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The Architecture of Supply Chain Digitalisation Research

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Abstract

The fourth *Industrial Revolution* is driving the creation of fully connected ecosystem. Organizations are now re-shaping their strategies to become fully transparent, including their supply chain management. The area of supply chain digitalisation is starting to attract growing attention; however, its research status remains unclear. We set out this study to understand what constitutes the underlying structure of its research, what topics have been investigated, what areas need further attention, how the existing literature can be classified, and how the discipline can move forward. We applied a mixed-method approach using both quantitative and qualitative techniques to achieve this. A bibliometric analysis of 331 articles with 12709 references was first conducted to discover the underlying knowledge foundation and evolution of supply chain digitalisation, current attention, and grouping of research into distinct clusters. Further, a qualitative review through content analysis was performed to interrogate our quantitative results. Research implications, and directions for future research are also discussed.

Keywords: Supply Chain Digitalisation, Meta-Analysis, Bibliometric, Content Analysis.

1. Introduction:

The fourth *Industrial Revolution* – also known as *Industry 4.0* – is taking place, and it is driving the creation of fully connected ecosystem within a firm's different functional areas. Organizations are re-shaping their strategies to move toward entirely integrated boundaries and to become fully transparent in their business practices including their supply chain management, which is now one of the determining success factors for organizations (Mentzer et al. 2001). Stemming from digital transformation, the fourth Industrial Revolution would allow firms, when developing supply chain management strategies, to attain flexibility and agility, thereby creating more values (Büyüközkan and Göçer 2018). This end-to-end supply chain connectivity through the era of digitalisation could place firms in the position of competitive advantage where they would be able to meet customer changing needs more efficiently (Khajavi et al. 2015, Porter and Heppelmann 2015). There are major opportunities for supply chain presented by digitalisation that include increased information availability and optimized inter-company logistics, supply chain visibility and transparency through end-to-end real-time information access and control, operations efficiency and maintenance, integration and collaboration, innovation and product design, and efficient inventory management (Kache and Seuring 2017).

Attributed to these qualities, supply chain digitalisation is gaining increasing amount of attention in both practice and research. In practice, it appears more firms are now applying different features of digitalisation such as radio frequency identification, big data, cloud computing, Internet of Things, and artificial intelligence amongst others to create integrated and self-optimizing supply chain systems enabling them to respond proactively to the ever-changing nature of markets (Büyüközkan and Göçer 2018). In research, the area of supply chain digitalisation is starting to attract growing attention with some of the topics such as 'radio

frequency' and recently 'big data' being investigated by some scholars; however, it is somehow unclear how the area of supply chain digitalisation has evolved and progressed in research with research status being unclear. There is a gap in the current literature to understand what constitutes the underlying structure of research in supply chain digitalisation, what topics have been investigated, what areas need further attention, how the existing literature can be classified, and how the discipline can move forward. Thus, this provides a compelling justification to conduct a meta-analytical form of investigation of supply chain digitalisation to understand its intellectual structure and progression. This can provide a somewhat comprehensive view of the extant literature on supply chain digitalisation and act as a reference point for future researchers in their attempt to investigate its different structures and subjects. Further, there seems to be limited attention directed at mixed-method analysis (both quantitative and qualitative) on research conducted within the discipline of supply chain digitalisation in the existing research. To fill the above gaps, this research aims to apply a bibliometric analysis approach to identify and visualize the underlying structure of supply chain digitalisation field of study and complement this bibliometric analysis by undertaking a content analysis of results.

The primary objective of this research, therefore, are as follows. *First*: scrutinizing the underlying knowledge foundation and evolution of supply chain digitalisation through a series of co-citation analyses applying quantitative indicators as well as content analysis of the highly co-cited documents. Other co-citation analyses including author, journal, institution, and country are also undertaken, so both micro and macro analyses of the filed are examined. *Second*: inclusive evaluation of the literature on supply chain digitalisation thereby enabling researchers to trace the shift and detect gaps in the research. This can provide reliable directions for future research. *Third*: assessing present research status to find the current attention of scholars as well as using

quantitative indicators to uncover the possible emerging trends. *Fourth*, grouping research into interrelated but distinct classifications to identify major sub-areas in the field. To achieve these objectives, a bibliometrics analysis software tool known as CiteSpace is used to identify influential studies, research frontiers, understudied areas, and research classification. CiteSpace goes beyond the mere citation counts for those studies conducted in the field and applies techniques such as co-occurrence network analysis of articles, burst detection, and multi-perspective clustering. We will individually discuss these techniques in the methods and results sections. *Finally*, hot articles, topics, and clusters as well as current trends will be content analyzed to add to our understanding of research on supply chain digitalisation.

The remainder of this research is as follows. In the next section, a brief overview of the research on literature reviews of the field as well as explaining the imperative of conducting quantitative literature reviews are discussed. Then, research methods, data collection procedure, and software tool used for analysis are described. This is followed by a discussion of the results and visualizing the discipline using both micro and macro indicators. At the end, the study includes relevant discussions, implications, and directions for future research and limitations.

2. Literature Review

Digitalisation is changing the way companies strategize their supply chain management practices. Technological and digital advancements are paving the way towards more interconnected activities and transparent flow of information amongst organization, its suppliers, and potential customers. This disruptive information effect is promised to deliver unforeseen values to all entities involved in the supply chain (Büyüközkan and Göçer 2018). Digital supply chain has been referred to as an intelligent, customer-centric, system integrated, globally connected and data driven mechanism that leverages new technologies to deliver valuable

products and services that are more accessible and affordable (Bhargava, Ranchal, and Othmane 2013, Büyüközkan and Göçer 2018). Further, numerous benefits have been associated with implementing successful digital supply chain management including: speed, flexibility, global connectivity, intelligence, transparency, scalability, etc. (Hanifan, Sharma, and Newberry 2014, Schrauf and Berttram 2016).

While the field of supply chain digitalisation is still in its infancy, there has been a growing amount of attention to investigate how technologies and IT-enabled advancements can be utilized in supply chain in its transformational route to become fully digitalised. Efforts to address supply chain digitalization are scattered across its different aspects (e.g. big data and cloud computing) and its respective literature appears to be unstructured and indeterminate. Reviewing the existing research on supply chain digitalisation reveals that little attention has been directed at conducting literature review studies, and those attempts have been mostly qualitative and narrative-based in nature with little quantitative evidence (Büyüközkan and Göçer 2018, Hofmann and Rüsch 2017, Wu et al. 2016). Further, some of these literature reviews only focus on a single aspect of supply chain digitalisation such as big data (Nguyen et al. 2017). This provides a sound justification to conduct a thorough literature review study on the subject of supply chain digitalisation. Therefore, we set forth this research to inclusively analyze the published work via a mixed method approach employing both quantitative and qualitative techniques. We explain in the research methods section the reason and imperatives to apply both methods in our research.

3. Research Methods:

Qualitative literature reviews can certainly enrich and advance understanding of a field of study; however, they are vulnerable to researchers' expertise and their subjective judgements and

interpretations. Qualitative literature reviews are limited in analyzing large data and might lack comprehensiveness because of individual researcher's capacity to provide an inclusive evaluation of a discipline under investigation (Shafique 2013, Liu et al. 2015). Quantitative literature review investigation of a discipline, however, can compensate these constraints, as well as providing reliable evidence to support and extend the claims made in those qualitative research, therefore, complement their findings (Ramos-Rodríguez and Ruíz-Navarro 2004, Shafique 2013, Yalcinkaya and Singh 2015). Quantitative literature review investigations can be employed to somehow inclusively evaluate knowledge generation and circulation, assess the extensive and scattered scientific communications, and propose pragmatic future research avenues within a field of study. Quantitative analysis of scholarly communication - commonly referred to as *bibliometrics* – is considered a reliable meta-analytical and scientometric approach that enables researchers to better realize the principal intellectual foundations within a field of study. Thus, we apply a mixed-method approach using both quantitative and qualitative techniques, to stay neutral and comprehensive in our analysis of supply chain digitalisaiton research. First, we conducted a quantitative literature review investigation to avoid our subjective judgement and interpretation; and then we content analyzed the quantitative results for further scrutiny.

3.1 Bibliometric analysis of supply chain digitalisation

Bibliometric is viewed as an authentic scientometric and meta-analytical approach to quantitatively assess the underlying structure of a particular discipline (Shafique 2013), and involves evaluating actions and relationship within a field of study (Narin, Olivastro, and Stevens 1994, Vinkler 2010). Bibliometric is defined as 'the quantitative study of physical published units, or of bibliographic units, or of the surrogates for either' (Broadus 1987, 376).

