according to two dimensions: the *planning horizon* (i.e. long-term, mid-term and short-term) and *supply chain process* (i.e. procurement, production, distribution, and sales). Broadly speaking, the SCP matrix covers the following activities:

- *strategic network design* is performed with a long-term focus, involving hardly reversible decisions (e.g. network structure; capacity and location) that roughly

define the overall cost and value in the supply chain, influencing the consecutive planning processes;

- *master planning* is performed with mid-term focus, connecting the strategic and operational decisions by defining the way to fulfill demand and matching available capacities with demand forecast;
- *production planning and scheduling* define the detailed scheduling and work allocation on machines and personnel, as well as lot sizing;
- at the inbound side, *purchasing and materials requirement planning* define materials required and procurement quantities from suppliers considering the previously defined constraints (e.g. bill-of-material, lead times and production capacity);
- at the outbound side, *distribution planning* decides the material flow between sites in the distribution network, while *transport planning* covers the planning of activities to transfer goods to customers (e.g. warehouse replenishment, route planning) with detailed knowledge on specific needs and orders.
- Finally, *demand planning and demand fulfillment* connect the internal planning with customers by means of sales planning. It often involves historical data on sales, trend and seasonality, product life cycle, and expected exceptional influences. The time spans from long-term strategic sales planning to short-term demand forecasting, going through aggregated to detailed level.

3. Review methodology

In order to answer the research questions, a systematic literature review on relevant publications was conducted aiming to provide rigorous and unbiased insight from the established body of knowledge (Tranfield et al., 2003). Firstly, a written protocol was developed during *the review planning*, specifying the tasks and criteria for each step of the review (Barbosa et al., 2018; Tranfield et al., 2003). Next, the *review conduction* entails the collection of materials based on the list of keywords and selection of materials utilizing the eligibility criteria (Lamba and Singh, 2017).

3.1 Material collection

The material collection started from the identification keywords to search for relevant publications, performed collaboratively by the group of authors. In particular, we did not restrict to papers with the precise use of *supply chain planning* as keyword, since the aim was to capture all relevant contributions on any SCP process. Instead, we consulted the extant review papers on related topics (Lamba and Singh, 2017; Nguyen et al., 2018; Tiwari et al., 2018; Wang et al., 2016) and drew a detailed list of keywords for the supply chain planning process (i.e. *supply chain, network design, demand planning, demand forecasting, sourcing, procurement, purchasing, production, manufacturing, scheduling, logistics, transport, inventory*) . Then, we cross-checked the list with the SCP matrix to ensure coverage on all planning activities in the supply chain, and this process enriched the set with two more keywords (i.e. *master plan*, demand fulfillment*). All the SCP-related keywords were connected by "OR" operator and combined with the keyword *big data* to search for knowledge at the intersection. Additionally, to ensure the queried articles have managerial implications, *management OR planning* was attached to the string.

The search was performed in "title, abstract and keywords" in the Scopus database, due to its broad coverage on literature in science, management and technology (Karaosman et al., 2017), and limited to peer-reviewed articles in English. Conference proceedings and book chapters were excluded to assure the consistency in the quality of input (Arunachalam et al., 2018). Moreover, as our aim was not to focus on the development of technology and specific algorithms (Ardito et al., 2018), only paper from subject area *Engineering; Business, Management and Accounting, Social sciences* and *Decisional sciences* were included. Finally, the starting year was set as 2013 when the seminal editorial linking BDA to the supply chain domain by Waller and Fawcett (2013) was published.

The search was conducted on February 2019, generating a list of 507 articles. Bibliographic information was exported to a database for further selection. Two authors individually checked a sample of the list and confirmed the validity of the aforementioned criteria.

