Industrial Marketing Management 90 (2020) 324–345

Contents lists available at ScienceDirect

Industrial Marketing Management

journal homepage: www.elsevier.com/locate/indmarman

# Agile supply chain management: where did it come from and where will it go in the era of digital transformation?

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ARTICLE INFO

*Keywords:*
Agility measurement
Barriers
Factors
Digitalization
Industry 4.0
Resilience
Structured literature review
Supply chain agility

ABSTRACT

In today's dynamic business environment, agile supply chain (ASC) has become a key strategic move to cope with market instability, handle competitive pressures and strengthen operational and organizational performance. Meanwhile ASC is a good example of a strategy drawing heavily on digitization since as a demand chain management it was information-centric and technology-centric from its inception. Yet, despite this relationship, a lack of coherence and clarity around the input of technology for ASC has impeded to portray accurately the relative importance of digitization in ASC strategies. This study provides a comprehensive and integrative review of 90 articles on ASC. By so doing, we contribute to the discussion about digitization in the supply chain in several ways. First, the paper reports descriptively and analytically how technology was addressed within the ASC literature. Second, it maps a nomological network of ASC research. Third, it finds that technology appears as a necessary but not-sufficient enabling factor for ASC deployment. Finally, a research agenda is proposed to suggest future research avenues to improve contributions to ASC performance.

## 1. Introduction

Agile supply chain (hereafter, ASC) has been widely recognized, as a critical strategy for companies to manage supply network, and develop flexible capabilities to meet rapidly changing customer demands (Zhang, 2011; Lim & Zhang, 2012; Cegarra-Navarro, Soto-Acosta, & Wensley, 2016; Felipe, Roldán, & Leal-Rodríguez, 2016; Gligor, Holcomb, & Feizabadi, 2016; Shams, 2016; Tse, Zhang, Akhtar, & Macbryde, 2016; Battistella et al., 2017; Kim & Chai, 2017; Nemkova, 2017; Um, 2017a). The concept of agility in the supply chain (hereafter, SC) was defined by Goldman, Nagel, and Preiss (1995) as a strategy of responsiveness and readiness to change in a volatile market place, where this strategy is exclusively demand driven. In sum, ASC is based on sensitivity to customer demand even under demand volatility. According to the definition proposed by Goldman et al. (1995), Ismail and Sharifi (2006) described SC agility as "the ability of the SC as a whole and its partners to rapidly align the network and its operations to the dynamic and turbulent requirements of the demand network". With this premise, the fundamental drivers of ASC are cost, efficiency and speed.

In his seminal article, Christopher (2000) made a strong case in showing how the routes to agility do necessarily involve digitization processes (e.g., Electronic Data Interchange (EDI), Internet, electronic point of sale (EPOS) and how ASC is inherently a digitally-enabled SC strategy. He suggested that that route to agility is conditional upon attainment of the following characteristics: 1) *market sensitive*; 2) *network based*; 3) *process integration*; and 4) *virtual* (Christopher, 2000). Yet, recent technological developments may further these information-centric characteristics of ASC. First, SCs are *market sensitive*. This means that the demand is detected from the market. Demand forecasting is not based on past trends but on the daily point of sale. Therefore, daily feedback are used to forecast the future demand. In present times, firms are focusing on the future. Therefore, their efforts focus on making it from today, by executing best practices to capture the emerging trends. One of these best practices would be listening to the customer. It is said that success of SC is based on the customer's feedback. Therefore, the voice of the customer is the real demand that drives the SC. The recent increase in abundant, multidirectional and real-time information flows, to which are subsequently applied big data analytics, drives new

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https://doi.org/10.1016/j.indmarman.2020.07.011
Received 22 November 2019; Received in revised form 28 June 2020; Accepted 15 July 2020

opportunities for improved demand management and market sensitivity (Monahan & Hu, 2015; Mussomeli, Gish, & Laaper, 2016; Richey et al. 2016; Schoenherr & Speier-Pero, 2015; Waller & Fawcett, 2013). In fact, it enables companies to better forecast demand on a micro-segment basis, to rearrange individual product assortments based on predicted customer behaviour, and to quickly adjust their customer strategies and offerings.

Concerning the *network-based* pillar, every partner must work towards the success of the entire SC. This configuration allows sharing the tasks among the actors of the SC on the basis of their core competencies and thus reducing the workload on specific partners. In this way, all the partners equally own the chain and overall chain performance matters for each of them.

*Process integration* is mainly based on three key concepts: collaboration, information sharing, and joint goals. Nowadays, companies are focusing on the managing of their core-competencies and outsourcing all other activities, and this form of collaboration is becoming even more widespread. More efficient and diversified information flows through digitization processes improve both the network and process pillars of ASC. In fact, they enable the integration of a greater number of network parties (Mussomeli et al., 2016), foster resilient network structures (Urciuoli & Hintsa, 2017), spur supply network-driven innovations (Schoenherr & Speier-Pero, 2015), and could potentially improve collaboration (Barratt, 2004), participatory decision, as well as co-creation (Monahan & Hu, 2015).

In *virtual-based* SC, the adoption of information technologies to share information among SC partners is essential to forecast and satisfy market demand. The information concerning market demand are shared. Collaboration among the SC partners is thus crucial and each partner, according to their capabilities, plans its activities to fulfil the demand. As such, a virtual based SC may result in end-to-end supply chain visibility, which is an important driver for competitive advantage (Mason-Jones & Towill, 1997). Improved virtuality enabled by more data collected via IT infrastructure (Wu, Yue, Jin, & Yen, 2016) to which are subsequently applied big data analytics (Richey Jr, Morgan, Lindsey-Hall, & Adams, 2016), could better identify the bottlenecks in the supply network and detect other problems affecting the activities of the SC thus contributing to end-to-end SC visibility.

Agility has thus made SC more information-centric to build in-depth understanding of lower order capabilities (Baker, 2008; Hazen, Bradley, Bell, In, & Byrd, 2017; Mishra, Mahapatra, & Datta, 2014; Routroy & Shankar, 2015), cooperate and leverage core resource competencies (Yusuf et al., 2014; Yusuf et al., 2014), and offer solutions to many problems existing in today's SC networks, such as excess inventory and potential shortages (Blome, Schoenherr, & Rexhausen, 2013; Costantino, Dotoli, Falagario, Fanti, & Mangini, 2012; Jain, Benyoucef, & Deshmukh, 2008; Sahu, Sahu, & Sahu, 2016; Samdantsoodol, Cang, Yu, Eardley, & Buyantsogt, 2017; Shin, Lee, Kim, & Rhim, 2015).

However, there are two major confusions in ASC context. In fact, although information favours ASC constitutions, it is unclear whether technology plays a significant role in this process. Second although, ASC has attained good heed among researchers and academics, and significantly contributed to the body of knowledge in the last decade, the majority of studies are survey and case-based papers, with a dearth of comprehensive review studies. Zhang and Sharifi (2000) and Sharifi and Zhang (1999) presented a method for attaining agility in manufacturing companies. Wu and Barnes (2011) reviewed decision-making models associated to ASC. Gligor and Holcomb (2012) reviewed the role of logistical capabilities in achieving agility, and Siddhartha and Sachan (2016) reviewed major models and frameworks to identify how to foster agility in organizations. Although all relevant and insightful, the few reviews on the subject of ASC do not provide a comprehensive overview of the research field to determine the extent to which the technological component of ASC has been investigated so far and what is its relative importance in contrast to other factors. Therefore, a few key issues remain untouched, and could constitute topics for future research in this area.

Thus, the objectives of this paper are: (a) to offer a comprehensive systematic review of the ASC domain published between 1999 and 2017; (b) to describe the main aspects of the ASC literature that has addressed technology within ASC; (c) to identify how technology has been studied in relation to ASC; and (d) to identify research gaps in the literature, especially pertaining to digitization within the ASC, to provide future research trends and opportunities. This paper considers five topic areas such as factor affecting ASC, barriers in developing ASC, partner selection under ASC, impact of ASC on business performance and ASC performance measurement.

The paper consists of six sections. Following the introduction, the next section illustrates the research methodology. In the third and fourth sections, the network analysis based on citation and co-citation analysis is conducted and the theoretical frameworks in the ASC research field have been discussed. The fifth section presents the results of the content analysis. Finally, conclusions, implications, and future research directions are discussed.

## 2. Research methodology

The methodology has been adapted by integrating different methodological approaches suggested to conduct a systematic review in the social sciences (Cerchione & Ertz, 2020; Easterby-Smith, Thorpe, & Jackson, 2012; Hillebrand & Biemans, 2003; Mostaghel, 2016; Petticrew & Roberts, 2006; Pittaway, Robertson, Munir, Denyer, & Neely, 2004). Summarising the above contributions, the paper integrates both citation and co-citation analysis (Vogel, Reichard, Batistič, & Černe, 2020), as well as the systematic review approaches proposed by Agrawal (2001) and Perkmann and Walsh (2007). The review of the literature adopts a three-step methodology as summarized below:

1) Phase of papers selection:
   - *Comprehensive material search*, in which articles have been found using a set of selected keywords;
   - D*efinition of criteria for inclusion/exclusion*, in which articles have been selected;
2) Phase of descriptive analysis:
   - *Descriptive analysis and classification of articles*, in which articles have been categorised according to descriptive dimensions;
3) Phase of theoretical and content analysis of the selected papers:
   - *Theoretical and content analysis*, in which selected articles have been described according to their theoretical model of reference. In addition, citation and co-citation analyses have been conducted to identify historiography results, clusters of main contributions and authors in the field, as well as analysis of clusters. Finally, all the contributions have been categorised into topic areas to get a full overview on the topic.

### 2.1. Comprehensive material search

To provide an overview of the concept of ASC and to be as exhaustive as possible, the comprehensive material search is conducted using both Scopus and Web of Science academic databases. A set of selected keywords such as “agil*” is used in combination with “supply chain”. The search resulted in a total of 454 hits, limiting the data range to the papers published between 1999 and 2017, as well as excluding duplicate papers indexed in both databases.

### 2.2. Definition of criteria for inclusion/exclusion

Three criteria for inclusion/exclusion of research products are defined as reported in Table 1 to limit the analysis only to papers strictly related to the topic under examination.

The *first criterion* defines those articles to include according to the

**Table 1**
Criteria for inclusion/exclusion.

| | Articles included | Articles excluded |
|---|---|---|
| *First criterion:* Analysis of the abstract and selection of articles whose abstract is focused on ASC | 127 | 327 |
| *Second criterion:* Analysis of the articles and selection of those focusing on ASC | 79 | 48 |
| *Third criterion:* Inclusion of additional articles most cited in the literature on ASC | 90 | 0 |

focus of their abstract. Considering that the research investigates ASC, articles without a focus on this topic, are excluded. Abstracts have been analysed by three different readers in parallel plus a fourth one in case of hesitation. According to the first criterion and considering the scope of this research, a total of 127 articles have been included. The *second criterion* refers to the focus of the article. The full-texts of the articles have been analysed independently by three researchers and 48 articles not focused on the research topic have been removed from the list, reducing the sample of articles to 79 papers at the end of the third step. The *third criterion* relates to the cited references. Eleven additional contributions have been added since they appeared as influential references in the literature. Therefore, a total amount of 90 articles is analysed in the subsequent phase of descriptive analysis.