The underlying knowledge structure of a domain of research as well as its origin and progression status can be visualized and traced using a bibliometric investigation (Börner, Chen, and Boyack 2003, Boyack, Klavans, and Börner 2005). A bibliometric research can unfold the most influential articles and authors, reveal current hot subjects, and classify a discipline into sub-categories – also known as research clusters (Ferreira et al. 2014, Nerur, Rasheed, and Natarajan 2008). As we will show, there are 331 published articles that have cited 12709 references collectively that we use to analyze the supply chain digitalisaiton discipline. Therefore, a quantitative bibliometric study can examine this amount of data, which would be unapprehensive, time-consuming, and overwhelming to analyze with scrutiny otherwise.

Our focus in this research is to assess research on supply chain digitalisation, draw a roadmap of its underlying intellectual structure and knowledge development and transition, and propose strategies for further development. To achieve this, a series of co-citation analyses of documents are performed. Co-citation analysis can reveal how knowledge has been evolved and progressed within a discipline (Small 1973, 1978). The fundamental principle behind co-citation is that when a pair of documents are cited together in subsequent document(s), they are expected to be related (Benckendorff and Zehrer 2013, Leung, Sun, and Bai 2017, Small 1973). A document that is co-cited more often in subsequent documents is believed to have stronger influence within a field of study (Liu et al. 2015).

3.2 Searching tactics and data gathering:

Our main interest in this study is to inclusively assess the published research on supply chain digitalisation by employing logical searching tactics from a reliable source to gather all the relevant data. Data was gathered using Web of Science (WoS), which is one of the most comprehensive sources to retrieve data for scientific activity, impact, and linkage. Both WoS and

SCOPUS are considered pioneering academic databases and considerable overlap exists between both (Jacso 2005). However, WoS covers a wide-ranging number of disciplines, and its records go back to 1900, while some of the records in SCOPUS go back as far as 1996 only. WoS also provides researchers with a broad bibliographical and citation information (Meho and Yang 2007). Therefore, we chose WoS as our source to extract bibliographical information.

We examined existing and pertinent literature review studies to identify a list of keywords to use in our search for published research on supply chain digitalisation. 12 academics with expertise on supply chain digitalisation were requested to review these keywords. After our analysis and feedback received from those academics, we identified 3 primary keywords *Supply*, *Logistics*, and *Operations* to focus on supply chain related studies and joined each one of these primary keywords with one of the secondary keywords to capture digitalisation-related research within supply chain discipline. These secondary keywords, alphabetically, are: *3D (Printing), Additive Manufacturing, Analytic, Analytics, Augment Reality, Augmented Reality, Automation, Big Data, Blockchain, Cloud, Connect, Connectivity, CPS (Cyber-Physical System), Crowdsourcing, Digital, Digital Platforms, Drone, e-supply, HCI (Human Computer Interaction), ICT (Information and Communication Technology), Industrial Internet, Industrie 4.0, Industry 4.0, (Artificial) Intelligence, Intelligent, IoS (Internet of Services), IoT (Internet of Things), Machine Learning, Machine to Machine or M2M Communication, Mass Customization, Mobile, Mobile Computing, Omni, PLM (Product Lifecycle Management), RFID (Radio Frequency), Robotic, SDV (Self-Driving Vehicles), Sensor, Smart, Third Platform, Third Industrial Innovation Wave, UAV (Unmanned Aerial Vehicle),* and *Virtual Reality*. We also limited our search in WoS to certain categories including '*Operations Research and Management Science'*, '*Business'*, '*Management'* and '*Economics'*.

After finalizing our search for these primary and secondary keywords, we collected all the relevant data from WoS (data collection was finalised in March 2018), which includes all the available bibliographical information for each article found. Further, we individually examined the results (this includes reviewing titles, keywords, abstracts, and literature reviews) to ensure the relevance of each article to supply chain digitalisation. We also screened the results to exclude editorials, errata, call for papers, introduction to special issues, book reviews, and conference proceedings to specifically focus on scholarly articles on supply chain digitalisation. These efforts led to finding 331 published articles with collectively 12709 cited references published in 95 different journals since 1984. Figure 1 illustrates the number of articles published each year between 1984 and 2018.

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It might be argued that there might be an influential document contributing to the development and advancement of knowledge in supply chain digitalisation without any bibliographical information in databases or published in an outlet not directly related to the core discipline of supply chain (e.g. *Information Systems Management*). To respond to these concerns, we demonstrate in the results section that there are some references amongst the highly co-cited documents that we did not extract any bibliographical information for (e.g. Manyika et al. 2011). They merely appear in the results because of their influential impact to the development and progression of supply chain digitalisation.

Next step is to analyze the bibliographical data that was extracted from WoS. Advancements in computer science and graphical tools have simplified the process of thoroughly analyzing a knowledge domain. There are several software tools developed in recent years to systematically conduct quantitative literature reviews, and to produce citations, co-citations, and cluster

analyses. In this research, we use a Java-based scientific visualization software package – CiteSpace – to run co-citations and cluster analyses.

3.3. Quantitative mapping

Using a science mapping technique could determine the intellectual structure of a field of study and its evolution and trace its development and progression. Science mapping and bibliometrics mapping is traditionally done using social network analysis tools such as UNICET, Pajek, VoSViewer, etc. However, there are now tools that have been specifically developed for knowledge visualization and analysis, one of which is CiteSpace. It is a combination of data mining algorithms, information visualization methods, and bibliometric tools that can analyze bibliographical data. It is considered as one of the most comprehensive science mapping tools in quantitative literature reviews and meta-analytical examinations (Chen 2006, Cobo et al. 2011). It enables researchers to perform various functions to facilitate appreciation and explanation of intellectual foundations, development, and progression of a field of study (Fang, Yin, and Wu 2017).

Concepts of nodes and links are the backbone of algorithms used in conducting scientometric analysis. Nodes represent a co-cited document (author, journal, institution, country, etc.); whereas links illustrate different relationships of the underlying network. A bigger node shows a higher combined co-citation for that node; while a thicker link between two nodes indicates high co-citation frequency for those two nodes (Chen 2006, Fang, Yin, and Wu 2017). Further, other algorithm functions including betweenness centrality, burst detection, and clustering are undertaken in this research. Betweenness centrality is applied to identify major topics in the development of a discipline. Burst detection is used to identify past and present emerging trends. Clustering is performed to classify co-citation networks into distinct groups (Chen 2014, Chen et

al. 2012, Chen et al. 2010, Feng et al. 2016) . We explain above terms in more details in the results section. After extracting data from WoS, we used CiteSpace 5.2 R2 to run our analysis of quantitative investigation of supply chain digitalisaiton literature. The oldest article we extracted data for published in 1984. So, we chose the analysis coverage to be from 1984 to 2018. Figure 2 illustrates the research flow from keywords identification to analyses and conclusions.

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4. Results:

In this section, we discuss the findings for the quantitative analysis of 331 articles and 12,709 references published on supply chain digitalisation since 1984. Results cover co-citation analyses of articles, journals, and institutions that have influenced the evolution and development of supply chain digitalisation as a discipline of investigation. They also include hot topics, possible future trends and grouping of published research. The intellectual interrelationship among scholars and their articles is analyzed using co-citation analyses (Liu et al. 2015). These analyses are conducted to unveil both micro and macro structure of the supply chain digitalisaiton field of study (Liu et al. 2015). Article co-citation analysis reveals the most influential articles, which shows those documents having the most influence within this field, and identifies the current topics and signals possible future trends through burst detection analysis (Chen et al. 2012).

4.1 Document co-citation analysis

Document co-citation analysis helps uncovering the link amongst the co-cited references and understanding of the underlying knowledge structure of a field of study. Significant and breakthrough research that has contributed to advance a field of study are identified through co-citation frequencies. The higher number of co-citation frequency for a given document signals its prominent role in developing and enriching the discipline (Small 1973, 1980, 2003). The

document co-cited network in supply chain digitalisation covered 331 published articles and includes 463 nodes (cited reference) and 6699 links. Co-citation analysis for each node shows a single cited article (author, journal, etc.). The size of the node demonstrates the cumulative co-citation occurrence for a given document, while the thickness of the link between two given documents shows the frequency in which these two documents have been cited together (Chen 2006, Chen et al. 2012). Figure 3 visualizes the findings for document co-citation analysis.