3.2 Material selection

The material selection followed a three-step process inspired by Brinch (2018). Firstly, the papers were screened to check for their research scope based on title, keywords and dissemination outlet. Excluded papers were either out-of-scope in terms of discipline (e.g. urban planning, tourism management) or certain searching elements were absent due to ambiguous use of terminology. Moreover, we removed editorials from the list since their major aim was to motivate future research and summarize the issue (Lamba and Singh, 2017). A shorter list of 167 papers was obtained. Secondly, an abstract and skim-through cut was performed to check the remaining papers for their compliance with the research objective (Ciccullo et al., 2018). Papers were removed if they only employ big data for generic supply chain issues such as sustainable management and value creation. These objectives have little implication on the planning phase of supply chains. We also dropped papers whose discussion on big data was immersed with other technologies (e.g. artificial intelligence, 3D printing), since the impact of big data is not evident. The list was reduced to 101 papers after this step. Finally, a reading cut was performed to ensure the included papers contribute to the research questions, that is, *"what SCP processes are influenced by BDA, and how they are affected?"*. With a detailed reading, we were able to remove articles that mentioned big data only in future research suggestion, and if the application of big data in SCP was not to the aim of aligning supply and demand (e.g. safety and eco-efficiency). The result of this three-step selection process returns a list of 51 papers *(the full list of papers reviewed is available upon request).*

The entire material selection process was performed by two authors in parallel, and any disagreement on inclusion and exclusion were solved by discussion. Our database tracked the entire history of each paper throughout the process, specifying the reason if it is excluded. Further, the selected materials were full-text reviewed and coded according to

three general aspects: BDA-related aspect, SCP-related aspect, and managerial implication. The content analysis process aimed to answer the proposed research questions (Tranfield et al., 2003).

3.3 Descriptive analysis

Significant growth is shown in the research area, from 1 paper in 2014 to 29 papers in 2018, indicating the increasing in relevance and dedication of research effort. Notably, the final list is highly concentrated (i.e. more than 4 papers) in a narrow range of research dissemination (Figure 1) which corresponds to the journals that have published special issues or special sections between 2015 and 2018 on a closely-related theme *(the list of special issues is available upon request)*.

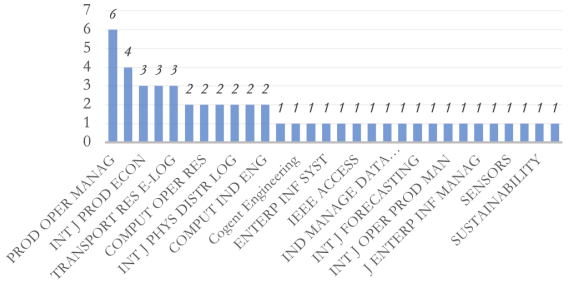

Figure 1: Paper distribution by Journal

4. Big data analytics in supply chain planning

This chapter presents the result of the literature review respectively for two dimensions: *current status of BDA in SCP processes*, which discusses the application of BDA models and algorithms in the SCP process with potential field of applications; and *managing BDA adoption in SCP process*, which discusses the issues related to BDA adoption in supply chains, such as challenges and barriers, capabilities required, as well as the enablers and determinants. *(The detailed classification of paper is available upon request).*

4.1 Current status of BDA in SCP processes

Supply chains are exposed to various types of data that could be potentially useful for various planning phases (Addo-Tenkorang and Helo, 2016). These data include structured data such as transaction records in traditional business applications (Arya et al., 2017); semi-structured data, such as the data recorded by sensors from smart objects (Lee et al., 2018); and unstructured data such as graphical and textual comments on the e-commerce web portal or social media posted by consumers (Hou et al., 2017). Extant literature reviews highlighted the value of big data according to supply chain process with reference to the SCOR model (i.e. plan, source, make, and deliver processes) (Barbosa et al., 2018; Brinch et al., 2018), in which the *time horizon* has not been considered as in the supply chain planning matrix.