### 2.3. Descriptive analysis and classification of articles

For the evaluation of the selected 90 articles, we perform a descriptive analysis before conducting an in-depth analysis of their contents. Once downloaded data from Scopus and Web of Science, all the analysis reported in this section were conducted using Microsoft Office 365® package and VOSviewer software.

#### 2.3.1. Articles over time

According to the distribution of articles over time (Fig. 1), the trend of articles on ASC has grown in recent years. Fig. 1 shows that the growth of ASC was slow between the 1999 and 2005 with a range of 1 to 3 articles per annum. During this 6-year time span, 14 articles were published. After 2005, the ASC literature grew significantly with 31 articles published between 2006 and 2012. During this time span, the number of published articles amounted 3 to 7 each year. The real growth started after the 2012. Consequently, 45 topical articles on ASC were published between 2013 and 2017, and herein the published articles ranged between 7 and 11 per year. When analysing the trend in these publications, we can see that 2006 is the tipping point when ASC went from being a burgeoning and even declining concept to a research field in its own right.

#### 2.3.2. Articles across journals

Due to the interdisciplinary nature of SC management, ASC research has been published in 39 different journals (see Table 2). In order to understand the subject areas of these 39 journals, the Scopus classification of subject areas for each journal were taken into account. Subsequently, the Scimago Journal Rank (SJR) values were used to highlight the influence of each journal. ASC has been published in business, management, and accounting, as well as in economics, econometrics, and finance, but also in engineering, computer sciences, and decision sciences. The marked contribution of this third group of disciplines leads credence to the relationship between ASC and a deeper technological and technical nexus as epitomized with agile software engineering and development (e.g. Dingsøyr, Nerur, Balijepally, & Moe, 2012), but also business intelligence, analytics, and data science (Larson & Chang, 2016). These results highlight that the topic of ASC is a crossroad research area that draws the attention of a variety of journals that publish papers focusing on different subject areas, especially business and technology. Furthermore, since 2006, topical research has increasingly been published in high impact factor journals, including *MIS Quarterly* and *Journal of Operations Management*. Additional top-tier journals include *Industrial Marketing Management, International Journal of Production Economics*, or *European Journal of Operational Research*, that have also published several studies on ASC including seminal papers (e.g., Agarwal, Shankar, & Tiwari, 2006; Christopher, 2000; Naylor, Naim, & Berry, 1999). Regarding SJR values, *Journal of Operations Management* (6.481 SJR), *International Journal of Production Economics* (2.475 SJR), *International Journal of Physical Distribution and Logistics Management* (2.407 SJR), and *Industrial Marketing Management* (2.375 SJR) appeared as top scorers in the ASC

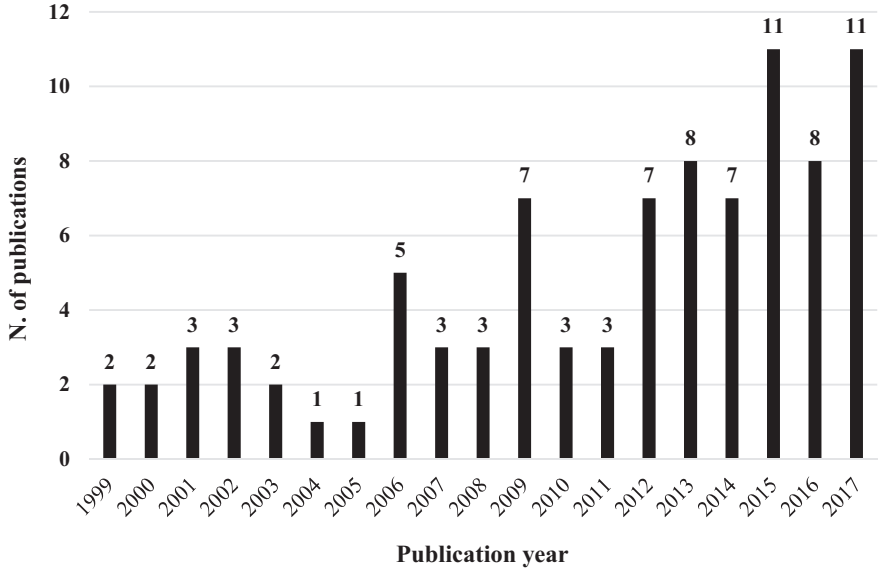


**Fig. 1.** Agile supply chain publications by year.

**Table 2**
Journals publishing agile supply chain research. (SJR values used in the analysis refer to 2018).

| | | Subject area | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Journal** | | **Art and humanities** | **Psychology** | **Business, management and accounting** | **Decision sciences** | **Engineering** | **Computer science** | **Economics, econometrics and finance** |
| IJPE | International Journal of Production Economics | | | • | • | • | | • |
| IJOPM | International Journal of Operations and Production Management | | | • | • | | | |
| SCM | Supply Chain Management: An International Journal | | | • | | | | |
| IJPR | International Journal of Production Research | | | • | • | • | | |
| JOM | Journal of Operations Management | | | • | • | • | • | |
| IJLM | International Journal of Logistics Management | | | • | | | | |
| ESWA | Expert Systems with Applications | | | | | • | • | |
| IJSOM | International Journal of Services and Operations Management | | | • | • | • | | |
| IJAMT | International Journal of Advanced Manufacturing Technology | | | | | • | • | |
| B | Benchmarking: An International Journal | | | • | | | | |
| JMTM | Journal of Manufacturing Technology Management | | | • | | • | • | |
| EJOR | European Journal of Operational Research | | | | • | | | |
| IJIM | International Journal of Information Management | | | | | | • | |
| MD | Management Decision | | | • | • | | | |
| IJOR | International Journal of Operational Research | | | | • | | | |
| JBR | Journal of Business Research | | | • | | | | |
| MBE | Measuring Business Excellence | | | • | | | | |
| IJPDLM | International Journal of Physical Distribution and Logistics Management | | | • | | | | |
| PPC | Production Planning and Control | | | • | • | • | • | |
| TEDE | Technological and Economic Development of Economy | | | | | | | • |
| RCM | Robotics and Computer-Integrated Manufacturing | | | | | • | • | |
| BPMJ | Business Process Management Journal | | | • | | | | |

(*continued on next page*)

**Table 2** (*continued*)

| Journal | | Subject area | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Art and humanities | Psychology | Business, management and accounting | Decision sciences | Engineering | Computer science | Economics, econometrics and finance |
| IMM | Industrial Marketing Management | | | • | | | | |
| IJASM | International Journal of Agile Systems and Management | | | • | • | | | |
| EAAI | Engineering Applications of Artificial Intelligence | | | | | • | • | |
| IJMSEM | International Journal of Management Science and Engineering Management | | | • | • | • | | |
| DSS | Decision Support Systems | • | • | • | • | | • | |
| JSIS | Journal of Strategic Information Systems | | | • | • | | • | |
| JPSM | Journal of Purchasing and Supply Management | | | • | | | | |
| JFMM | Journal of Fashion Marketing and Management: An International Journal | | | • | | | | |
| EJIS | European Journal of Information Systems | | | | | | • | |
| IJMTM | International Journal of Manufacturing Technology and Management | | | • | • | • | • | |
| IJDSST | International Journal of Decision Support System Technology | | | | | | • | |
| MIS | MIS Quarterly: Management Information Systems | | | • | • | | • | |
| M | Measurement: Journal of the International Measurement Confederation | | | | | | | |
| IISE | IISE Transactions | | | | | • | | |
| JIRS | Journal of Intelligent and Robotic Systems: Theory and Applications | | | | | • | • | |
| KPM | Knowledge and Process Management | | | • | | | | |
| JMPT | Journal of Material Processing Technology | | | | | • | • | |

| Journal | Subject area | | | | Number of papers | Percentage (%) | Timeline | SJR score |
|---|---|---|---|---|---|---|---|---|
| | Materials science | Physics and astronomy | Mathematics | Social sciences | | | | |
| IJPE | | | | | 15 | 16.6 | 1999–2017 | 2.475 |
| IJOPM | | | | | 6 | 6.6 | 2001–2016 | 2.095 |
| SCM | | | | | 6 | 6.6 | 2006–2016 | 2.103 |
| IJPR | | | | | 4 | 4.4 | 2010–2017 | 1.585 |

(*continued on next page*)

**Table 2** (*continued*)

| Journal | Subject area | | | | Number of papers | Percentage (%) | Timeline | SJR score |
|---|---|---|---|---|---|---|---|---|
| | Materials science | Physics and astronomy | Mathematics | Social sciences | | | | |
| JOM | | | | | 4 | 4.4 | 2006–2015 | 6.481 |
| IJLM | | | | • | 4 | 4.4 | 2007–2017 | 0.871 |
| ESWA | | | | | 3 | 3 | 2015 | 1.190 |
| IJSOM | | | | | 3 | 3.3 | 2012–2017 | 0.237 |
| IJAMT | | | | | 3 | 3.3 | 2009–2013 | 0.987 |
| B | | | | | 3 | 3.3 | 2001–2016 | 0.593 |
| JMTM | | | | | 3 | 3.3 | 2011–2017 | 0.954 |
| EJOR | | | | | 2 | 2.2 | 2006–2017 | 2.205 |
| IJIM | | | | • | 2 | 2.2 | 2012–2013 | 1.711 |
| MD | | | | | 2 | 2.2 | 2008–2012 | 0.731 |
| IJOR | | | | | 2 | 2.2 | 2015–2017 | 0.335 |
| JBR | | | | | 2 | 2.2 | 2012–2017 | 1.684 |
| MBE | | | | | 2 | 2.2 | 2015–2017 | 0.378 |
| IJPDLM | | | | • | 2 | 2.2 | 2001–2002 | 2.407 |
| PPC | | | | | 2 | 2.2 | 2009–2014 | 1.427 |
| TEDE | | | | | 1 | 1.1 | 2013 | 0.774 |
| RCM | | | • | | 1 | 1.1 | 2004 | 1.405 |
| BPMJ | | | | | 1 | 1.1 | 2006 | 0.557 |
| IMM | | | | | 1 | 1.1 | 2000 | 2.375 |
| IJASM | | | | | 1 | 1.1 | 2007 | 0.400 |
| EAAI | | | | | 1 | 1.1 | 2008 | 0.881 |
| IJMSEM | | | | | 1 | 1.1 | 2011 | 0.426 |
| DSS | | | | | 1 | 1.1 | 2013 | 1.536 |
| JSIS | | | | | 1 | 1.1 | 2016 | 1.432 |
| JPSM | | | | | 1 | 1.1 | 2009 | 1.424 |
| JFMM | | | | | 1 | 1.1 | 207 | 0.653 |
| EJIS | | | | • | 1 | 1.1 | 2006 | 2.036 |
| IJMTM | | | | | 1 | 1.1 | 2015 | 0.228 |
| IJDSST | | | • | | 1 | 1.1 | 2016 | 0.164 |
| MIS | | | | | 1 | 1.1 | 2003 | 4.212 |
| M | | • | • | • | 1 | 1.1 | 2015 | 0.724 |
| IISE | | | | | 1 | 1.1 | 2000 | 1.383 |
| JIRS | | | | | 1 | 1.1 | 2002 | 0.575 |
| KPM | | | | | 1 | 1.1 | 2009 | 0.398 |
| JMPT | • | | • | | 1 | 1.1 | 2002 | 1.719 |

domain.