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Results indicate that the document with the highest number of co-citation frequency is authored Lee and Özer (2007) published in the *Production and Operations Management*, and titled 'Unlocking the Value of RFID', which has been co-cited 24 times. Focusing on RFID concept in supply chain, authors of this article argue that there is a credibility gap of the value of RFID in which most claims on the benefits of RFID remain unsubstantiated. While being a disruptive technology, they believe, RFID yet to achieve its full potentials. The second one (20 co-citation count) is authored by Ngai et al. (2008a) published in the *International Journal of Production Economics*, and titled 'RFID Research: An Academic Literature Review (1995–2005) and Future Research Directions'. This research focused on analysing 85 academic journal papers on RFID published between 1995 and 2005 to provide a snapshot of the composition of the RFID research. Authors classified RFID research into 4 categories including: technological issues, applications areas, policy and security issues, and other issues. A document authored by Sarac, Absi, and Dauzère-Pérès (2010) published in the *International Journal of Production Economics*, is tied at 20 co-citation and titled 'A Literature Review on the Impact of RFID Technologies on Supply Chain Management'. This research also focused on reviewing the literature on RFID with emphasis on the impact of RFID technologies on supply chain. Authors

argued that there are some technical and economic obstacles limiting the use of RFID technologies to improve supply chain. The fourth highly co-cited document is by Chen and Paulraj (2004) with 17 co-citation count published in the *Journal of Operations Management* and titled 'Towards a Theory of Supply Chain Management: The Constructs and Measurements'. To fill the gap of a systematic development of supply chain management instruments, authors analyzed 400 articles related to supply chain management to provide a set of reliable measurements in order to contribute toward theory building in supply chain management. The fifth is authored by Rekik, Sahin, and Dallery (2008) with 16 co-citation frequency published in the *International Journal of Production Economics*, and titled 'Analysis of the impact of the RFID technology on reducing product misplacement errors at retail stores'. Focusing on retail stores, this research addressed the inventory inaccuracies and argued that misplacement type errors could be eliminated using RFID technology. Table 2 shows the top 20 highly co-cited documents along with their specific focus. It is worth mentioning that while there are topical papers amongst the highly co-cited documents, both theoretical and methodological evolutions are also amongst these findings.

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4.2 Burst detection:

There is another algorithm known as 'burst detection' is built in CiteSpace that measures and detects sharp increases in citation a document receives in a period of time (Kleinberg 2003). Burst detection analysis assists in identifying past trends, current hot topics, and possible future research direction (Chen 2006, 2014, Feng et al. 2015). This analysis can also be used to identify the research that has influenced the development of a field of study. How the further advancement of a discipline is being formed can be understood through burst detection analysis,

which could specify knowledge frontiers and orientations in a discipline. Most active areas of research are also recognized through burst detection analysis (Chen 2006). Our analysis of supply chain digitalisation area for detecting burst documents uncovered 11 documents with past or current sharp increase in their co-citation lives. Table 2 presents results for burst detection analysis along with burst start and finish year for a given document as well as individual document's burst strength. Document with high burst strength suggest their more influential role in developing the knowledge structure in a discipline, while documents with current citation eruption indicate current research frontiers and hot topics.

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Burst analysis results suggest that research on supply chain digitalisation has started with an increasing attention to understand how RFID technology can improve supply chain mechanism. The scholarly focus, however, seems to be directing at exploring and investigating how data science can improve supply chain management efficiency.

4.3 Cluster analysis

One of the ultimate goals to undertake quantitative literature reviews is to distinctly group and map the major structural knowledge in a research discipline into sub-areas, or what is commonly referred to as clustering. A multi-perspective approach has been developed within CiteSpace applying structural, temporal, and semantic patterns while using both *citing* and *cited* references to explicate co-citation clusters. Specifically, a hard-clustering approach is employed that uses non-overlapping clusters, with the application of spectral clustering algorithm. Five different indicators are used to form clusters in CiteSpace: *betweenness centrality*, *modularity Q*, *silhouette*, *burst*, and *sigma (∑)*. Further, three different algorithms are applied to label clusters: *term frequency-inverse document frequency* (tf*idf), *log-likelihood ratio* (LLR) tests, and *mutual*

information (MI) (Dunning 1993, Salton, Wong, and Yang 1975).

Cluster analysis in CiteSpace resulted in attaining 6 major clusters with modularity Q of 0.6, which indicates independent clusters with well-structured connections amongst them. The value obtained for mean silhouette is 0.6, which shows the homogeneity of the identified clusters. Figure 3 shows the results of cluster analysis using articles' abstracts. As abstract for an article tends to provide more thorough information on the objectives, methods, and findings, than its title and/or keywords, we decided to analyze all abstracts for 331 records. To label clusters, we used all 3 labelling algorithms (*tf*idf, LLR, and MI*) available in CiteSpace, while going back and forth in citing and cited references for each cluster. Citing articles are those that cite a member or members of a given cluster; while cited references are members of each cluster. Table 4 presents the clusters from largest to smallest based on the number of members for each cluster (cited references). Top contributing members – cited references – for a cluster are provided, as well as top citing articles with the highest number for the portion of the references cited by these articles.

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The first sub-area of research that emerged is of research addressing RFID in supply chain, which is the largest cluster with the highest number of members attracting most of research. The second cluster includes studies focusing on supply chain agility, which is also one of the research frontiers sub-areas in supply chain digitalisation discipline. The third cluster includes studies using big data in supply chain, and also on the edge of current research. The fourth sub-area, and one of the two most current research trends, includes studies addressing the phenomenon of digital manufacturing and its influence on supply chain. The other most current research trend is cluster five, in which research is targeting the concept of Internet of Things in supply chain. The

last cluster involves research on cloud technologies in supply chain, which also is the least attended sub-area of supply chain digitalisation. Cluster analysis results suggest that 2 of the clusters – *RFID* and *cloud* – seem to be inactive receiving little attention in recent research, while the other 4 are considered current research trends taking place at the edge of the scholarly knowledge development.

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4.4 Author co-citation network

The analysis of author co-citation assists in identifying the networks of invisible college (White and Griffith 1981). It determines prominent authors who have played a critical role to shape the intellectual structure of a discipline and its evolution and development in terms of the associations amongst these authors (Nerur et al. 2008, McCain 1990) . Table 4 and Figure 5 show the most influential authors in the area of supply chain digitalisation research.

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As shown *Lee L. Hau*, *Ngai EWT*, *Angappa Gunasekaran*, *Samuel Fosso Wamba*, and *Martin Christopher* are the top 5 researchers who have been co-cited most frequently in supply chain digitalisation research.

4.5 Journal co-citation network

Journals are considered as one of the major channels for scholarly communication (Tsay, Xu, and Wu 2003). Journal co-citation is a useful tool to unveil the macro structure of a discipline, and identify scholarly outlets that have contributed the most to its intellectual formation and development (Liu et al. 2015). Figure 6 illustrates the journal co-citation analysis.

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Table 5 shows the top 20 contributors to the macro structure of the supply chain digitalisation area of research.

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4.6 Country and institution co-citation network

We also examined co-citation analysis for country and institution to identify the top influential countries and institutions that have contributed significantly to the development and evolution of supply chain digitalisation research. Results specify that USA (102), China (58), and England (42) are the top 3 co-cited countries. This suggests that researchers from US, China, and UK are most co-cited researchers in supply chain digitalisaiton. while Hong Kong Polytechnic University, University of Nottingham, and University of Hong Kong emerged as the top co-cited institutions.

4.7 Qualitative analysis of quantitative findings

Using 331 articles with 12709 references, we undertook several quantitative analyses to reveal significant studies, research frontiers, unattended areas, and research organization. To interrogate and complement these results, we carry out a qualitative examination of our findings, which we discuss in the subsequent sections.

4.7.1 Knowledge foundation and evolution

In Table 1 the top 20 co-cited documents are recorded. A close inspection of the 20 titles of these articles reveals that they could be largely themed around 5 distinct yet interrelated categories, from largest to smallest as follows, RFID (9), Big data (5), supply chain performance (2), theory (2) and method (2). At first glance, the theoretical domain appears to be restricted to

resource-based view and the theory of supply chain management. This suggests that there has been little if any theoretical evolution in this domain given that the earliest article by Chen and Paulraj is dated 2004. This is also reflected in the small number of conceptual papers in the top 20. The results also demonstrate the influence of data in supply chain management with 15 out of 20 articles mentioning data or a data related term (RFID, Big data, information) in the title. The earliest article by Kärkkäinen (2003) is empirical and investigates the efficiency gains of employing RFID in the supply chain for short shelve life goods. Data-driven studies gradually transited from a focus on RFID to Big Data, this is apparent by the fact that the most recent articles contain Big Data in their title, the most current being a systematic review by Wamba et al. (2015). The general trend thus suggests resource base-view as the key theoretical paradigm underpinning research in this field. Consistent with this view, the most critical resource appears to be data with the focus evolving from RFID to Big data. From the methodological perspective, results indicate the dominance of survey research.