The presence of BDA in *demand planning* bridges the manufacturers to their customers, which was once "invisible" in the realm of e-commerce. Better utilizing the user-generated big data helps to understand the final decision of acquisition from the consumers (Boone et al., 2019; Hou et al., 2017; Lau et al., 2018; See-To and Ngai, 2018). Application of sentiment analysis and neural network analysis on customer reviews (Hou et al., 2017; Lau et al., 2018), as well as reviewers characteristics (Hou et al., 2017), can improve the forecast accuracy for e-commerce online product sales (Hou et al., 2017; Lau et al., 2018). Analysis of other customer-generated data such as keywords search can also improve the out-of-sample forecast error for online retailers (Boone et al., 2019). As sales and operation planning (i.e. S&OP) is the input for the entire supply chain planning process, more accurate forecast on sales and demand profile can inform decisions in inventory planning. For example, the fashion industry, being exposed to a demand pattern with high fluctuation, benefits from the use of big data (Ren et al., 2019) since analysis on social media data (Choi, 2018) and point of sales data (Boone et al., 2019) is able to inform inventory decisions in quick response programs. Manufacturers can also apply advanced analytics on query data (Papanagnou and Matthews-Amune, 2018) and clickstream data (Huang and Van Mieghem, 2014) to improve inventory decisions by handling demand volatility. In a more generic term, Hofmann (2017) highlighted that, among all the big data levers (i.e. volume, velocity and variety), the high velocity of big data has the most significant role in improving forecast accuracy, hence, mitigating the bullwhip effect. As for short-term sales planning in *demand fulfillment*, similar aim is evident in improving forecast accuracy. See-To and Ngai (2018) developed a visualization method to improve short-run demand forecasting at the product level based on customer review analysis, while Sagaert et al. (2018) studied the use of macroeconomy data to empower tactical sales prediction.

Regarding *purchasing and material planning*, the value of big data mainly pertains to the issue of supplier selection, where data are available not only from financial statements, as in the traditional methods, but also unstructured data such as newscasts, papers and social media posts are of great interests. The presence of BDA provides opportunities to identify inefficiencies and extract value from the procurement processes (Moretto et al., 2017).

Production planning and scheduling is an area attracting evident research effort to implement BDA. The use of big data can support the planning activities of machine scheduling and shop floor control. Within the industrial setting, sensors- and RFID-equipped smart objects collect mass real-time data from the shop floor and manufacturing processes, that can be used to identify potential bottlenecks (Subramaniyan et al., 2016), predict cycle time (Wang et al., 2018), performing dynamic production scheduling (Sadic et al., 2018) and managing shop floor material flows (Zhong et al., 2015). The application of BDA in this domain is mainly short-term oriented relying on the property of "real-time", to react and re-schedule according to the abnormality in the production systems based on predictive analytics. Comparatively, BDA in production planning is more matured than the other planning processes both in terms of research and adoption, where applicable models and algorithm are already observed in practice in contrast to the other areas that are still explorative in the value and use of big data.

Finally, as for *distribution and transport planning*, BDA may contribute to short-term transport planning, improving process efficiency and transparency for logistics providers through the use of local and network data (Ilie-Zudor et al., 2015). Based on predictive analytics, unstructured data source such as weather and traffic condition can also be used as input in predicting truck arrival time so to support fleet planning (van der Spoel et al., 2017).

However, notably, our sample did not capture any contribution regarding *strategic network design* and *master planning* even if they were explicitly included as keywords in the material collection phase. Besides, some of the planning activities presented in the SCP matrix were also untouched and we will comment in the next chapter.

4.2 Managing BDA adoption in SCP processes

Leveraging on the potential of existing BDA models and algorithms, managerial aspects is the key to reap BDA benefit in SCP process (Aryal et al., 2018). Over the years, researchers have investigated various aspects regarding the adoption of BDA in SCP processes, ranging from the opportunities and challenges for BDA adoption, the enablers and barriers, to the capability required for successful BDA implementation in business.

A wide range of *opportunities* is presented in the application of BDA in SCP processes. Quality of independent and dependent demand planning would be improved with insight gained from final customers (Brinch et al., 2018) and material flow could be synchronized autonomously (Roßmann et al., 2018). Increased granularity in information allows optimized demand and logistics planning with shorter planning cycles (Kache and Seuring, 2017). However, *challenges* exist both at the corporate level and the supply chain level, as the adoption of BDA requires necessary IT capabilities, clearly defined business strategy and system transformation (Kache and Seuring, 2017).

There are factors enable the adoption of BDA in SCP processes (i.e. *enabler*). Perceived benefits of BDA and top management support have the most significant impact on firms intention to adopt BDA (Lai et al., 2018). Financial support, big data skills and organizational change management are also leading drivers to the success of big data initiatives in supply chains (Lamba and Singh, 2018). Richey et al. (2016) highlighted the importance of supply chain system integration, risk and security governance and partner transparency on successful BDA integration. Factors that hinder (i.e. *barrier*) the adoption of BDA in SCP include the change in mindset of the employees (Dutta and Bose, 2015), availability of capable and experienced professionals (Schoenherr and Speier-Pero, 2015), readiness of IT capabilities and clearly defined business strategies (Kache and Seuring, 2017).