### 2.3.3. Leading authors of the field

As for the leading authors analysis, we found that the 90 articles included in the sample were written by 187 researchers. It is worth mentioning that many articles were co-authored by more than one researcher. To avoid bias related to abbreviated or full names of authors (e.g., *Gunasekaran, Angappa* and *Gunasekaran, A*. which appear two different authors, while they refer to the same person), we manually checked the authors of all the articles. Table 3 reports the most prolific authors, number of papers published in peer-reviewed journals and their affiliation. This table takes only into consideration first authors in authors list. Similarly, the number of contributions is based on the number of papers the authors published as first author. Both Chong Wu, from China, and David Barnes, from the UK are leading ASC field's authors with 6 articles each. Thus, scholars from both developed and developing countries share interest into ASC.

### 2.3.4. Performance of countries and regions

Subsequently, we analysed the performance of countries and regions on ASC research. Fig. 2 shows the publication world map designed using the Microsoft Office 365® package. Total sample articles belong to 19 countries. Notably, few articles were co-authored by authors from different countries and, at the same time, other articles were co-authored by authors from the same country. In the last situation, the country is counted only once even if two or more authors co-authored the paper. The USA appeared as the most prolific country with 35 published articles followed by UK (25), India (15), China (13), Iran (10), South Korea (6), Taiwan (4), and Germany (3), respectively. Further, France, Italy, Malaysia, and Singapore contributed with 2 articles for each. Likewise, Belgium, Canada, Egypt, Greece, Lithuania, Philippines, and Australia contributed with 1 article on ASC literature. It appears that the American-born concept of ASC has gained traction outside of the USA and especially in Asian developing countries. Besides, it seems that ASC research has not attained significant heed in other regions such as Africa and Australia.

### 2.3.5. Most frequent keywords

Keywords analysis is a method of content analysis that maps a particular research field by using publication keywords (Callon, Courtial, Turner, & Bauin, 1983). The aim of this analysis is to identify frequent words mentioned in a paper and to extract the conceptualization behind the words. It enables researchers to dive deeper into the actual content of a paper, and to capture the co-occurrence relationship between concepts. According to Geng et al. (2020), the most frequent keywords offer a deep understanding of key topics. The VOSviewer software was used to visualize the density of the keywords. Within the sample articles, a total of 463 unique keywords were identified. For the holistic analysis, only keywords with at least 4 repetitions were used. Therefore, a total of 45 keywords were shortlisted and Fig. 3 presents their related heat density map. Fig. 3 shows two red spots. The first important red spot includes important keywords such as supply chain management, management, strategy, performance, model, integration, flexibility, and agility. The second red spot includes keywords such as capabilities, supply chain agility, firm performance, systems, and resource-based view. The first keywords group takes a bird's eye perspective on the field with a deep focus on higher-order strategic, managerial, and even systemic thinking. In contrast, despite evoking systems, the second group leans more towards day-to-day matters and operational imperatives. Of particular interest is capability building, as well as maximizing efficiency and performance. Both groups are of importance and interest, but it is striking to see how that distinctiveness emerged from the analysis. The distance between the two keywords indicates their relatedness. The higher the distance between two keywords, the lower its relatedness. The keyword “management” appeared as most cited keyword with 31 occurrences, followed by performance (25), agility (24), integration (23), capabilities (20), supply chain agility (20), model (19), flexibility (18), and supply chain management (16), as, respectively, the most frequently mentioned keywords in the literature.

Fig. 3. Heat map of keywords

**Table 3**
Leading authors in agile supply chain research.

| First authors[a] | Country | Number of contributions | Timeline |
|---|---|---|---|
| Chong Wu | China | 6 | 2009–2014 |
| David Barnes | UK | 6 | 2009–2014 |
| David M. Gligor | USA (4) + Malaysia (1) | 5 | 2012–2016 |
| Saurav Datta | India | 5 | 2013–2016 |
| Siba Sankar Mahapatra | India | 5 | 2013–2016 |
| Mary C Holcomb | USA | 4 | 2012–2016 |
| Angappa Gunasekaran | USA | 3 | 1999–2014 |
| Jae-Nam Lee | South Korea | 3 | 2015–2017 |
| Jafar Razmi | Iran | 3 | 2015 |
| Joseph Sarkis | USA | 3 | 2001–2007 |
| Kaveh Khalili-Damghani | Iran | 3 | 2011–2013 |
| Srikanta Routroy | India | 3 | 2015–2017 |
| Swagatika Mishra | India | 3 | 2013–2015 |
| V Sambamurthy | USA | 3 | 2003–2010 |
| Yahaya, Y. Yusuf | UK | 3 | 1999–2014 |

[a] Only authors appearing as first author at least 3 times have been included in the analysis and reported in this table.

### 2.3.6. Most cited papers on the topic of ASC

Table 4 reports the 15 most cited papers on ASC. The analysis refers to the Scopus citations received until June 27, 2020. Sambamurthy, Bharadwaj, and Grover (2003) is the most cited article with 1656 citations followed by Christopher (2000) and Yusuf, Sarhadi, and Gunasekaran (1999) with 1058 and 664 citations, respectively. Incidentally all of these three studies provide extensive discussions about the integration of IS/IT for agility purposes. In the aftermath of both Yusuf et al.'s (1999) and Christopher's (2000) papers, Sambamurthy et al.'s (2003) impactful study contributed to broaden scholars' and practitioners' understanding about the strategic role of IT in firm performance. They showed how IT investments and capabilities influence firm performance through agility as a significant organizational capability. This mediating effect of agility between IT investments and firm performance has subsequently been refined and extended in multiple studies (e.g., Liu, Ke, Wei, & Hua, 2013; Chakravarty et al., 2013; Gligor & Holcomb, 2012). These results further show that digitization will improve firm competitiveness and performance in as much as it results into enhanced agility, hence, to be more of a demand chain management (Jüttner, Christopher, & Baker, 2007), rather than a supply chain management alone. Fig. 1 informed that 2006 constituted a tipping point in ASC scholarship, Table 4 enables to see specifically which studies contributed to this state of affairs, namely Agarwal et al. (2006), Overby, Bharadwaj, and Sambamurthy (2006), Swafford, Ghosh, and Murthy (2006) or Lin, Chiu, and Chu (2006). One key feature of these studies is their attempt to formalize the agile concept (in contrast to other nomologically-related ones such as lean or leagile for example (e.g., Agarwal et al., 2006) and thus to measure it quantitatively (e.g., Lin et al.'s (2006) fuzzy agility index). Providing quantitative rigor was easier due to the IT- and information-centric nature of ASC (Christopher, 2000). Quantification also rendered the abstract and vague concept of ASC more concrete and accessible for a whole range of stakeholders including scholars.