4.7.2 Current and emerging trends

In Table 2, the results of the burst detection analysis are displayed. At a glance the results indicate a similar trend to that observed with the co-citation analysis, however, at a more fine-grained level, the burst detection permits some precision to be added. As previously observed, the most influential works examine the role of data in the supply chain in the form of RFID and Big data. RFID related works are the early pace-setters dominating the knowledge domain from 2008 to 2015. The influence of this stream of literature peaked between 2009 and 2014, the results show 4 articles each achieving a burst strength greater than 4 for this period. The influence of RFDI begins to drop in 2015, the results indicate that from 2015 until the present the most dominant research works have Big data as their focus with 3 articles achieving a burst

strength in excess of 4, the highest being 4.9 registered by the work of McAfee et al. (2012). At around the same time RFID was ceding its dominance over to Big Data, the knowledge field welcomed the emergence of resource-based view as a key player. According to the results Barney's (1991) seminal paper remained relevant up until 2016. At an average time for the initial burst from the year of publication of 2.2 years, RFID related studies impacted on the development of the field faster than Big Data related work with an average time to burst of 3 years. In general, however, the low averages indicate that the most influential work, those boasting high burst strengths, tend to make an impact relatively early in their co-citation lives the earliest being Wamba et al. (2008) and Bottani and Rizzi (2008) each having a major influence 1 year following publication and the latest being the articles by Kärkkäinen (2003) making an impact 5 years after publication. Barney's work is the exception contributing significantly to the field some 23 years after it was first published. This comes as no surprise though given that the supply chain digitalisation knowledge domain is still relatively nascent in its evolutionary track. Looking forward and extrapolating the current trend, not to mention advances in data science, it appears that Big Data and related technologies will continue to exert a major influence on how the field evolves, and as long as this is the case, RBV will remain the more likely theoretical companion.

4.7.3 Classifications and sub-areas

Cluster analysis is based on the analysis of the actual articles and has revealed five dominant clusters; RFID, Supply chain agility and Performance, Big data and Cloud Computing, Digital Manufacturing and 3DP, and Internet of Things and Omni Channel. According to the results of the cluster analysis, the knowledge domain of supply chain digitalisation is being influenced by 4 sub-areas namely: data science, supply chain agility and performance, digital manufacturing and

3DP, and internet of things and omni channel. RFID and big data and cloud computing clusters have significant overlap and can be combined into a single sub-area as data science. To complement the quantitative analysis, we conducted a full contents analysis of each of the articles that feature in each of those clusters. We content-analyzed the cited references as well as the citing references. In Appendix 1 characteristics of these scholarly works are presented and these include Aims/Objectives/Research Questions, method and underpinning theory. Further, drawing on the RBV as the main theoretical underpinning of digitalized supply chain, the clusters can be reorganized and grouped under higher level classifications as follows: digital supply chain strategy, resources, capabilities and performance.

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The dominant supply chain strategies being studied are digital manufacturing and omni channel. Resources are the building blocks for the implementation of strategies, the findings in this context is consistent with the premise of RBV particularly highlighting 3DP as the most relevant resource in the study of digital manufacturing. On the other hand, internet of things appears to be the most important resource associated with an omni-channel strategy. Big data, RFID and cloud computing are all variously influential technological resources in the implementation of the aforementioned strategies. The clusters related to these resources are more common given that not only are they integral to digital manufacturing and omni-channel, they are also key inputs in the make-up of different supply chain capabilities. Indeed, the cluster analysis reveals supply chain agility and performance as the second most popular sub-area of research. Supply chain agility is associated with an organisation's capability to respond to unexpected market changes and convert these changes to business opportunities (Swafford, Ghosh, and Murthy 2008). The growing emphasis on the need for supply chain agility to sustain

competitive advantage (Ngai, Chau, and Chan 2011) has been acknowledged; it is thus hardly surprising that performance, although unpacked here, should be mentioned alongside agility as one of the most dominant clusters.

5. Discussions and Future Research

This research was set out to fill the existing gap of limited literature reviews on supply chain digitalisaiton discipline. To achieve this, three primary objectives were put forth: 1) exploring the anatomy of supply chain digitalisation knowledge through a series of co-citation analyses applying quantitative indicators as well as content analysis to uncover its evolution and development; 2) examining research disposition on supply chain digitalisation to understand the current scholarly attention and unveil possible emerging trends; 3) identifying major research groups within supply chain digitalisation.

To address the first objective, highly co-cited references were identified to trace the knowledge development, evolution and progression. The results were, then, content-analyzed to further scrutinize the intellectual foundation and advancement of the supply chain digitalisation research. The highly co-cited references indicate the origin of scholarly research in supply chain digitalization (i.e. RFID) and its progression (i.e. big data). Results also specified topical, theoretical and methodological contributions that have influenced the research formation and growth. Second objective was set forth to identify research trends and frontiers using burst detection analysis and further content analysis of those references identified with an eruption in their citation life. Both quantitative and qualitative analyses confirmed that RFID has received a considerable attention from academic communities while the direction appears to be shifting towards data science and big data analytics with resource-based view becoming the fundamental theory used in the research stream going forward. The last objective was to group research into

major areas. Our investigations demonstrate that data science, supply chain agility and performance, digital manufacturing and 3DP, and Internet of Things and omni channel are the main research segments.

We combine our findings from our detailed analyses in arriving at a tentative future research agenda featuring five paths. These paths include: data science-enabled supply chain management, supply chain agility, humanizing manufacturing through digital manufacturing strategy, omni channel, and resource-based view and beyond

5.1 Data science-enabled supply chain management

Research involving the intersection of data science and supply chain management is *en vogue*. The results of all the quantitative analyses speak with one voice in attesting to this trend. Close examination of the articles that constitute this cluster reveals a mixed bag of methodological approaches although systematic reviews represent the lion share. In the main, irrespective of methodological preferences, key authors investigating the data science phenomenon in the context of supply chains are doing so with supply chain optimization as the main motivation. For example, Opresnik and Taisch (2015) found that through the implementation of an appropriate Big Data strategy in servitization manufacturers can differentiate themselves from the ones that are already servitizing. Arya et al. (2017) findings echo those of Osprenik and Taisch in that the application of Big Data analytics was found to provide greater inventory and supply visibility in the spare parts supply chain of the army.

By employing a longitudinal case study Wamba et al. (2015) showed that not only can Big Data be leveraged for commercial gains, but it can allow a real-time access and sharing of information across local and national government agencies for improved decision making to enhance emergency service response. Although Hazen et al. (2014) are primarily concerned with

data quality they are keen to stress that the lack thereof can plague supply chain firms that rely upon Big Data to drive growth and innovation. In essence, the most influential research presently being undertaken falls in line with the resource-based view perspective focussing on the value-added potential of Big Data. Notable omissions however are the contextual enablers, both inside and outside of the firm. Hazen et al. (2014) have recognised data quality as one such enabling factor.

Our train of thought as it concerns a future research agenda around the theme of data science-enabled supply chain is however less technological in nature but rather more social. Arya et al. (2017) have recognised the large deficiency of staff and skills that can handle Big Data Analytics (BDA) in the context of the army. Our sense is that this is a widespread concern across all sectors and perhaps one of the main barriers in the adoption of data science in supply chains. More research is undoubtedly needed to further our understanding of how data science is changing the work place and specifically the prerequisite human resources requirements needed to efficiently implement a relevant strategy in supply chains.

5.2 Supply chain agility

Supply chain agility as a sub research area is the second most influential only to the data science stream of research. The findings of our detailed analysis are somewhat interesting. As shown in Appendix 1, the cited articles are mostly conceptual papers with the exception of I. van Hoek, Harrison, and Christopher (2001). In this work the authors attempt to formulate and test an agile supply chain framework, first by reviewing the literature followed by a survey for the purpose of validation. It is not the fact that all the other papers in this cluster address the conceptual development of dynamic capabilities seen by many as the theoretical underpinning of agility that makes this cluster unique. It is the absence of any work that edges supply chain

agility research towards the digital era that is surprising. Given the current and future trends that bestow data science a preeminent role in supply chain management affairs, supply chain practitioners and researchers alike stand to benefit from an agenda that gives priority to illuminating the role data science play in developing supply chain agility. In particular, this research agenda should seek to uncover the nature of the facilitators as well as inhibitors of future data science-enabled supply chain agility whilst also seeking to examine how and when this leads to enhanced supply chain performance.

5.3 Humanizing manufacturing through digital manufacturing strategy

Digital manufacturing, at least in the form of additive manufacturing, promises to revolutionize the way manufacturing activities are organized moving away from an impersonal and concentrated view of production associated with multinational conglomerates to one which nurtures production democratization, espouses the promise of tailored products with low cost and short delivery time (Zanetti et al. 2015) as well as being sensitive to local preferences. Digital manufacturing and 3DP has emerged as one of the most influential body of work in the context of supply chain digitalisation with most of the references in our results focusing on additive manufacturing. Hence, we restrict our contribution on future work, that is, to additive manufacturing.