As a result, firms need to master the capabilities required both at the organizational level as well as personnel level to successfully manage BDA integration in the current business. At the firm level, capabilities on data generation, integration and management and data-driven culture are the basis to measure BDA capability maturity in the supply chain domain (Arunachalam et al., 2018). As for the personnel level, BDA technical knowledge, BDA technology management knowledge, business knowledge and relational knowledge are equally important to quickly respond to customers and ascertain competitive position in the market (Mandal, 2018).

5. Research gap and future research

Results from the literature review suggested several gaps in the extant body of knowledge in adopting BDA in SCP processes. Suggestions for future research are discussed in the following section and summarized in Table 1.

5.1 Insufficient coverage of BDA in SCP processes

Although literature has already devoted increasing attention to this research area, the impact of BDA has not been explored on many supply chain planning processes, especially regarding the long-term planning activities. Just to name a few, *plant location and production system planning* and *master production scheduling* are prominent aspects where BDA can definitely contribute with valuable insights. The characteristics of big data include not only *variety*, addressing the increasing granularity in data collected, but the information could also be used at the aggregated level to inform strategic decisions.

Therefore, despite the prosperity of research publications and the fact that the value of big data might have been over-hyped from its marketing aspect (Wieland et al., 2016), we believe further investigation is still in need to shed light on the impact of BDA on specific planning processing in supply chains. Future research can be designed to investigate the inclusion of new data sources, or to address situations when traditional demand forecast methods based on historical data are relatively weak, such as the demand for new product introduction.

5.2 Weak supply chain perspective in planning process

Our review captured 51 papers on the intersection of BDA and SCP processes, while most of the studies are restricted to a single planning process for a single organization within the supply chain planning cycle. Although some planning phases have been warmly investigated in literature, such as mid-term sales planning, machine scheduling and shop floor control, few contributions have discussed the implication of BDA integration to multiple processes, and little has been done to approach for solutions with cross-organizational collaboration (Giannakis and Louis, 2016).

We believe further investigation is needed to understand whether the adoption of BDA in planning could bring benefits at the supply chain level, and how supply chain partners should face the challenge for integration and coordination with the presence of big data. Future research can be designed to study the SCP process at the organizational borders, namely collaborative demand planning with customers and collaborative procurement planning with suppliers, to better understand the value of information sharing in the big data era.

5.3 Limited empirical studies and assessment on performance

Empirical studies are in need to quantitatively assess the benefit of BDA adoption in SCP (Choi et al., 2018). Past

research has been mainly explorative in investigating the value of big data in the supply chain domain, shedding light on possible fields of application and potential benefits based on qualitative statements. Instead, limited contributions have quantitatively assessed and proved the value of big data, providing support to the selection of BDA models and techniques for specific settings (Choi et al., 2018). Therefore, empirical studies are in need to connect the research development in academy and practitioners, so as to align the development of BDA and to establish measures for assessing the performance.

Future research can be designed to address this issue by combining theoretical perspectives with the use of real data (Tiwari et al., 2018). We believe the benefit of conducting empirical research is significant, as BDA itself is a practical problem, and academic research on big data has been originally led by interests from practitioners. Linking to the issue of weak supply chain perspective as discussed above, empirical research could provide potential implication on the influence of data sharing among supply chain partners.

5.4 Absence of roadmap towards BDA adoption in SCP

Managing BDA adoption in SCP requires sound consideration on all the factors involved, including enablers (e.g. organizational changes) and necessary technical capabilities as discussed in section 4.2. There is still space to develop further study to support decision-makers in understanding the impact of adopting BDA in SCP on the organizational and physical design of supply chains, and the appropriate paths and roadmap to develop such skills and capabilities. Supply chain agility, flexibility and responsiveness can be empowered by the "velocity" of big data, while frequent *re-planning* and *re-scheduling* require also the adaption of physical structure and process redesign. Moreover, the traditional hierarchical planning approach might also be challenged by the prosperity of data (Feng and Shanthikumar, 2018), changing the logic of SCP to a parallel or concurrent manner in response to the real-time events.