### 2.3.7. Articles by topic area

Five topic areas have been identified and papers have been grouped

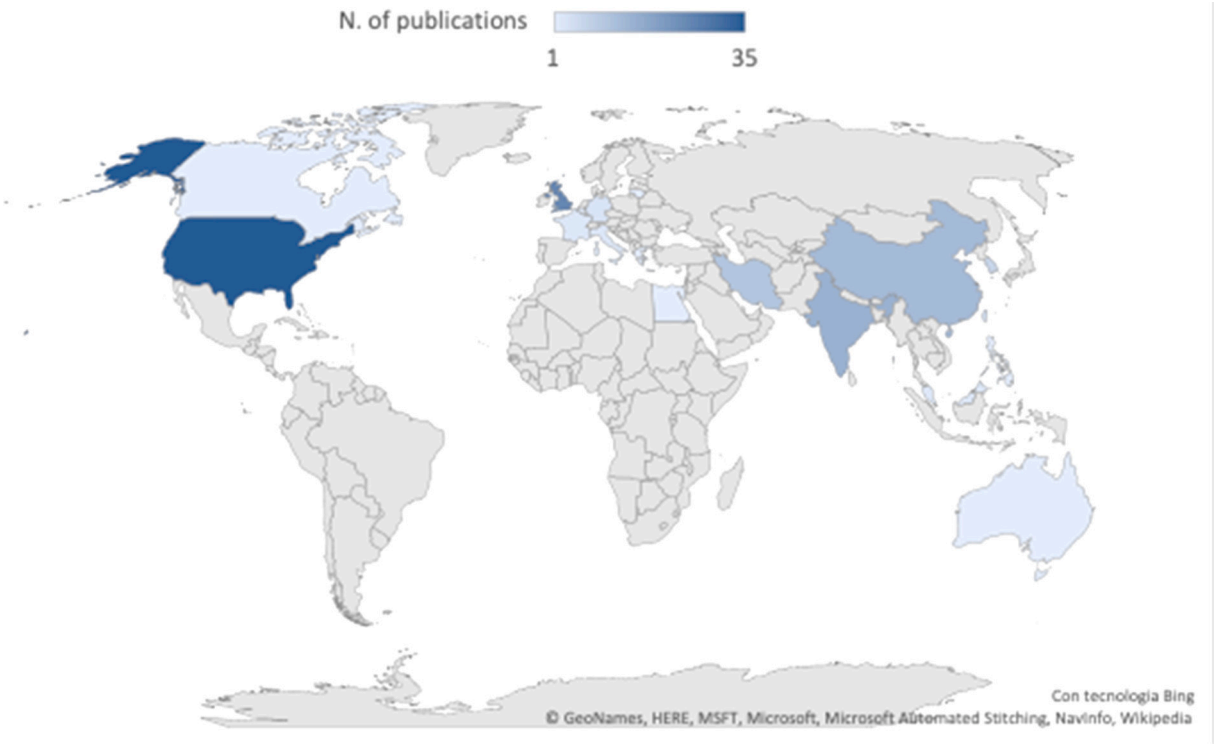


**Fig. 2.** Agile supply chain publications by first author's country of affiliation.

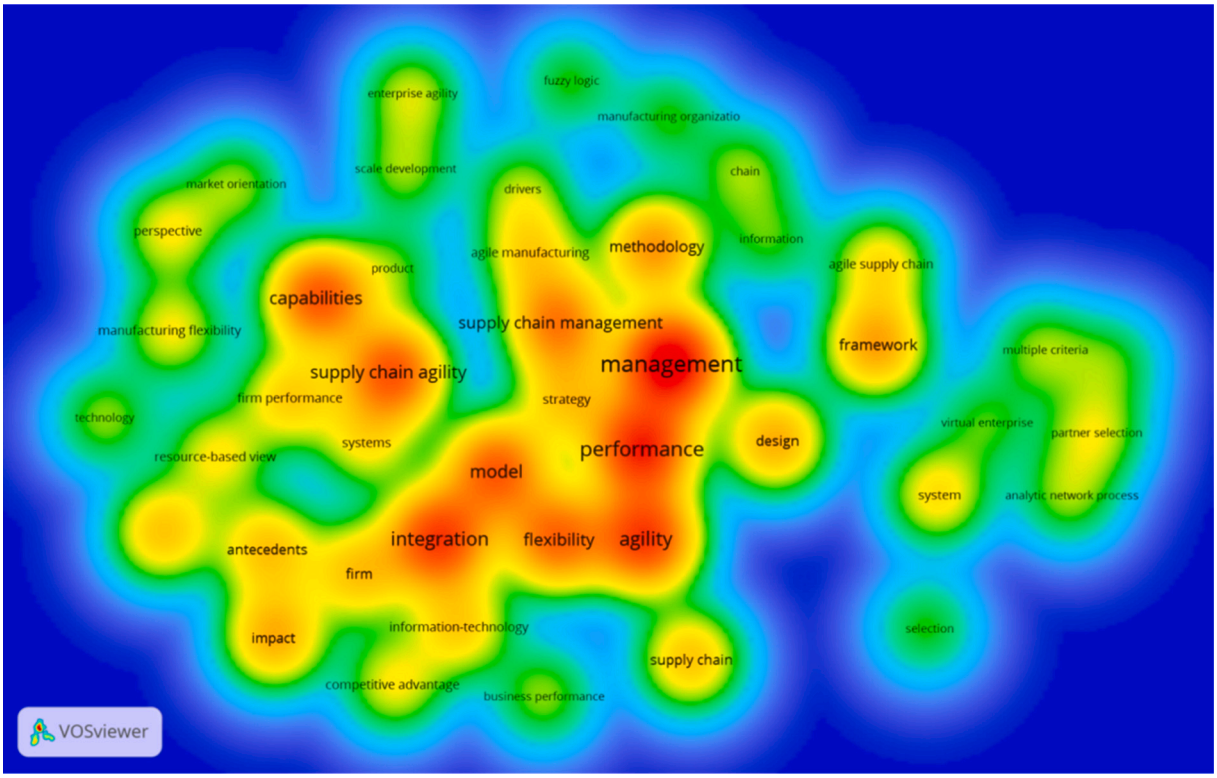


**Fig. 3.** Citation network of the evolution of the ASC field (based on historiography).

into them. We shall analyse the treatment of technology across all of these areas:

1. "Factors affecting ASC" in which authors analyse main organizational, managerial and relational factors related to the introduction of the agility concept in supply chain;
2. "Barriers in developing ASC" in which authors describe the main factors hindering the development of ASC;
3. "Suppliers selection under ASC" in which authors analyse new mechanisms and approaches adopted for partners selection;
4. "Impact of supply chain agility on business performance" in which the impact of agility on individual firm performance is analysed;

**Table 4**
Top 15 ASC articles based on citations.

| Reference | Journal | Scopus citations |
|---|---|---|
| Sambamurthy et al. (2003) | MIS Quarterly | 1656 |
| Christopher (2000) | Industrial Marketing Management | 1058 |
| Yusuf et al. (1999) | International Journal of Production Economics | 664 |
| Agarwal et al. (2006) | European Journal of Operational Research | 536 |
| Braunscheidel and Suresh (2009) | Journal of Operations Management | 488 |
| Overby et al. (2006) | European Journal of Information Systems | 477 |
| Swafford et al. (2006) | International Journal of Production Economics | 612 |
| van Hoek, Harrison, and Christopher (2001) | International Journal of Operations & Production Management | 477 |
| Lin et al. (2006) | International Journal of Production Economics | 341 |
| Power, Sohal, and Rahman (2001) | International Journal of Physical Distribution & Logistics Management | 306 |
| Swafford, Ghosh, and Murthy (2008) | International Journal of Production Economics | 272 |
| Mason-Jones and Towill (1999) | International Journal of Production Economics | 257 |
| Inman, Sale, Jr, and Whitten (2011) | Journal of Operations Management | 212 |
| Liu et al. (2013) | Decision Support Systems | 194 |
| Tsourveloudis and Valavanis (2002) | Journal of Intelligent and Robotic Systems | 178 |

5. "ASC performance measurement" in which authors investigate the correlation between agility and supply chain performance.

Table 5 highlights that "Factors affecting ASC" is the largest topic area (including 33 articles); "ASC performance measurement" includes 23 articles; "Impact of supply chain agility on business performance" includes 19 articles; "Suppliers selection under ASC" includes 18 articles, and "Barriers in developing ASC" includes 5 articles. It should be noted that several articles deal with more than one topic area. For this reason, the contributions reported in Table 5 exceeds the total number of articles analysed (90). There is no topic specifically focused on technology. Instead, technology is examined across each of these various areas.

## 3. Network visualization

### 3.1. Citation analysis

We used the CiteNetExplorer to analyse and visualize the network of citations. This tool highlights primordial articles in two ways. First, it points out articles which have citation links with at least ten other core articles (van Eck & Waltman, 2014). Second, this tool uses a transitive reduction method under which reduction considers merely necessary relations referred as the sole connection between two articles. Furthermore, it visualizes the developed network with publication year on the vertical axis and nearness between the articles on the horizontal axis (van Eck, Waltman, Dekker, & van den Berg, 2010; Vogel et al., 2020). In this line, we set the resolution parameter to 1 and the minimum cluster size to 5 which resulted into the detection of 156 citation links among the 46 core articles published on ASC.

#### 3.1.1. Historiography results

Fig. 3 highlights that the work of Jay B. Barney "*Firm resources and sustained competitive advantage*" published in 1991 appears as the first contribution for developing ASC research. Jay B. Barney is Professor of Strategic Management at the University of Utah, Salt Lake City, United States, and best known for his contribution to the resource-based theory of competitive advantage. The contribution of Paul Kidd "*Agile manufacturing: Forging new frontiers*" published in 1994 came out as the second contribution towards the evolution of ASC literature. In 1995, other relevant contributions characterized the evolution of the ASC literature, i.e. the contribution of Steven L. Goldman et al. "*Agile competitors and virtual organizations: Strategies for enriching the customer*" and the paper of Ashok Kumar and Jaideep Motwani "*A methodology for assessing time-based competitive advantage of manufacturing firms*" published in the same year.

As for the most relevant papers in terms of citations in this network, the work of Martin Christopher "*The agile supply chain: competing in volatile markets*" published in 2000 in Industrial Marketing Management is highly cited by other scholars. Martin Christopher is Professor of Logistics and Supply Chain Management at Cranfield School of Management, Cranfield, United Kingdom with expertise on lean and agile strategies. The aforementioned work of Steven L. Goldman et al. was also highly cited in the ASC literature. Furthermore, the paper of Yahaya Y. Yusuf et al. "*Agile manufacturing: The drivers, concepts and attributes*" published in 1999, and the paper of Ching-Torng Lin et al. "*Agility index in the supply chain*" published in 2006, emerge as highly cited studies in the network.

#### 3.1.2. Thematic results

To develop deep understating about the development of the ASC domain and how the state-of-art has been moved forward over the time period, the thematic analysis allows us to identify two main clusters (cluster 1 = blue; cluster 2 = green) including 46 core articles as shown in Fig. 3. Both cluster 1 and cluster 2 comprise 23 articles.

Although the two clusters include an equal number of articles, cluster 1 (blue) (Fig. 4) reports a higher number of citation links (64). The early theme under this cluster deals with *agile manufacturing as a competitive advantage* (Christopher, 2000; Goldman et al., 1995; Kidd, 1994; Kumar & Motwani, 1995). Another important theme concerns *agility measurement* (Arteta & Giachetti, 2004; Giachetti et al., 2003; Sieger et al., 2000; Van Hoek et al., 2001). This theme covers agile measurement indicators, agile capabilities measurement and evaluation, and agile performance measurement. In addition, another theme which appeared in this cluster regards *partners' selection for ASC* (Luo et al., 2009; Sarkis et al., 2007; Wu et al., 2009; Wu & Barnes, 2010). This theme covers strategic supplier selection models, partners' selection criteria, information processing models, and multi-objective programming model for suppliers' selection. The last theme under first cluster deals with the *antecedents of SC agility* (Bottani, 2010; Swafford et al., 2006). This theme covers both internal and external enablers, such as procurement/sourcing flexibility, manufacturing flexibility, distribution/logistics flexibility, market competition, technological changes, market changes, customer needs, and social factors.

In the cluster 2 (green) (Fig. 5), there are 55 citation links. The early theme in this cluster concerns *firm's dynamic capabilities* (Barney, 1991; Eisenhardt & Martin, 2000; Teece, Pisano, & Shuen, 1997; Yusuf, Gunasekaran, Adeleye, & Sivayoganathan, 2004). This theme leverages on the resource-based view in environments affected by rapid changes. Another important theme regards the *development and implementation of agile and lean strategies* (Aitken, Christopher, & Towill, 2002; Katayama & Bennett, 1999). Subsequent crucial theme in this cluster is represented by the *digitization of SC* (Braunscheidel & Suresh, 2009; Lee, 2004; Sambamurthy et al., 2003; Vickery et al., 2010). This theme