Scrutinizing our findings, it appears that most articles in this research path, so far, are literature reviews, following a similar trend to other clusters. It is useful here to consider the citing and cited references as two distinct groups. The cited references tend to be earlier studies, empirical in nature and preoccupied with the optimization potential of additive manufacturing. For instance, Holmstrom and Partanen (2014) show that the introduction of digital manufacturing in the service supply chain of the F-18 Super Hornet facilitated an improved

redesign of the F-18 environmental control system. Thus, the authors conclude that digital manufacturing has the potential to decrease supply chain complexity by offering simpler and more effective solutions which in turn are beneficial to performance and costs savings. In addition to performance benefits Wagner and Walton (2016) also found that additive manufacturing technologies produce less waste compared to conventional manufacturing processes.

Moreover, the article by Durach, Kurpjuweit, and Wagner (2017) is empirical and draws on experts from industry and academia to interrogate, amongst others, the expected impacts of additive technologies on the supply chain in the manufacturing industry. Rather than focussing exclusively on the manufacturing process Durach and his colleagues provide a more holistic perspective. The findings in this work are indeed closer to the democratizing aspirations of digital manufacturing built on a view of the future where individuals and indeed local actors play a more active role in production activities. While large scale home fabrication is not envisaged the findings point to a near future scenario in which additive manufacturing changes supply chains in such a way that business models begin to integrate customers in decentralized, local manufacturing. This paradigm shift indeed will help to showcase a more democratized side of manufacturing where integration includes both suppliers and consumers. Yet there is relatively little if any understanding of the support structure required to achieve this. There is thus an urgent need for research into the business and operations models supportive of decentralized manufacturing. In particular, future research should pay attention to the *a priori* local enablement and institutional and regulatory changes needed to support the establishment, evolution and sustainability of local production systems.

5.4 Omni channel

The corpus of the Internet of Things and omni-channel research path have largely been concerned with omni-channel, with minor focuse on RFID and the technology and value added of IoT in supply chains. Thus, based on these observations it is our contention that the omni-channel represents the most influential body of work in this research avenue. Uniting around their motivation to showcase the importance of e-commerce in supply chains the articles in this research path employ varied methodological approaches. Hubner, Wollenburg, and Holzapfel (2016) employ an exploratory survey to investigate how retailers develop from separate multi-channel (MC) to integrated omni-channel (OC) fulfilment. Peinkofer et al. (2015) used 4 experiments to explain the effect of price promotions on consumer expectations of product availability and their reactions to stockouts in an online retail environment. The literature review presented by Kozlenkova et al. (2015) focus on the intersection between supply chain management and marketing. The findings of this work illuminate the growing importance of omni-channel as the optimal distribution strategy for competing in the digital era. Notwithstanding, the authors recognise a serious lack of research directed at omni-channel noting that existing research tends to examine only one channel of distribution or an addition of an online channel.

By definition omni-channel commerce allows firms to sell goods or provide services to customers through as many channels as possible (Lee 2017). The diversification of channels whilst diversifies data sources also rapidly generates an enormous amount of data; these are in fact characteristics of data science. It is thus surprising that the most influential works fail to acknowledge the potential centrality of data science in delivering an omni-channel strategy. In light of these findings, the dearth of empirical work and supplemented by the trend suggesting the growing importance of data science in supply chain we believe make a strong case for future

research in this research route to more closely examine the dynamics of data science in omni-channels.

5.5 Resource-based view and beyond

As noted by Van de Ven (2007), nothing is as practical as good theory. Theory provides a way to 'make sense of what would otherwise be inscrutable or unmeaning empirical findings' (Gaile, Clarke, and Huff 2009, 286). According to Melnyk, Flynn, and Awaysheh (2018) it is that which makes a field like operations and supply chain management a science, rather than a set of practices or an art, providing a roadmap for investigating the research problem, elucidating relevant constructs and expected relationships between them, and avoiding extraneous constructs and relationships. As can be observed in Appendix 1 the most dominant theory underpinning empirical work is the resource-based view it is therefore not surprising that the empirical works tend to focus on optimization of the supply chain by leveraging technological resources be it Big Data or 3DP. Transaction cost economics and contingency theory have been touted by Waller and Fawcett (2013) as theoretical perspective besides RBV that could be usefully employed to illuminate the dynamics of data science in supply chains. We feel that the notion of absorptive capacity can be grafted in to complement any one of those theory. We see this as a fruitful agenda given that these technological resources or innovation often resides the focal supply chain. The notion of absorptive capacity concerns how organisations acquire new knowledge and leverage it to generate strategic gains (Cohen and Levinthal 1990). In this sense we propose that future research works focus on the 4 key knowledge domains of absorptive capacity as follows

(1) Acquisition – how new digital resources are obtained;
(2) Assimilation – how these new resources are incorporated into existing practices and processes;

(3) Transformation – how these digital resources are used to develop new processes and routines, and

(4) Exploitation – how these digital resources are used to increase commercialisation.

6. Limitations

There are a few limitations to this research. *First*, there is always a lag time between when an article is accepted, when it is published, and when it will be cited or co-cited in another article. This might result in a bias toward articles published earlier, as the impact of recently published work can only be identified over time. *Second*, all the articles examined in this research were published in English. Inclusion of non-English articles could result in somewhat modified findings. *Third*, it is often observed that academic researchers are inclined to refer to high quality or ranked journals and/or cite well-known scholars more. *Fourth*, online versions and in press articles do not appear in WoS search result. *Finally*, we only analyzed the author co-citation network. Research can tap into how the author and collegial network and their affiliations is dispersed in academic communities. This could help understanding the social and collegial structure behind the intellectual development of this field.

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Figures:

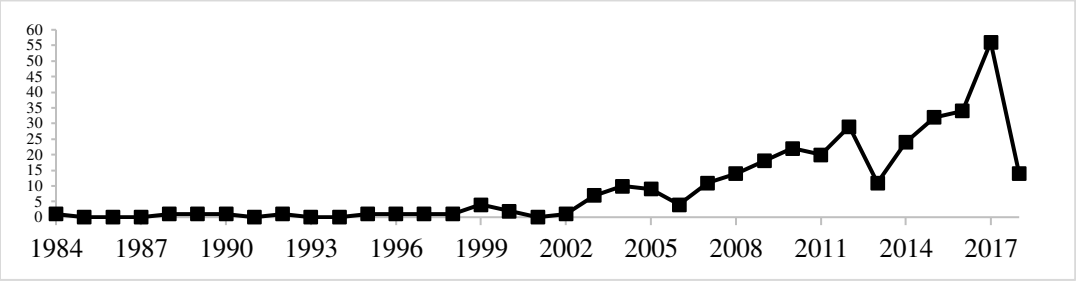

Figure 1: Number of supply chain digitalisation articles between 1984 and 2018

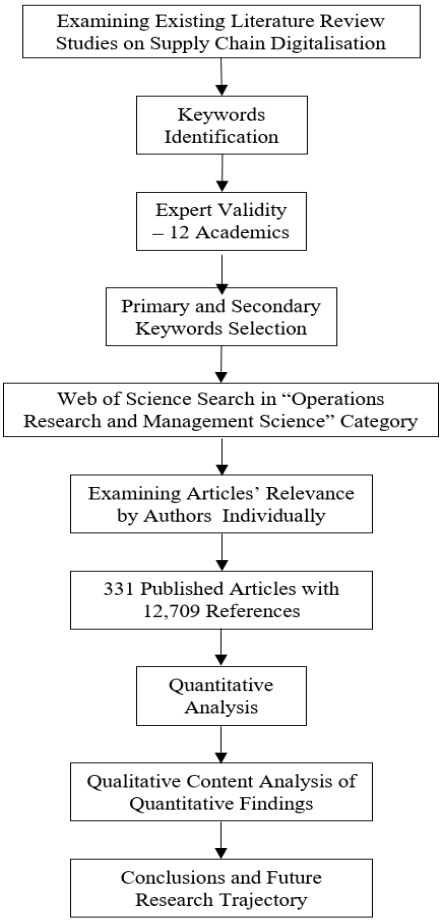

Figure 2: Research and data collection flow

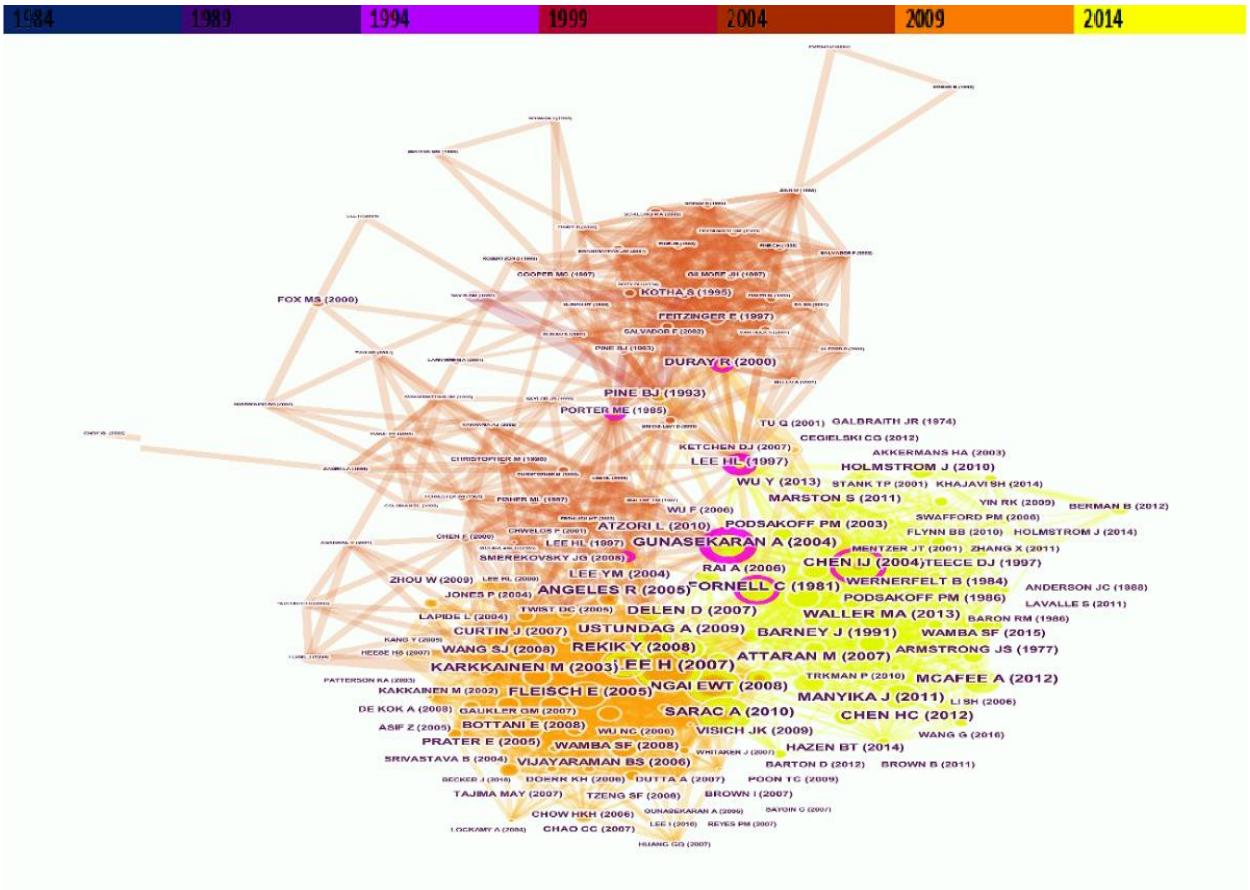

Figure 3: Document co-citation in supply chain digitalisation *(colors represent the year of citation or connection).*

Note: For instance, orange color denotes those articles published or connected between 2009 and 2013. Color figure can be viewed online).