Together with the discussion on current literature gaps, new questions also emerge. One might doubt whether it still make sense to develop thorough and robust long-term plans with the aid of big data analytics following the traditional hierarchical planning logics; or it is more relevant to establish more flexible organizational and supply chain structures in order to quickly respond to early alerts in the supply chains. However, these open debate in the field are expected to trigger further knowledge development.

Table 1 Criticalities and future research

Research gap	Suggestion for future research
Insufficient coverage of BDA in SCP processes	Address research effort to the under-investigated SCP processes.
Weak supply chain perspective in the planning process	Investigate the SCP activities at the boundary of supply chain partners. Investigate the impact of information sharing at the supply chain level.
Limited empirical studies and assessment on performance	Develop performance measures to evaluate the benefit of BDA adoption. Design empirical studies to reinforce the connection between academy and practitioners with real data.
Absence of roadmap towards BDA adoption in SCP	Develop roadmap for BDA adoption in SCP considering all the influencing factors. Investigate the physical change required as complement to the technical skills.

6. Conclusion

In this paper, a systematic literature review was performed on 51 research contributions between 2013 and 2019 (February) regarding the intersection of big data analytics and supply chain planning. The papers were synthesized according to the *supply chain planning process* for its current status of BDA adoption in SCP, discussing the data sources and techniques; and the managerial issues related to the BDA adoption were summarized. The study contributes to the literature, drawing the landscape of the current research development on BDA in SCP, and provides insights and suggestions to complete the puzzle with future studies.

The literature review shows that *demand planning* and *production planning and scheduling* have been the two most investigated areas of application of BDA in supply chain planning, and extant studies are mainly focused on the short-term planning processes. The *velocity* of big data has empowered supply chain planners with real-time structured and unstructured information regarding the status of the planning objects, facilitating the quick response to react to supply chain events; while the *variety* of big data provides more granular information regarding personal choices and history, enabling short-term planning with a greater level of detail and higher accuracy. However, research gaps have been made evident from the review, including the insufficient coverage of BDA in specific SCP process, weak supply chain perspective in the planning activities, and limited empirical studies and methods to assess performance. Suggestions for future research are provided for each of these research gaps, aiming to serve as guidance for future research design.

Finally, the study has potential limitations. We have relied on a single database (i.e. Scopus) for material selection, while a comparison with other databases could help to improve literature coverage. As for keyword selection, we reckon that *big data* could be named in various synonyms, while we restricted to the precise term in seek of accurate target. Emerging issues, such as sustainability and product lifecycle management, were not included in this study as we targeted the regular SCP planning activities in the manufacturing sector, however, it would be interesting for future research to consider these elements to investigate the potential implications on planning.

References

Accenture. (2014), *Big Data Analytics in Supply Chain : Hype or Here to Stay?*, *Accenture Report*.

Addo-Tenkorang, R. and Helo, P.T. (2016), Big data

applications in operations/supply-chain management: A literature review, *Computers and Industrial Engineering*, Elsevier Ltd, Vol. 101, pp. 528–543.

Ardito, L., Scuotto, V., Del Giudice, M. and Petruzzelli, A.M. (2018), A bibliometric analysis of research on Big Data analytics for business and management, *Management Decision*, Vol. In press.

Arunachalam, D., Kumar, N. and Kawalek, J.P. (2018), Understanding big data analytics capabilities in supply chain management: Unravelling the issues, challenges and implications for practice, *Transportation Research Part E: Logistics and Transportation Review*, Elsevier Ltd, Vol. 114, pp. 416–436.

Arya, V., Sharma, P., Singh, A. and De Silva, P.T, M. (2017), An exploratory study on supply chain analytics applied to spare parts supply chain, *Benchmarking: An International Journal*, Vol. 24 No. 6, pp. 1571–1580.

Aryal, A., Liao, Y., Nattuthurai, P. and Li, B. (2018), The emerging big data analytics and IoT in supply chain management : a systematic review, *Supply Chain Management: An International Journal*, Vol. In press.