**Table 5**
Paper distribution by topic area.

| Topic area | References | |
|---|---|---|
| 1. Factors affecting ASC (33) | Bidhandi & Valmohammadi, 2017 | Lin et al. (2006)* |
| | Bottani (2010) | Liu et al. (2013)* |
| | Braunscheidel and Suresh (2009) | Lowry and Wilson (2016) |
| | Brusset (2016) | Moon, Lee, and Lai (2017) |
| | Chan, Ngai, and Moon (2017) | Nemkova (2017)* |
| | Chiang, Kocabasoglu-Hillmer, and Suresh (2012) | Overby et al. (2006) |
| | Christopher (2000) | Sambamurthy et al. (2003) |
| | DeGroote and Marx (2013)* | Sangari and Razmi (2015) |
| | Gligor (2014) | Sangari, Razmi, and Zolfaghari (2015) |
| | Gligor and Holcomb (2012) | Swafford et al. (2006) |
| | Gligor and Holcomb (2014) | Swafford et al. (2008) |
| | Gligor et al. (2016) | Tse et al. (2016)* |
| | Huang, Ouyang, Pan, and Chou (2012) | Um (2017a) |
| | Inman et al. (2011)* | Vickery, Drogea, Setiab, and Sambamurthya (2010)* |
| | Khan and Pillania (2008) | |
| | Kim and Chai (2017) | Yang (2014)* |
| | Li, Lin, and Wang (2006) | Yusuf et al. (1999) |
| 2. Barriers in developing ASC (5) | Hasan, Shankar, and Sarkis (2007) | Masson, Losif, Mackerron, and Fernie (2007) |
| | Matawale, Datta, and Mahapatra (2013) | Storey, Emberson, and Reade (2005) |
| | Mason-Jones and Towill (1999) | |
| 3. Suppliers selection under ASC (18) | Abdollahi, Arvan, and Razmi (2015) | Mokadem (2017) |
| | Alimardani, Zolfani, Aghdaie, and Tamosaitiene (2013) | Qrunfleh and Tarafdar (2013) |
| | Alimardani, Rabbani, and Rafiei (2014) | Ren, Yusuf, and Burns (2009) |
| | Beikkhakhian, Javanmardi, Karbasian, and Khayambashi (2015) | Sarkis, Talluri, and Gunasekaran (2007) |
| | | Wu and Barnes (2009) |
| | Cerruti, Mena, Skipworth, and Ernesto (2016) | Wu, Barnes, Rosenberg, and Luo (2009) |
| | Lee, Cho, and Kim (2015) | Wu and Barnes (2010) |
| | Luo, Wu, and Rosenberg (2009) | Wu and Barnes (2012) |
| | Matawale, Datta, and Mahapatra (2016) | Wu and Barnes (2014) |
| | Mishra, Sahu, Datta, and Mahapatra (2015) | |
| 4. Impact of supply chain agility on business performance (19) | Blome et al. (2013) | Roberts and Grover (2012) |
| | DeGroote and Marx (2013)* | Shin et al. (2015) |
| | Eckstein, Goellner, Blome, and Henke (2015) | Tarafdar and Qrunfleh (2017) |
| | Gligor, Esmark, and Holcomb (2015) | Tse et al. (2016)* |
| | Inman et al. (2011)* | Um (2017b) |
| | Khan, Bakkappa, Metri, and Sahay (2009) | Vickery et al. (2010)* |
| | Yang and Liu (2012) | Wu, Tseng, Chiu, and Lim (2017) |
| | Liu et al. (2013)* | Yang (2014)* |
| | Nemkova (2017)* | Yusuf, Gunasekaran, et al. (2014) |
| | Power et al. (2001) | |
| 5. ASC performance measurement (23 papers) | Agarwal et al. (2006) | Routroy, Potdar, and Shankar (2015) |
| | Arteta and Giachetti (2004) | Routroy and Shankar (2015) |
| | Ganguly, Nilchiani, and Farr (2009) | Sahu et al. (2016) |
| | Giachetti, Martinez, Saenz, and Chen (2003) | Samantra, Datta, Mishra, and Mahapatra (2013) |
| | Jain et al. (2008) | Sarkis (2001) |
| | Khalili-Damghani and Taghavifard (2012) | Sieger, Badiru, and Milatovic (2000) |
| | Khalili-Damghani and Tavana (2013) | Tsourveloudis and Valavanis (2002) |
| | Khalili-Damghani, Taghavifard, Olfat, and Feizi (2011) | van Hoek et al. (2001) |
| | Lin et al. (2006)* | Weber (2002) |
| | Mishra et al. (2014) | Yang and Li (2002) |
| | Patel, Samuel, and Sharma (2017) | Yauch (2011) |
| | Potdar and Routroy (2017) | |

* These papers deal with two topic areas.

covers the impact of information technology investment and infrastructure on organizational capabilities and ASC performance. Finally, *SC integration and flexibilities* (Prater, Biehl, & Smith, 2001; Swafford et al., 2008) and *logistics efficiency* (Gligor & Holcomb, 2012) emerged as two additional important themes.

In summary, in this section we analysed the outcomes of the historiography and thematic knowledge building patterns under ASC over time. Firstly, we investigated the core articles grouped into clusters, the articles more strongly connected within their own cluster, and slightly connected with other clusters. Secondly, we analysed how the two clusters focus on different themes contributing to the ASC literature. Vogel et al. (2020) recommend to perform co-citation analysis after the historiography and thematic knowledge to uncover more insights. Accordingly, the next section is dedicated to co-citation analysis.

### 3.2. Co-citation analysis

In this study, we use co-citation analysis with VOSviewer to perform science mapping. Co-citation appears, when both A and B (considering that A and B may be articles, authors, or journals) are together cited by C (where C may be an article, an author, or a journal) (Ertz & Leblanc-Proulx, 2018). High (low) co-citations demonstrate similar (different) research themes and interests (Benckendorff & Zehrer, 2013). The network of citations provides evidence of the intellectual base of a knowledge domain (Liu, Yin, Liu, & Dunford, 2015).

#### 3.2.1. Co-citation analysis of cited references

To develop a better understanding pertaining to the theoretical roots of the sampled articles, we use a co-citation analysis in which the quoted references constitute the key element of analysis. Within the

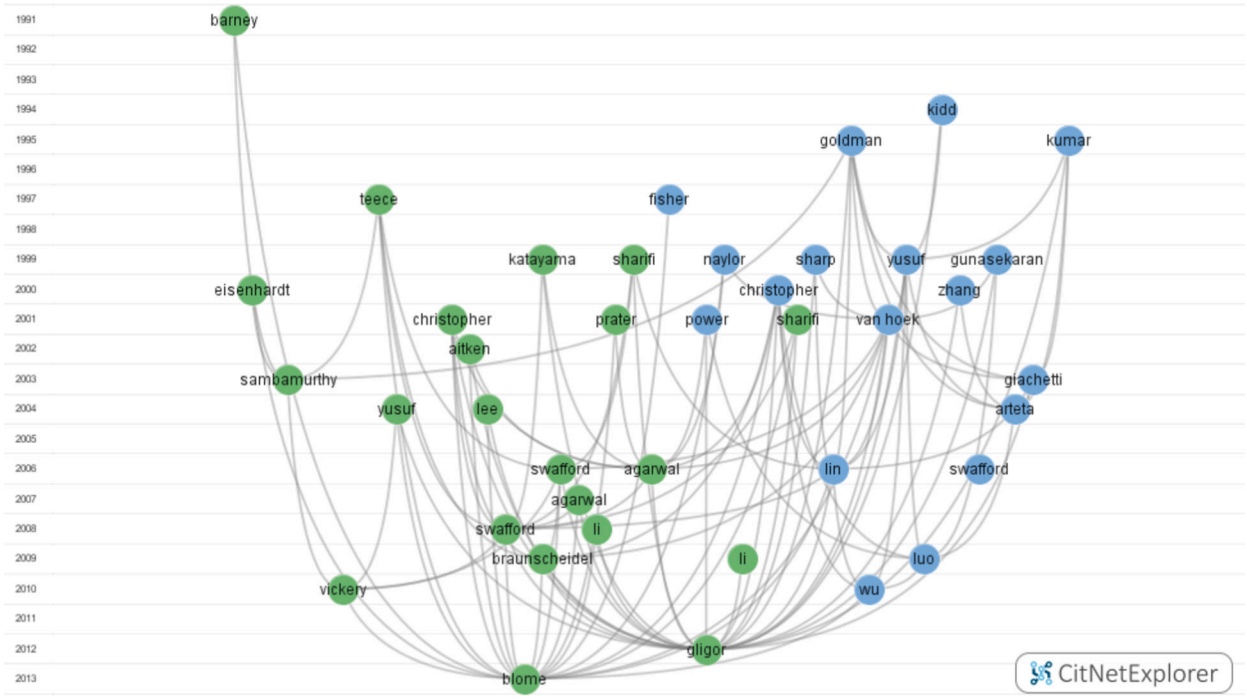


**Fig. 4.** Citation network of the evolution of the ASC field under cluster 1.

original sample of 90 articles, a total of 3210 cited references were identified which were further reduced to articles with a minimum of 6 citations, resulting in 103 useful references. From the 103 references, 11 were methodological papers that are unrelated to the field of ASC and were thus removed from the sample. The co-citation analysis was, therefore, performed on the reduced sample of 92 items. Fig. 6 shows the articles that are the most frequently cited together being grouped within clusters. Node size indicates the frequency of citation of a given article by other articles in the dataset.

"*The agile supply chain: Competing in volatile markets*" published by Christopher (2000) emerged as the most co-cited article (40 times). Lin et al.'s (2006) *"Agility index in the supply chain"*, Yusuf et al.'s (1999) *"Agile manufacturing: The drivers, concepts, and attributes"*, and Swafford et al.'s (2006) *"The antecedents of supply chain agility of a firm: Scale development and model testing"*, emerged respectively as the second (27 co-citations), third (26), and fourth (25) most co-cited papers. Interestingly, Swafford et al.'s (2008) *"Achieving supply chain agility through IT integration and flexibility"* and Agarwal et al.'s *"Modeling agility of supply chain"* (2007) appeared not only frequently co-cited (both being co-cited 21 times) but also made the case for a better integration of IT to achieve ASC. These two papers were thus frequently co-cited by authors who approached ASC from an IT or digitization perspective.

Further, network analysis classified the 92 papers into 3 clusters. The first cluster (in red) comprises 36 articles. The research under this cluster represents the "*drivers of SC agility*" including Swafford et al. (2006, 2008), or Agarwal et al. (2006). The second cluster (in green) encompasses 28 articles. Research pertaining to this cluster revolves around the "*organizational capabilities for achieving SC agility*" including Burgess (1994), Baker (2008), or Jain et al. (2008). The third and last cluster (in blue) includes 28 articles. The articles of this group focus on "*defining and measuring agile capabilities*" with studies such as Lin et al. (2006), Yusuf et al. (1999), Naylor et al. (1999) or Christopher (2000).

In light of Fig. 6, it is very interesting to see that, although Barney (1991) constituted the first base for ASC research, Goldman et al.'s (1995) book "*Agile competitors and virtual enterprises*" intersects simultaneously the three clusters, since it constituted a seminal work that laid the foundations for the idea of agility in organizations. This contribution has been used by other influential authors who furthered research on agility in the 1990s and in the beginning of the 2000s, such as Yusuf et al. (1999) and Christopher (2000). Christopher's (2000) article really appears central in the field by conceptualizing the notion of ASC. This interesting and valuable contribution published in *Industrial Marketing Management* connected the previous research stream, concerned with agility in manufacturing (Yusuf et al., 1999; Zhang and Sharifi, 2000; Sharifi and Zhang, 1999), with a new stream of research more focused on the concept of ASC (e.g., Lin et al., 2006; Swafford et al., 2006, 2008).