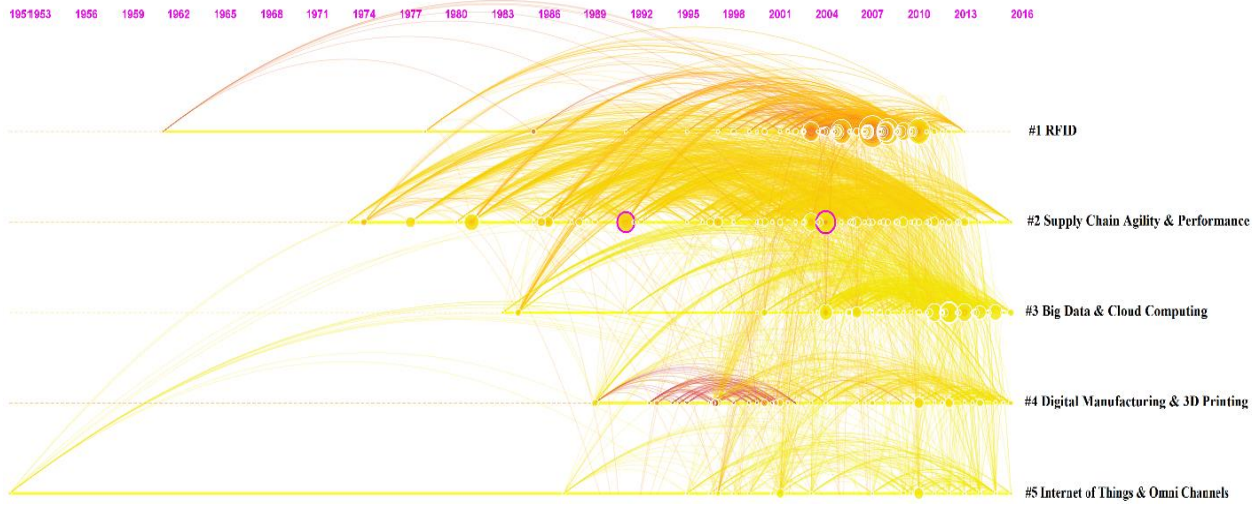

Figure 4: Cluster analysis

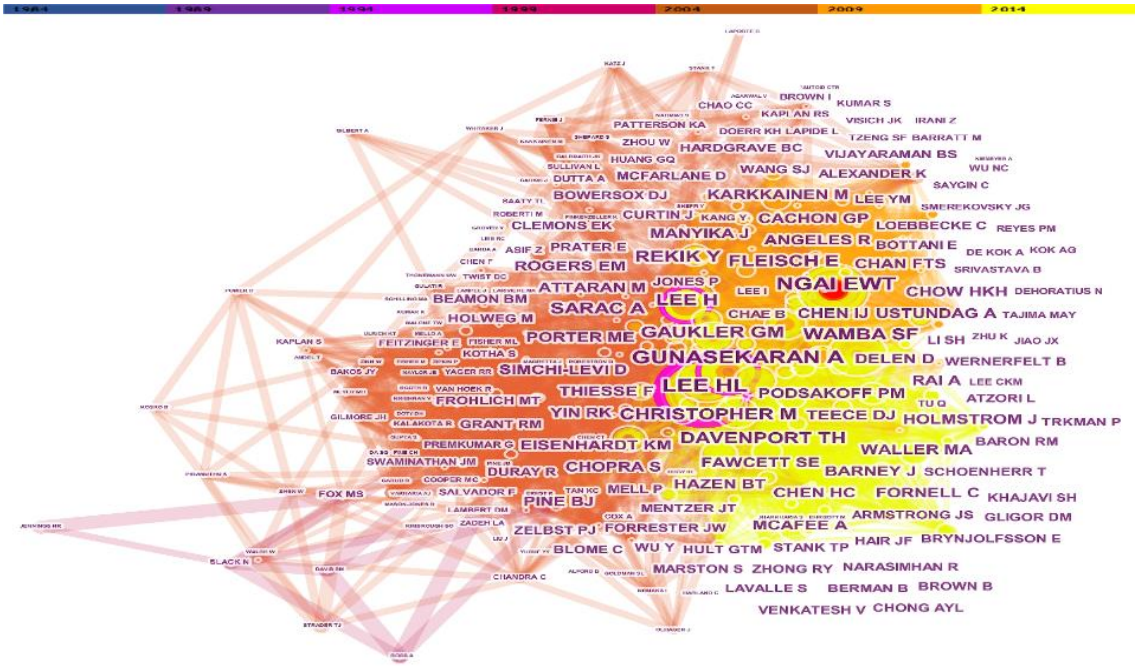

Figure 5: Author co-citation analysis

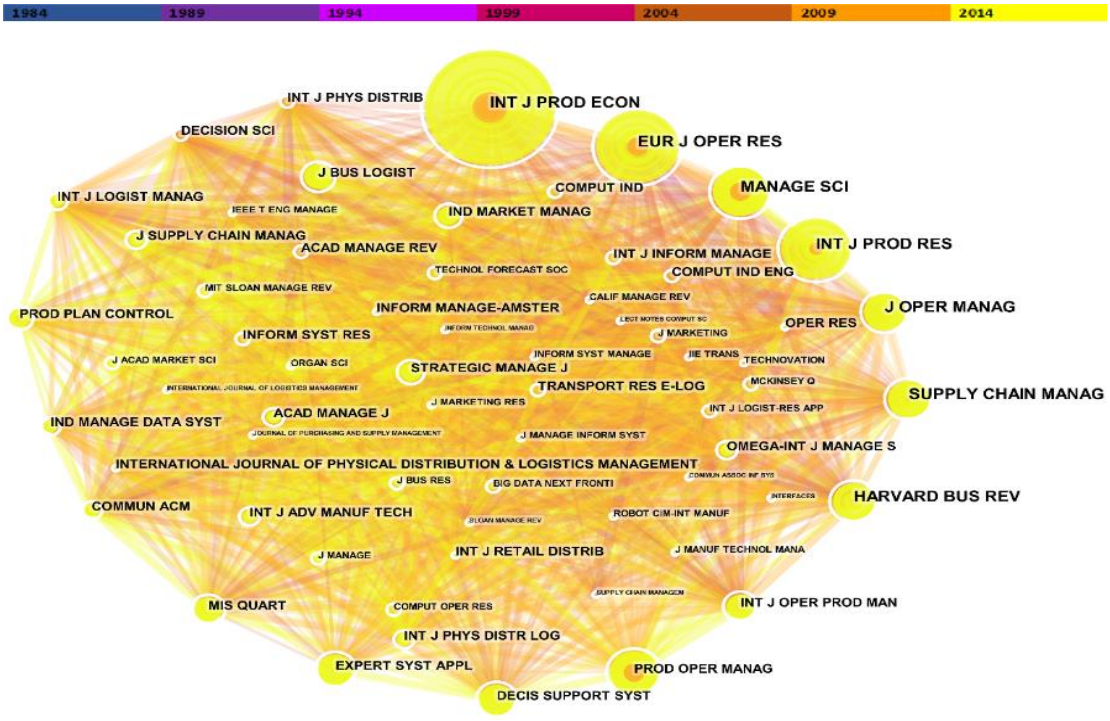

Figure 6: Journal co-citation analysis

Tables:

Table 1: Top 20 co-cited references in supply chain digitalisation discipline

No.	Freq*	Author (Year)	Title	Source[1]	WoS[2]
1	24	Lee and Özer (2007)	Unlocking the Value of RFID	POM	231
2	20	Ngai et al. (2008a)	RFID Research: An Academic Literature Review (1995–2005) and Future Research Directions	IJPE	299
3	20	Sarac et al. (2010)	A Literature Review on the Impact of RFID Technologies on Supply Chain Management	IJPE	205
4	17	Chen and Paulraj (2004)	Towards a Theory of Supply Chain Management: The Constructs and Measurements	JOM	721
5	16	Rekik et al. (2008)	Analysis of the Impact of the RFID Technology on Reducing Product Misplacement Errors at Retail Stores	IJPE	104
6	16	Fornell and Larcker (1981)	Evaluating Structural Equation Models with Unobservable Variables and Measurement Error	JMR	18959
7	14	Angeles (2005)	RFID Technologies: Supply-Chain Applications and Implementation Issues	ISM	328
8	14	Delen, Hardgrave, and Sharda (2007)	RFID for better supply-chain management through enhanced information visibility	POM	142
9	14	Ustundag and Tanyas (2009)	The impacts of Radio Frequency Identification (RFID) Technology on Supply Chain Costs	TRP-E	78
10	14	Waller and Fawcett (2013)	Data Science, Predictive Analytics, and Big Data: A Revolution That Will Transform Supply Chain Design and Management	JBL	130
11	14	McAfee et al. (2012)	Big Data: The Management Revolution	HBR	518
12	13	Chen, Chiang, and Storey (2012)	Business Intelligence and Analytics: From Big Data to Big Impact	MIS Q	769
13	13	Kärkkäinen (2003)	Increasing Efficiency in the Supply Chain for Short Shelf Life Goods Using RFID Tagging	IJRDM	N/A
14	13	Manyika et al. (2011)	Big Data: The Next Frontier for Innovation, Competition, and Productivity	McKinsey	N/A
15	13	Attaran (2007)	RFID: An Enabler of Supply Chain Operations	SCM-IJ	110
16	13	Gunasekaran and Ngai (2004)	Information Systems in Supply Chain Integration and Management	EJOR	362
17	13	Barney (1991)	Firm Resources and Sustained Competitive Advantage	JM	14088
18	13	Fleisch and Tellkamp (2005)	Inventory Inaccuracy and Supply Chain Performance: A Simulation Study of a Retail Supply Chain	IJPE	176
19	12	Podsakoff et al. (2003)	Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies	JAP	15566
20	11	Wamba et al. (2015)	How 'Big Data' Can Make Big Impact: Findings from a Systematic Review and a Longitudinal Case Study	IJPE	109

*Co-citation Frequency

1: Source: POM: Production and Operations Management; IJPE: International Journal of Production Economics; JOM: Journal of Operations Management; IJRDM: International Journal of Retail & Distribution Management; HBR: Harvard Business Review; JAP: Journal of Applied Psychology; MISQ: MIS Quarterly; JMR: Journal of Marketing Research; JM: Journal of Management; JBL: Journal of Business Logistics; TRP-E: Transportation Research Part E-Logistics and Transportation Review; EJOP: European Journal of Operational Research; McKinsey: McKinsey and Company; ISM: Information Systems Management; SCM-IJ: Supply Chain Management-An International Journal

N/A: Not Applicable

2: Web of Science Citation Count as of April 2018

Table 2: Burst detection analysis

	Author (Year)	Title	Source	Strength	Begin	End	1984-2018
1	Kärkkäinen (2003)	Increasing Efficiency in the Supply Chain for Short Shelf Life Goods Using RFID Tagging	IJRDM	3.765	2008	2011	
2	Lee and Özer (2007)	Unlocking the Value of RFID	POM	4.963	2009	2014	
3	Fleisch and Tellkamp (2005)	Inventory Inaccuracy and Supply Chain Performance: A Simulation Study of a Retail Supply Chain	IJPE	4.402	2009	2013	
4	Wamba et al. (2008)	Exploring the impact of RFID technology and the EPC network on mobile B2B eCommerce: A case study in the retail industry	IJPE	4.135	2009	2010	
5	Bottani and Rizzi (2008)	Economical assessment of the impact of RFID technology and EPC system on the fast-moving consumer goods supply chain	IJPE	3.714	2009	2013	
6	Sarac et al. (2010)	A Literature Review on the Impact of RFID Technologies on Supply Chain Management	IJPE	3.873	2012	2015	
7	Barney (1991)	Firm Resources and Sustained Competitive Advantage	JM	4.076	2014	2016	
8	McAfee et al. (2012)	Big Data: The Management Revolution	HBR	4.9	2015	Current	
9	Chen et al. (2012)	Business Intelligence and Analytics: From Big Data to Big Impact	MIS Q	4.543	2015	Current	
10	Waller and Fawcett (2013)	Data Science, Predictive Analytics, and Big Data: A Revolution That Will Transform Supply Chain Design and Management	JBL	4.192	2015	Current	
11	Manyika et al. (2011)	Big Data: The Next Frontier for Innovation, Competition, and Productivity	McKinsey	3.836	2015	Current	

POM: Production and Operations Management; IJPE: International Journal of Production Economics; IJRDM: International Journal of Retail & Distribution Management; HBR: Harvard Business Review; MISQ: MIS Quarterly; JM: Journal of Management; JBL: Journal of Business Logistics; McKinsey: McKinsey and Company

Red tape shows the burst life for an article

Table 3: Cluster Analysis

Cluster	Citing Article	Cited Reference
#1 RFID	Lee and Lee (2010), Pfahl and Moxham (2014), Vlachos (2014)	Balocco et al. (2011), Ngai et al. (2008b), Powell and Dent-Micallef (1997)
#2 Supply Chain Agility & Performance	Tuan (2016b, 2016a)	Eisenhardt and Martin (2000), Grant (1996), I. van Hoek et al. (2001), Teece (2007)
#3 Big Data & Cloud Computing	Arya et al. (2017), Lamba and Singh (2017), Roden et al. (2017)	Hazen et al. (2014), Opresnik and Taisch (2015), Waller and Fawcett (2013), Wamba et al. (2015)
#4 Digital Manufacturing & 3D Printing	Durach et al. (2017), Rogers, Baricz, and Pawar (2016), Ryan et al. (2017), Salvador, Rungtusanatham, and Forza (2004)	Duray et al. (2000), Holmstrom and Partanen (2014), Gavirneni, Kapuscinski, and Tayur (1999), Loomba and Nakashima (2012), Wagner and Walton (2016)
#5 Internet of Things & Omni Channel	Haddud et al. (2017), Scuotto et al. (2017)	Kozlenkova wt al. (2015), Hubner et al. (2016), Peinkofer et al. (2015), Thiesse and Buckel (2015), Wortmann and Flücher (2015)

Table 4: Author Co-Citation Frequency

No.	Frequency	Author	No.	Frequency	Author
1	50	Lee HL	11	20	Podsakoff PM
2	37	Ngai EWT	12	18	Manyika J
3	36	Gunasekaran A	13	18	Angeles R
4	33	Wamba SF	14	18	Fawcett SE
5	30	Christopher M	15	18	Chen IJ
6	26	Davenport TH	16	17	Ustundag A
7	25	Gaukler GM	17	17	Mcafee A
8	24	Fleisch E	18	17	Simchi-levi D
9	22	Rekik Y	19	17	Attaran M
10	21	Sarac A	20	17	Porter ME