Barbosa, M.W., Vicente, A. de la C., Ladeira, M.B. and de Oliveira, M.P.V. (2018), Managing supply chain resources with Big Data Analytics: a systematic review, *International Journal of Logistics Research and Applications*, Taylor & Francis, Vol. 21 No. 3, pp. 177–200.

Boone, T., Ganeshan, R., Jain, A. and Sanders, N.R. (2019), Forecasting sales in the supply chain: Consumer analytics in the big data era, *International Journal of Forecasting*, Elsevier B.V., Vol. 35 No. 1, pp. 170–180.

Brinch, M. (2018), Understanding the value of big data in supply chain management and its business processes: Towards a conceptual framework, *International Journal of Operations and Production Management*, Vol. 38 No. 7, pp. 1589–1614.

Brinch, M., Stentoft, J., Jensen, J.K. and Rajkumar, C. (2018), Practitioners understanding of big data and its applications in supply chain management, *The International Journal of Logistics Management*, Vol. 29 No. 2, pp. 555–574.

Choi, T.-M., Wallace, S.W. and Wang, Y. (2018), Big Data Analytics in Operations Management, *Production and Operations Management*, Vol. 27 No. 10, pp. 1868–1883.

Choi, T.M. (2018), Incorporating social media observations and bounded rationality into fashion quick response supply chains in the big data era, *Transportation Research Part E: Logistics and Transportation Review*, Elsevier Ltd, Vol. 114, pp. 386–397.

Ciccullo, F., Pero, M., Caridi, M., Gosling, J. and Purvis, L. (2018), Integrating the environmental and social sustainability pillars into the lean and agile supply chain management paradigms: A literature review and future research directions, *Journal of Cleaner Production*, Elsevier Ltd, Vol. 172, pp. 2336–2350.

Dutta, D. and Bose, I. (2015), Managing a Big Data project : The case of Ramco Cements Limited, *International Journal of Production Economics*, Elsevier, Vol. 165, pp. 293–306.

Feng, Q. and Shanthikumar, J.G. (2018), How Research in Production and Operations Management May Evolve in the Era of Big Data, *Production and Operations Management*, Vol. 27 No. 9, pp. 1670–1684.

Giannakis, M. and Louis, M. (2016), A multi-agent based system with big data processing for enhanced supply chain agility, *Journal of Enterprise Information Management*, Vol. 29 No. 5, pp. 706–727.

Hofmann, E. (2017), Big data and supply chain decisions: the impact of volume, variety and velocity properties on the bullwhip effect, *International Journal of Production Research*, Taylor & Francis, Vol. 55 No. 17, pp. 5108–5126.

Hou, F., Li, B., Chong, A.Y.L., Yannopoulou, N. and Liu, M.J. (2017), Understanding and predicting what influence online product sales? A neural network approach, *Production Planning and Control*, Taylor & Francis, Vol. 28 No. 11–12, pp. 964–975.

Huang, T. and Van Mieghem, J.A. (2014), Clickstream data and inventory management: Model and empirical analysis, *Production and Operations Management*, Vol. 23 No. 3, pp. 333–347.

Ilie-Zudor, E., Ekárt, A., Kemeny, Z., Buckingham, C., Welch, P. and Monostori, L. (2015), Advanced predictive-analysis-based decision support for collaborative logistics networks, *Supply Chain Management*, Vol. 20 No. 4, pp. 369–388.

Kache, F. and Seuring, S. (2017), Challenges and opportunities of digital information at the intersection of Big Data Analytics and supply chain management, *International Journal of Operations & Production Management*, Emerald Group Publishing Limited, Vol. 37 No. 1, pp. 10–36.

Karaosman, H., Morales-Alonso, G. and Brun, A. (2017), From a systematic literature review to a classification framework: Sustainability integration in fashion operations, *Sustainability (Switzerland)*, Vol. 9 No. 1.

Lai, Y., Sun, H. and Ren, J. (2018), Understanding the determinants of big data analytics (BDA) adoption in logistics and supply chain management: An empirical investigation, *The International Journal of Logistics Management*, Vol. 29 No. 2, pp. 676–703.

Lamba, K. and Singh, S.P. (2017), Big data in operations and supply chain management: current trends and future perspectives, *Production Planning and Control*, Taylor & Francis, Vol. 28 No. 11–12, pp. 877–890.