### 3.2.2. Co-citation analysis of cited authors

After processing the cited references retrieved from the 90 articles belonging to the dataset, a total of 2629 authors were identified. Using VOSviewer, this pool was further trimmed down to authors with at least 10 citations, resulting in 66 authors. We removed 11 authors of seminal methodological papers such as Hair, Podsakoff, Fornell, Larcker, or Nunnally, further reducing the total number of relevant ASC authors to 55. The clustering algorithm placed together sets of authors sharing similar characteristics (Radicchi et al., 2004) (Fig. 7). The analysis reveals that Christopher M. is the most co-cited author and appears more frequently cited along Sharifi H, Goldman SL, Agarwal A, and Gunasekaran A. Besides, Yusuf YY is the second most co-cited author. He is frequently cited with Lin CT, Vinodh S and Zhang Z. Moreover, Swafford PM appears the third most co-cited author, especially with Lee HL, Fisher ML, van Hoek RI or Narasimhan R. Fig. 7 further reveals that leading authors such as Christopher M, Swafford PM, Yusuf YY are closely related since they appear frequently cited together.

Furthermore, network analysis classified the 55 authors into three clusters shown in Fig. 7. Each cluster consists of a few leading ASC scholars whose contributions played a crucial role in the development of ASC research. The first cluster (in red) consists of 23 authors. This cluster includes world-renowned ASC authors such as Swafford PM, Gligor DM, Lee HL, van Hoek RI, Fisher ML, and Sambamurthy V. The second cluster (in green) comprises 16 authors. Interestingly, this cluster includes the leading researchers of SC management such as Christopher M and Gunasekaran A. It also includes Sharifi H, Agarwal A, and Goldman NL. The third cluster (in blue) consists of 16 authors, including Yusuf YY., Lin CT, Vinodh S, Wu C, and Power DJ.

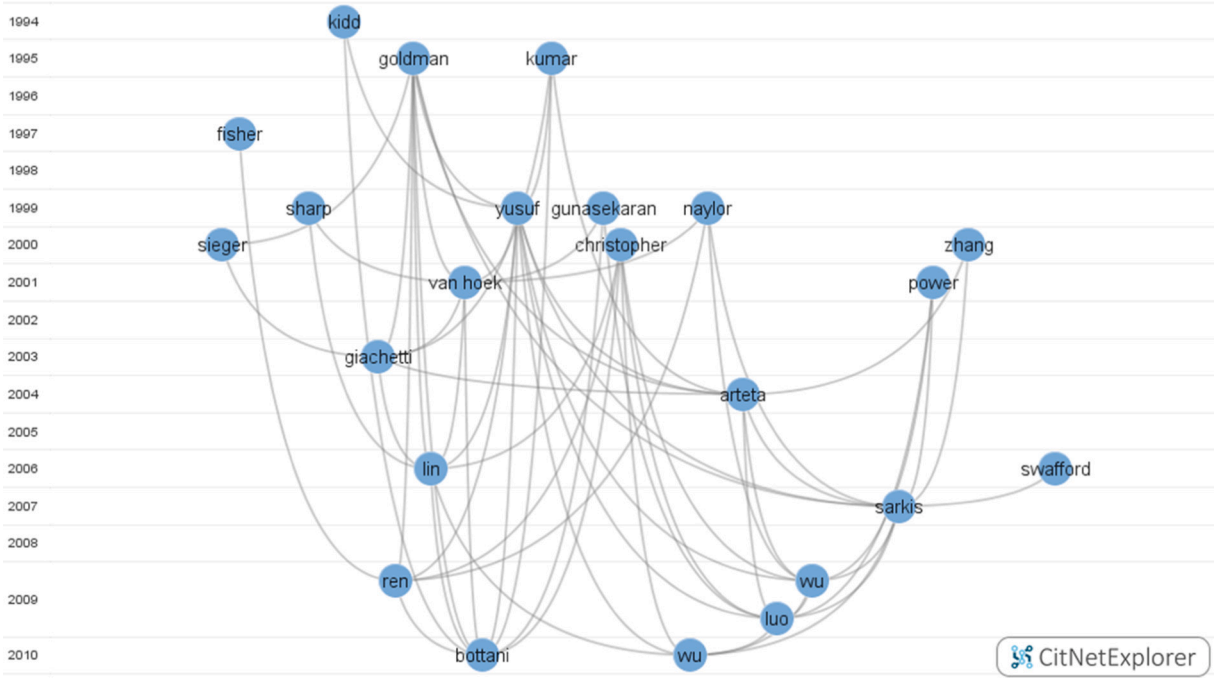


**Fig. 5.** Citation network of the evolution of the ASC field under cluster 2.

Finally, Fig. 7 also depicts clearly the two clusters of authors, namely cluster two (green) and cluster three (blue), that were primarily concerned with agility in manufacturing and agile virtual enterprises such as Yusuf (cluster 3), Sharifi and Goldman (both in cluster 2), but also Gunasekaran (cluster 2) and Lin (cluster 3). These authors are all tightly connected to each other in a close net of inter-relationships.

## 4. Theoretical frameworks

In this section, the papers have been analysed through the lens of the research designs and dominant theories developed in this context.

Fisher (1997) was one of the first scholars to connect agility with SC management. This endeavour spurred the application of SC theories to further develop the field of ASC. Prior to digging deeper into those theories, it is worth mentioning that the literature can be broadly classified into two groups: one concerned with the development of quantitative model using a diverse set of quantitative theories and approaches such as ANP-based methods (Agarwal et al., 2006), PLS-SEM (Akter, Fosso Wamba, & Dewan, 2017), the agile methodology for software development (Dingsøyr et al., 2012), fuzzy methods (Beikkhakhian et al., 2015; Khalili-Damghani & Taghavifard, 2012) or hybrid models using DEMATEL, ANP, TOPSIS, SWARA or VIKOR

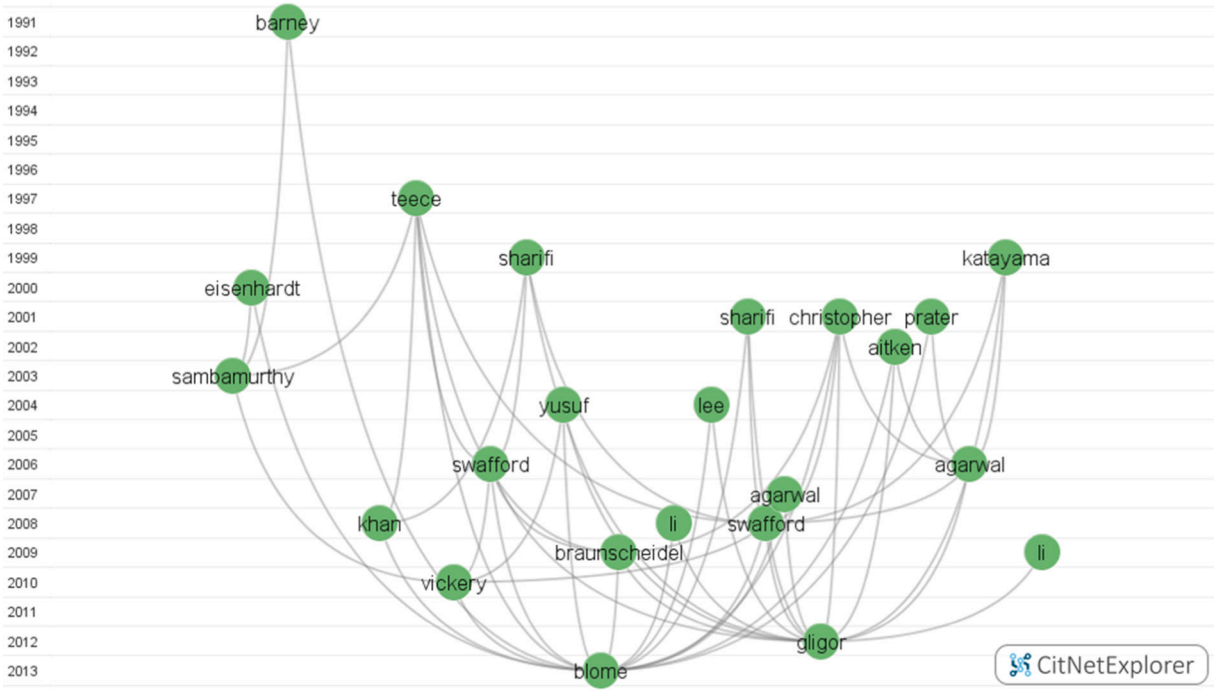


**Fig. 6.** Co-citation network of co-cited articles.

methods (Alimardani et al., 2013; Alimardani et al., 2014). The second group comprises the remaining studies covering essentially definition, measurement and analysis of antecedents, mediators, moderators and outcomes of SCA. In this group, it is first striking to see that the majority of studies, even quantitatively empirical ones, are not theory-driven, rather, they are focused on specific constructs and variables (e.g., virtual enterprise, virtual supply chain, IT). These results are consistent with (Gligor et al. 2013, Gligor, 2014).

From the theories that were nonetheless identified, a total of eleven of them were found in the ASC domain. Relational measurement theory was first in row followed by fuzzy set theory, resource-based view (RBV), continuous improvement and organizational learning theory, theory of resource complementarities, Dempster-Shafer theory, dynamic capability, network structure theory, strategic-choice theory, information theory, and contingency theory. Table 6 summarizes how these theories enriched the ASC literature. While researchers conducted empirical research, efforts were made also to develop conceptual frameworks and decision-making models. In fact, previous studies conducted surveys (Chiang et al., 2012; Eckstein et al., 2015; Qrunfleh & Tarafdar, 2013; Swafford et al., 2006; Vickery et al., 2010; Wu & Barnes, 2009; Yang, 2014; Yang & Liu, 2012), multi-criteria decision-making models (Lin et al., 2006; Wu & Barnes, 2010), and conceptual frameworks (Giachetti et al., 2003). Under such theoretical testing, special attention was given to SC integration and customer/marketing sensitivity (using fuzzy set theory), SC flexibilities (using resource-based view and dynamic capability), information technology and organizational initiatives (using theory of resource complementarities), agility of customer, supplier and competitors, network structures (using network structure theory), lean and agile strategies, strategic supplier development, postponement, SC responsiveness (using strategic-choice theory), information sharing, information technology capability and operational collaboration (using information theory), and SC adaptability and product complexity (using contingency theory). These contributions enriched the state-of-art on ASC and strengthened the firm's operational and financial performance (Blome et al., 2013).

As shown in Table 6, we notice that more recent studies tend to integrate different theories. For instance, Tarafdar and Qrunfleh (2017) use the information-processing view of the firm and Nemkova (2017) uses effectuation theory. However, in other studies the lack of an underlying theory appears justifiable. For example, Moon et al. (2017) use no theory because their research is more exploratory in purpose, while Mokadem (2017) lacks a theory due to the nature of the study (i.e., classification of supplier selection criteria). Overall, we concur with Gligor et al. on the fact that the use of theory was not prevalent in extant SCA research, but we advance that this has changed over the last decade, suggesting a certain formalization of the field.