Table 5: Journal Co-Citation Frequency

Freq	Journal	IF	Freq	Journal	IF
183	International Journal of Production Economics	3.49	82	Production and Operations Management	1.85
145	European Journal of Operational Research	3.3	77	Decision Support Systems	3.22
135	International Journal of Physical Distribution and Logistics Management	2.58	77	Expert Systems with Applications	3.93
124	Management Science	2.82	73	MIS Quarterly	7.27
113	International Journal of Production Research	2.33	61	Communication of the ACM	4.03
112	Journal of Operations Management	5.21	59	Industrial Management and Data Systems	2.21
95	Supply Chain Management-An International Journal	4.07	58	Production Planning and Control	2.37
92	Journal of Business Logistics	2.88	55	International of Journal Logistics Management	1.61
91	Harvard Business Review	3.23	55	Decision Sciences	1.6
86	International Journal of Operations and Production Management	3.34	51	Industrial Marketing Management	3.17

Freq: Co-citation Frequency; IF: WoS Impact Factor (2017 Journal Citation Reports)

Table 6: Higher Level Classification of Clusters

Strategy	Resources	Capabilities	Performance
• Digital Manufacturing • Omni channel	• RFID • Big data • Cloud computing • 3DP • Internet of Things	• Agility	• Supply chain performance

Appendix:

Appendix 1

Qualitative Review of Cluster Analysis Key Articles

Article	Aims/Objectives/RQs	Method	Theoretical underpinning
	Digital Manufacturing and 3DP (cited articles)		
Duray et al. (2000)	In this research, we develop a configurational model for classifying mass customizers based on customer involvement in design and product modularity. We validate this typology through an empirical analysis and classification of 126 mass customizers. We also explore manufacturing systems and performance implications of the various mass customization configurations	Survey	
Gavirneni et al. (1999)	In this paper, we study partial and complete information sharing in a supplier-retailer setting, and also compare these to a base case of no information.	Mathematical modelling	
Holmstrom and Partanen (2014)	To explore the forms that combinations of digital manufacturing, logistics, and equipment use are likely to take and how these novel combinations may affect the relationship among logistics service providers, users, and manufacturers of equipment	Is employed to examine possible digital manufacturing-driven transformations. The F-18 Super Hornet is used as an illustrative example of a service supply chain for a complex product.	Brian Arthur's theory of combinatorial technological evolution
Loomba and Nakashima (2012)	In this article, we examine the role of sorting used products before disassembly for parts retrieval and remanufacturing under stochastic variability based on customer demand using a Markov decision process.		
Wagner and Walton (2016)	The purpose of this research was to shed light on the current and future states of AM in the aviation industry.	Focus groups with nearly 50 aviation professionals from aircraft original equipment manufacturers (OEMs), suppliers, maintenance repair overhaul providers, and AM service providers and AM production firms	
	Digital Manufacturing and 3DP (citing articles)		
Durach et al. (2017)	The purpose of this paper is to offer empirical insights on emerging additive manufacturing (AM) processes, barriers to their adoption and a timeline of expected impacts on the supply chain in the manufacturing industry	A multi-stage survey study was conducted with a panel of 16 experts from industry and academia	
Rogers et al. (2016)	This study aims to identify and classify the available types of 3D printing services, with the scope of determining the potential implications that such services could have on the supply chains of manufacturing firms and creating a research agenda for future studies	Literature review on the potential supply chain impacts of 3D printing	
Ryan et al. (2017)	The purpose of this paper is to evaluate the existing scenarios for 3D printing (3DP) in order to identify the 'white space' where future opportunities have not been proposed or developed to date.	Structured literature review Both academic and trade publications.	
Salvador et al. (2004)	The paper explores how a firm's supply chain – meant as the whole of its supply, manufacturing and distribution networks – should be configured when different degrees of customization are offered.	A multiple case study including firms in the telecommunications, transportation vehicles and food processing equipment industries	Configurational theory
	Big data (Cited articles)		
Hazen et al. (2014).	The goal of this paper is to introduce and stress the need for the monitoring and control of data quality in supply chain management processes and provide a starting point for future research and applications.	Mathematical modelling plus secondary data	Systems theory, The knowledge-based view, and Organizational information processing view
Opresnik and Taisch (2015)	In this article we propose a new basis for competitive advantage for manufacturing enterprises called a Big Data Strategy in servitization. We scrutinize how	Conceptual simulation involving s steps of (1) Visualization of the situation (2) Performing an operation on the situation	Resource-based view Dynamic capabilities

	manufacturers can exploit the opportunity arising from combined Big Data and servitization. Therefore, the concept of a Big Data Strategy framework in servitization is proposed	(3) Observation of causal relations (the effects of the operations from the previous step are analysed in regard to the level of competitive advantage	
Waller and Fawcett (2013)	An editorial commentary that illuminates the myriad of opportunities for research where supply chain management (SCM) intersects with data science, predictive analytics, and big data, collectively referred to as DPB	Commentary	Transaction cost economics Resource-based view Contingency theory Resource dependence theory Agency theory Institutional theory
Wamba et al. (2015)	Clarify the definition and concepts related to 'big data'. Develop a conceptual framework for the classification of articles dealing with 'big data'. Use the conceptual framework to classify and summarize all relevant articles. Conduct an in-depth analysis of a longitudinal case study of an Australian state emergency service which is currently using 'big data' for improved operations delivery. Develop future research directions where the deployment and use of 'big data' is likely to have huge impacts.	A systematic review and case study	
	Big data (citing articles)		
Arya et al. (2017)	The purpose of this paper is to explore the use of big data analytics (BDA) in spare parts supply chain of the army	Systematic literature review	
Lamba and Singh (2017)	This paper seeks to explore the current status of big data research in three key domains of O&SCM, namely procurements, manufacturing and logistics which are vital cogs in the O&SCM process. This work also discusses some frameworks which will facilitate integration of 3 V model of big data in some important domains of O&SCM which have relatively not been addressed by researchers till now	Systematic literature review	N/a
Roden et al. (2017)	In this paper, we explore how Big Data can be used across different sectors in leading organisations and examine the ways in which it is fostering change in the core operations models of organisations	Series of secondary qualitative case studies	
	Supply chain agility and performance (cited articles)		
Eisenhardt and Martin (2000)		Conceptual	Dynamic capabilities
Grant (1996)		Conceptual	Knowledge-based view theory
I. van Hoek et al. (2001)	Development of an agile supply chain framework	Conceptual development through a literature review and survey	
Teece (2007)			Dynamic capabilities
	Supply chain agility and performance (citing articles)		
Tuan (2016a)	The purpose of this paper is to decipher the catalyzing role of cultural intelligence in its chain effect, through corporate social responsibility and trust, to supply chain performance and competitive intelligence.	Survey and SEM-based analysis of cross-sectional data provided by 392 respondents from MNCs in Vietnamese business landscape	Corporate social responsibility
Tuan (2016b)	The primary aim of this research is to investigate the relationships between supply chain agility and its dynamic precursors including organisational ambidexterity and external knowledge sharing. The research further examines the moderating role of competitive intelligence for the relationship between organisational ambidexterity and supply chain agility	Survey involving sample of 381 respondents from chemical manufacturing companies in Vietnam	Resource-based view
	Internet of things and Omni channel (cited article)		
Hubner et al. (2016)	The purpose of this paper is to investigate how retailers develop from separate multi-channel (MC) to integrated omni-channel (OC) fulfilment.	More than 60 internationally active retailers and experts from Germany participated in an exploratory survey.	No theory

Kozlenkova et al. (2015)		Review of the literature	No theory
Peinkofer et al. (2015)	This research develops a theoretical framework, based on expectation-disconfirmation theory, to explain the effect of price promotions on consumer expectations of product availability and their reactions to stockouts in an online retail environment	Four experimental study Expectation-disconfirmation theory	Expectation-disconfirmation theory
Thiesse and Buckel (2015)	The study aims to analyse and discuss the impact of design choices, technology characteristics, and external influences on the economic efficiency of RFID.	More RFID than omnichannel or IOT	No theory
Wortmann and Flüchter (2015)	To reflect on the technology and value added of IoT in supply chain	An essay on IoT,	No theory
Internet of things and Omni channel (citing articles)			
Haddud et al. (2017)	RQ1. What are the potential benefits organizations, and their entire supply chains, that are likely to gain from the adoption of IoT? RQ2. What are possible challenges organizations, and their entire supply chains, that are likely to face when adopting IoT?	Online survey and 87 participants completed the survey followed by SEM	No theory