Lamba, K. and Singh, S.P. (2018), Modeling big data enablers for operations and supply chain management, *The International Journal of Logistics Management*, Vol. 29 No. 2, pp. 629–658.

Lau, R.Y.K., Zhang, W. and Xu, W. (2018), Parallel Aspect-Oriented Sentiment Analysis for Sales Forecasting with Big Data, *Production and Operations Management*, Vol. 27 No. 10, pp. 1775–1794.

Lee, J.H., Do Noh, S., Kim, H.J. and Kang, Y.S. (2018), Implementation of cyber-physical production systems for quality prediction and operation control in metal casting, *Sensors (Switzerland)*, Vol. 18 No. 5.

Mandal, S. (2018), An examination of the importance of big data analytics in supply chain agility development: A dynamic capability perspective, *Management Research Review*, Vol. 41 No. 10, pp. 1201–1219.

Mishra, D., Gunasekaran, A., Papadopoulos, T. and Childe, S.J. (2018), Big Data and supply chain management: a review and bibliometric analysis, *Annals of Operations Research*, Springer US, Vol. 270 No. 1–2, pp. 313–336.

Moretto, A., Ronchi, S. and Patrucco, A.S. (2017), Increasing the effectiveness of procurement decisions: The value of big data in the procurement process, *International Journal of RF Technologies: Research and Applications*, Vol. 8 No. 3, pp. 79–103.

Nguyen, T., ZHOU, L., Spiegler, V., Ieromonachou, P. and Lin, Y. (2018), Big data analytics in supply chain management: A state-of-the-art literature review, *Computers and Operations Research*, Elsevier Ltd, Vol. 98, pp. 254–264.

O'Marah, K., John, G., Blake, B. and Manenti, P. (2014), The Chief Supply Chain Officer Report 2014: Pulse of the profession, *SCM World*, No. September, pp. 1–52.

Papanagnou, C.I. and Matthews-Amune, O. (2018), Coping with demand volatility in retail pharmacies with the aid of big data exploration, *Computers and Operations Research*, Elsevier Ltd, Vol. 98, pp. 343–354.

Ren, S., Chan, H.L. and Siqin, T. (2019), Demand forecasting in retail operations for fashionable products: methods, practices, and real case study, *Annals of Operations Research*, Springer US.

Richey, R.G.J., Morgan, T.R., Lindsey-Hall, K. and Adams, F.G. (2016), A global exploration of Big Data in the supply chain, *Internation Journal of Physical Distribution & Logistics Management*, Vol. 46 No. 8, pp. 710–739.

Roßmann, B., Canzaniello, A., von der Gracht, H. and Hartmann, E. (2018), The future and social impact of Big Data Analytics in Supply Chain Management: Results from a Delphi study, *Technological Forecasting and Social Change*, Elsevier, Vol. 130 No. January 2017, pp. 135–149.

Sadic, S., de Sousa, J.P. and Crispim, J.A. (2018), A two-phase MILP approach to integrate order , customer and manufacturer characteristics into Dynamic Manufacturing Network formation and operational planning, *Expert Systems With Applications*, Elsevier Ltd, Vol. 96, pp. 462–478.

Schoenherr, T. and Speier-Pero, C. (2015), Data science, predictive analytics, and big data in supply chain management: Current state and future potential, *Journal of Business Logistics*, Vol. 36 No. 1, pp. 120–132.

See-To, E.W.K. and Ngai, E.W.T. (2018), Customer reviews for demand distribution and sales nowcasting: a big data approach, *Annals of Operations Research*, Springer US, Vol. 270 No. 1–2, pp. 415–431.

van der Spoel, S., Amrit, C. and van Hillegersberg, J. (2017), Predictive analytics for truck arrival time estimation: a field study at a European distribution centre, *International Journal of Production Research*, Taylor & Francis, Vol. 55 No. 17, pp. 5062–5078.

Stadtler, H. and Kilger, C. (2005), *Supply Chain Management and Advanced Planning (3rd Edition)*, *Springer*.

Subramaniyan, M., Skoogh, A., Gopalakrishnan, M., Salomonsson, H., Hanna, A. and Lämkull, D. (2016), An algorithm for data-driven shifting bottleneck detection, *Cogent Engineering*, Cogent, Vol. 3 No. 1, pp. 1–19.