Also, only few theories are drawn from the marketing area. The few studies founding their conceptual frameworks on marketing theories include Braunscheidel and Suresh (2009) using Slater and Narver's (1995) as well as Day's (1994) market orientation theory; and Tarafdar and Qrunfleh (2017) invoking customer relationship but not as their central theory and rather as a key mediator in their model. This is surprising given that marketing-oriented theories are well-adapted to achieve a crucial objective of SCA and that is, the dynamic adaptation to customer demand. In fact, SCA requires firms to continually analyse changes in customer needs, seek customer feedback and input, cope with changes in customer demand, or monitoring customers' expectations and satisfaction (Droge, Vickery, & Jacobs, 2012; Koufteros, Rawski, & Rupak, 2010; Ralston, Blackhurst, Cantor, & Crum, 2015). Therefore, key marketing theories such as customer-led relationship marketing (Grönroos, 2004) coupled with value theory (Ravald & Grönroos, 1996), value co-creation theory (Galvagno & Dalli, 2014), market orientation theory (Day, 1994; Slater & Narver, 1995), or service-dominant logic (Vargo & Lusch, 2008), could provide meaningful and much-needed insights into the demand side when studying SCA.

## 5. Content analysis and results

Finally, an in-depth content analysis of the 90 papers reported in Table 5 has been performed. It offers a comprehensive analysis of the

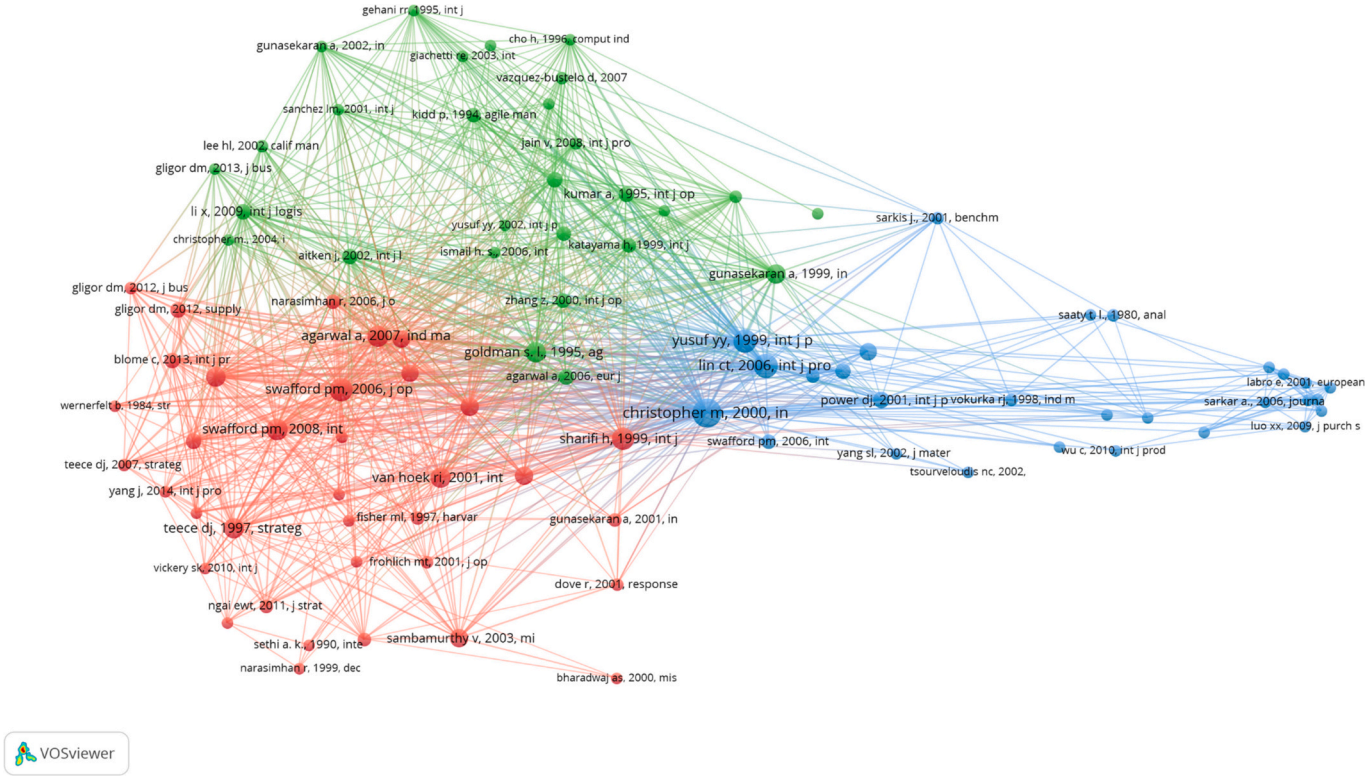


**Fig. 7.** Co-citation network of co-cited authors.

**Table 6**
SC theories in ASC context.

| No. | Theoretical approach | Primary method | Study aim | Focus | Independent constructs (IC) /Dependent constructs (DC) | Contribution |
|---|---|---|---|---|---|---|
| 1 | *Relational measurement theory*Giachetti et al. (2003) | Conceptual | Development of a measurement framework for agility | Analysis of different forms of agility measurement | NA | The research provides a comprehensive analysis of existing agility measurement methods. |
| 2 | *Fuzzy set theory*Lin et al. (2006) | Multi-criteria Decision-making model with fuzzy logic | Formulation of a fuzzy agility index | Antecedents of SC agility | IC: collaborative relationships, process integration, information integration, customer/marketing sensitivity<br>DC: SC agility | The research provides an agility index which has been tested positively in a Taiwanese firms' context for efficacy. |
| 3 | *Resource-based view*Swafford et al. (2006) | Survey | To establish the key factors that determine SC flexibility and test their association with SC agility. | SC agility scale development and model testing | IC: Procurement/sourcing flexibility, manufacturing flexibility, distribution/logistics process<br>DC: SC agility | The research highlights that SC agility is directly and positively influenced by the extent of flexibility that exists in the procurement/sourcing and production processes of the SC, and indirectly influenced by the extent of flexibility within distribution/logistics processes. |
| 4 | *Continuous improvement and organizational learning theory*Wu and Barnes (2009) | Survey | To provide feedback and continuous improvement during the supplier selection process in ASC. | Supplier selection for ASC | IC: Complexity-fit, costs–benefits | The research confirms that collaboration with right partners provides opportunities to enter a new market, to ensure high quality raw materials, to adopt the latest technologies, to overcome financial constraints and to attain organizational learning. |
| 5 | *Theory of resource complementarities*Vickery et al. (2010) | Survey | Investigating the impact of SC IT and SC organizational initiatives on SC agility | Antecedents of SC agility | IC: Supply chain IT, supply chain organizational initiatives<br>DC: Agility, firm performance | The research shows that IT and organizational initiatives have a complementary effect on agility. |
| 6 | *Dempster-Shafer theory* Wu and Barnes (2010) | Multi-criteria Decision-making model | Development of supplier selection criteria for SC agility | Supplier selection for SC agility | NA | The research formulates practical supplier selection criteria for selecting SC agility enabling suppliers. |
| 7 | *Dynamic capability*Chiang et al. (2012) | Survey | Investigating the effect of strategic sourcing and strategic flexibility on SC agility. | Drivers of SC agility | IC: Strategic sourcing<br>DC: firm's strategic flexibility, SC agility | The research shows the positive impact of both strategic sourcing and flexibility on SC agility, while partial mediation effect was further proved on the part of strategic flexibility. |
| 8 | *Network structure theory*Yang and Liu (2012) | Survey | Investigating the relationship between superior network structure, SC agility, and firm performance | Firm performance via agility and network structure | IC: Customer agility, Supplier agility, Competitor agility,<br>DC: Network closure, Structural hole, Firm performance | The research shows the positive impact of enterprise agility on network structure and organizational performance as well as the impact of network structure on organizational performance. Further, research confirmed that network structure mediates the effect of enterprise agility on organizational performance. |
| 9 | *Strategic-choice theory*Qrunfleh and Tarafdar (2013) | Survey | Investigating the function of strategic supplier partnership and postponement regarding lean and agile SC strategies and SC responsiveness. | Influence of strategic choices | IC: Lean SC strategy, agile SC strategy<br>DC: Strategic supplier partnership, postponement, SC responsiveness, firm performance | The research shows that strategic supplier partnership mediates the association between a lean SC strategy and SC responsiveness, and that postponement partially mediates the association between SC agility strategy and SC responsiveness. Lastly, SC responsiveness improves firm performance. |
| 10 | *Information theory*Yang (2014) | Survey | Antecedents of manufacturers SC agility and the connection of SC agility with firm performance | Antecedents of SC agility | IC: Information sharing, firm's IT capability, operational collaboration<br>DC: Firm's SC agility, cost efficiency, performance | The research shows IT capability and operational collaboration with suppliers as antecedents of SC agility. Also, research reported the significant mediating influence of cost efficiency between the SC agility and firm's performance. |

(*continued on next page*)

**Table 6** (*continued*)

| No. | Theoretical approach | Primary method | Study aim | Focus | Independent constructs (IC) /Dependent constructs (DC) | Contribution |
|---|---|---|---|---|---|---|
| 11 | *Contingency theory*Eckstein et al. (2015) | Survey | Investigating the effect of SC agility and SC adaptability on cost and operational performance | Predictors of agile based performance | IC: SC adaptability, product complexity<br>DC: SC agility, cost performance, operational performance | The research highlights that SC agility and SC adaptability significantly and positively impact both cost and operational performance, and supported the mediating role of SC agility between SC adaptability and performance. Likewise, research claimed the moderating effect of product complexity between SC adaptability and cost performance as well as between SC adaptability and operational performance. |

variety of issues covered within the literature on ASC context and emphasizes how technology has been investigated and conceptualized in relation to the overall ASC construct.

### 5.1. Factors affecting ASC

Early on, several claims were formulated in the burgeoning ASC literature proffering IT-enabled processes for agility (Burgess, 1994), as a synthesis of diverse technologies (Burgess, 1994; Kidd, 1994) with high information and value-creating content (Goldman & Nagel, 1993).

Consequently, a first group of studies examining factors effecting ASC, focused on the multifarious roles of technology. To Yusuf et al. (1999, p. 41), technology is a key decision domain of an agile organisation. Christopher (2000) classified factors affecting ASC in four categories: physical collaboration, information systems, alignment, and flexibility. In addition, three studies showed how information technology (IT) investments and IT integration positively impact ASC (Overby et al., 2006; Sambamurthy et al., 2003; Swafford et al., 2008). Most of subsequent literature on this subject came to similar conclusions. Using a principal component analysis, Bottani (2010) reproduced Yusuf et al.'s (1999) quantitatively "technology decision domain" but found it is the most relevant agile attribute, after employees' roles and competency. She also found that agile attributes must be matched with relevant agility enablers, and she also underscored how "technical tools" such as "virtual enterprise formation tools and metrics" (e.g., computer-aided systems, flexible manufacturing/assembly systems) or "management information systems" (Gunasekaran, 1998), are "the most important enablers for a company to become agile" (Bottani, 2010, p. 260). Other relevant enablers included engineering tools, information tools (e.g., enterprise resource planning systems [ERP], intranet/extranet connections), and time-value analysis techniques (e.g., electronic data interchange [EDI], virtual prototyping tools), all being IT-related tools (Bottani, 2010). Further studies refined the underlying mechanism of technological IT integration and agility with additional conceptual accuracy and refinements. Huang et al. (2012) conducted a case study involving *Haier*, China's largest producer of household appliances, and concluded that IT influences the competency of achieving operational agility. Liu et al. (2013) showed how firm flexible IT infrastructure, IT assimilation and absorptive capacity affects the degree of agility in SC. Additionally, Lowry and Wilson (2016) stated that both IT service quality and internal IT service perception affect firm's IT agility.