Tiwari, S., Wee, H.M. and Daryanto, Y. (2018), Big data analytics in supply chain management between 2010 and 2016: Insights to industries, *Computers and Industrial Engineering*, Elsevier, Vol. 115 No. October 2017, pp. 319–330.

Tranfield, D., Denyer, D. and Smart, P. (2003), Towards a methodology for developing evidence-informed management knowledge by means of systematic review, *British Journal of Management*, Vol. 14, pp. 207–222.

Waller, M.A. and Fawcett, S.E. (2013), Data science, predictive analytics, and big data: A revolution that will transform supply chain design and management, *Journal of Business Logistics*, Vol. 34 No. 2, pp. 77–84.

Wang, G., Gunasekaran, A., Ngai, E.W.T. and Papadopoulos, T. (2016), Big data analytics in logistics and supply chain management: Certain investigations for research and applications, *International Journal of Production Economics*, Elsevier, Vol. 176, pp. 98–110.

Wang, J., Yang, J., Zhang, J., Wang, X. and Zhang, W.C. (2018), Big data driven cycle time parallel prediction for production planning in wafer manufacturing, *Enterprise Information Systems*, Taylor & Francis, Vol. 12 No. 6, pp. 714–732.

Wieland, A., Handfield, R.B. and Durach, C.F. (2016), Mapping the Landscape of Future Research Themes in Supply Chain Management, *Journal of Business Logistics*, Vol. 37 No. 3, pp. 205–212.

Zhong, R.Y., Huang, G.Q., Lan, S., Dai, Q.Y., Chen, X. and Zhang, T. (2015), A big data approach for logistics trajectory discovery from RFID-enabled production data, *International Journal of Production Economics*, Vol. 165, pp. 260–272.

Appendix A. Classification of the list of full text reviewed paper

Table 2: Classification of literature by SCP process

SCP process	Reference
Strategic network planning	**Physical distribution structure**: - **Plant location and production system**: -
Demand planning	**Product program and strategic sales planning**: - **Mid-term sales planning**: Hou et al., (2017); Lau et al., (2018); Boone et al., (2018); Boone et al., (2019); Ren et al., (2019); Choi (2018); Hofmann (2017); Feng and Shanthikumar (2018)
Demand fulfillment & ATP	**Short-term sales planning**: See-To and Ngai, 2018; Sagaert et al., (2018); Boone et al., (2018)
Master planning	**Master production scheduling**: - **Personnel planning**: -
Production planning and Scheduling	**Lot-sizing, machine scheduling and shop floor control**: Feng and Shanthikumar (2018); Feng et al., (2018); Lee et al., (2018); Wang et al., (2018); Subramaniyan et al., (2016); Babiceanu and Seker (2016); Sadic et al., (2018); Woo et al., (2018); Zhong et al., (2015); Zhong et al., (2017); Zhuang et al., (2018) **Short-term personnel planning**: -
Distribution and transport planning	**Distribution planning**: - **Warehouse replenishment**: - **Transport planning**: Jin and Kim (2018); van der Spoel et al., (2017); Brandau and Tolujevs (2013)
Purchasing & material requirement planning	**Materials program and supplier selection**: Moretto et al., (2017); Ijadi et al., (2018) **Material requirements planning**: -
Other processes	**Inventory planning**: Bertsimas et al., (2016); Huang and Van Mieghem (2014); Papanagnou and Matthews-Amune (2018) **Spare parts demand planning**: Andersson and Jonsson (2018); Zheng and Wu (2017); Arya et al., (2017)
Collaboration and coordination	Giannakis and Louis (2016)
General SC managerial issues	**Performance impact**: Brinch et al., (2018); Roßmann et al., (2018); Richey et al., (2018) **BDA adoption (enabler/barrier, opportunity/challenge)**: Lai et al., (2018); Lamba and Singh (2018); Kache and Seuring (2017); Queiroz and Telles (2018); Schoenherr and Speier-Pero (2015); Dutta and Bose (2015) **BDA capability**: Arunachalam et al., (2018); Yu et al., (2018); Schoenherr and Speier-Pero (2015); Mandal (2018)