Yet, only a handful studies offered empirical evidence of causality that firm's IT capabilities, organizational initiatives, and operational collaborations are significant predictors of improved ASC (Vickery et al., 2010; Yang, 2014). Among them, DeGroote and Marx (2013) demonstrated that IT assists firms to detect and face demand changes in the market enhancing the adequacy, accuracy, accessibility, and on-time information flows among SC actors. Meanwhile, three studies stated that firm's strategic flexibility significantly impact SC agility (Chan et al., 2017; Chiang et al., 2012; Khan & Pillania, 2008).

Actually, some studies that sought to determine the key factors for attaining agility barely mentioned the technological component (e.g., Sangari et al., 2015), while others did not mention it at all (Moon et al., 2017; Um, 2017a). Sangari et al. (2015) developed a schema including the factors that assist in attaining agility. The study found twelve critical factors that positively impact ASC (i.e., culture of learning and changes, collaboration among SC partners, management commitment and support, integration of agility into strategic context if the SC, information flow, use of agile-enabling technologies, intra-organizational collaboration, competency of employees, well recognized need for agility, management competency and continues improvement of the SC and business environment). Moon et al. (2017) employed a qualitative approach (i.e., interviews) to identify the most important ASC success factors. The field analysis conducted in South Korea's *Dongdaemun* fashion market reveals that the most important factors are: a self-

sufficient structure, different integrated network, strong entrepreneurship, close and long-lasting seller relationships, and quick-response delivery and inventory replenishment. Um (2017a) surveyed 363 manufacturing UK and South Korean firms and suggest that external integration and internal variety management strategy positively influence both SC flexibility and agility.

A second group of studies focused on the importance of information sharing within the ASC. Li et al. (2006) introduced two models (i.e., Directed Acyclic Supply Network and Impact Network), to make the case that on-time information sharing from the downstream firm could alert the upstream stage about SC disruption which further can contribute in taking best decisions to offset the effect of the disruption. Sangari and Razmi (2015) conducted a survey of 184 manufacturing firms in Iran and found that business intelligence competence positively impacts ASC. Tse et al. (2016) demonstrate how external learning positively influences ASC. Furthermore, Kim and Chai (2017) showed how information sharing, supplier innovation, and strategic sourcing positively related to ASC. While, in the literature, external and internal managerial processes are also found as dominant factors that affect ASC (Brusset, 2016). Braunscheidel and Suresh (2009) found that external flexibility positively relates to ASC. However, it is unclear how recent advances in Industry 4.0 namely Big Data emanating from Internet of Things systems and ICT, onto which are applied Machine Learning (ML) frameworks (e.g. Decision Trees, Naïve Bayes Classification, Logistic Regression, Support Vector Machines, Clustering, Ensemble Methods, Principal Component Analysis, or Singular Value Decomposition) (Le, 2016), and other smart predictive informatics tools (Lu, 2017), could further advance those information sharing capabilities.

To summarize, the contributions focused on this first area analyse the extent to which technology has been identified as a key factor affecting ASC. It appears that technology is an essential component of ASC but that its presence is either too implicit to be mentioned or that its deployment is contingent upon more fundamental factors as those identified by Sangari et al. (2015), Moon et al. (2017), or Um (2017a). Additionally, past research provides little insight into how recent advances commonly referred to under the industry 4.0 umbrella, contribute to the information sharing factor inherent to ASC. Future research could use past reviews on those technologies (e.g., Lu, 2017) in order to investigate these relationships.

### 5.2. Barriers in developing ASC

While Storey et al. (2005) classified ASC barriers into two groups: organizational and behavioural barriers, Mason-Jones and Towill (1999) reported that two out of six major obstacles to gain agility pertain to lack of technology and poor information flow. More evidently, Masson et al. (2007) adopted a case study approach and found that the lack of technical expertise, is one of three major complexities which hinder a firm's efforts from attaining the desirable level of agility, and possibly the most crucial one. Hasan et al.'s (2007) study provided deeper insights into the dynamic interactions between a broad range of barriers to agile manufacturing. First, they identified 11 major barriers preventing firms from achieving ASC. One pertains directly to technology: unavailability of appropriate technology. Two others pertain more indirectly to technology but are crucially related to it: lack of sound appraisal technique to justify high investment in advanced manufacturing technology (i.e., advanced appraisal techniques), poor partnership (SC) formation and management (i.e., technical compatibility, interoperability, and standardisation in technology). More importantly, unavailability of appropriate technology is not the root cause of failure in implementing agility. Instead, both inappropriate measures and lack of methodologies constitute the key antecedents influencing the lack of appraisal technique to justify investments in technology, and poor incorporation of flexibility measures, respectively. Both of these barriers create lack of top management support and commitment, which spurs unavailability of appropriate technology. The results point that technology appropriateness is a consequence of more fundamental managerial and leadership processes. Hence, a lack of managerial approach based on the PDCA framework, for example, is the fundamental obstacle to agility, rather than lack of technology per se.

From the analysis of barriers hindering the efforts of developing ASC, two research gaps are apparent. First researchers may zoom in the technological barrier by seeking to identify the lack of which types of technology is particularly hindering. Second, with the growth of industry 4.0 and the crucial need for further integration and connexion of the ASC, numerous technologies have grown in prominence over the last decade (Wang, Gunasekaran, Ngai, & Papadopoulos, 2016). Yet, it remains unclear to what extent varying types of shortcomings in the broader Industry 4.0 technological ensemble (i.e., Internet of Things, Cyber Physical System, Information and Communication Technology, Enterprise Architecture, or Enterprise Integration (Lu, 2017) dampen agility in SC. Furthermore, through increased virtualization, decentralization, and network building, the industry 4.0 perspective is also changing the manufacturing landscape (Brettel, Friederichsen, Keller, & Rosenberg, 2014). Yet, current manufacturing systems and thus ASC configurations are yet to adapt to Industry 4.0 requirements (Qin, Liu, & Grosvenor, 2016). In order to accurately capture unique drawbacks to this attainment, researchers may shift referent of the agile concept as considering it part of a broader whole – along with 'lean' - called 'smart manufacturing' or Industry 4.0 (Elnagar, Weistroffer, & Thomas, 2018; Yli-Ojanperä, Sierla, Papakonstantinou, & Vyatkin, 2018). In doing so, we suggest a close reading of Qin et al. (2016) on a multi-layered framework for an implementation structure of Industry 4.0 or Yli-Ojanperä et al.'s (2018) adaptation of agile manufacturing to the reference architecture model industry 4.0.

### 5.3. Suppliers selection under ASC

Given the crucial importance of network integration in ASC, the literature on supplier selection in ASC context is ripe with studies on supplier selection. This topic has been assessed according to two perspectives: (1) methods used for supplier selection; and (2) criteria used for supplier selection (Abdollahi et al., 2015).

First, methods for supplier selection share the specificity of blending IT-supported statistical, algorithmic, and decision sciences approaches. For example, techniques include analytic network process (ANP) (Sarkis et al., 2007), ANP and integer programming (Wu et al., 2009), ANP and data envelopment analysis (DEA), artificial neural networks (ANN) (Luo et al., 2009), ANN and fuzzy set theory (Wu & Barnes, 2014), decision support methodology (Ren et al., 2009), feedback and continuous improvement systems (Wu & Barnes, 2009), hybrid multiple attribute decision making (MADM) method (Alimardani et al., 2013), ISM method (Beikkhakhian et al., 2015), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and fuzzy analytical hierarchy process (AHP) (Lee et al., 2015), Multi-Objective Optimization on the basis of Ratio Analysis plus full multiplicative form (MULTIMOORA) (Mishra et al., 2015), or vague set theory (Matawale et al., 2016).

Second, with regards to criteria, it should first be noted that supplier selection depends mainly on firms' manufacturing strategy (e.g., lean or agile) (Mokadem, 2017). While lean manufacturing strategies call for incorporating partners who can improve firm's overall efficiency (e.g., cost, quality, delivery (Abdollahi et al., 2015), agile manufacturing strategies require suppliers who can improve firm's capabilities to address promptly customer requirements (e.g., human, technological, managerial, and cultural (Abdollahi et al., 2015). However, although technology was identified as one criterion for supplier selection (Abdollahi et al., 2015; Alimardani et al., 2013), and despite the fact that technology (i.e., communication and e-commerce system, capability of R&R and innovation, and production facilities and capacity), is a criterion for selecting suppliers in agile contexts, but not in lean ones (Abdollahi et al., 2015), technology is not the most important

criterion in supplier section. For example, Sarkis et al. (2007) underline four criteria (timeliness, price, quality, and quantity) to choose providers. Qrunfleh and Tarafdar (2013) highlighted the significance of time-to-market and identified the suppliers' ability to minimize the cycle-time as the most important criteria of their selection. Cerruti et al. (2016) examined the case studies of footwear manufacturers located in Italy and concluded that the specialization of suppliers could play a more vital role in improving production processes. In fact, using their integrated approach for supplier portfolio selection, Abdollahi et al. (2015) found that both human and managerial capabilities directly affect cultural and technological abilities as supplier selection criteria rather than the reverse.

To wrap up the discussion about agile supplier selection, a key aspect can be emphasized for future research. Overall, these results about the lack of centrality of the technology criterion in supplier selection overlaps with previous findings showing that managerial and leadership issues are fundamental hindrances to ASC (e.g., Hasan et al., 2007), whereas education and competency capabilities are the most important factor enabling ASC (e.g., Bottani, 2010; Yusuf et al., 1999). This does not downplay the importance of technology in ASC altogether. Rather, a deeper focus on the intertwining between managerial and leadership frameworks as well as education and competency development programs for technological improvements is needed. Future research should pay particular attention to those competences and education programs as well as managerial and leadership tools that could most adequately develop capabilities that are needed to master the digitization trend, be it in Industry 4.0 or other frameworks.

### 5.4. Impact of ASC on business performance

Earlier descriptive analyses showed that past research emphasized agility as key mediator between IT investments or capabilities and firm performance (e.g., Christopher, 2000; Sambamurthy et al., 2003; Yusuf et al., 1999). Several studies of this group confirmed this finding (e.g., Power et al., 2001; Vickery et al., 2010).

Others provided further processual details and thus nomologically-related constructs about the underlying process governing the agile-performance link. For example, Yang and Liu (2012) specified that agile abilities generate a competitive advantage to attain superior performance. Agility has been found to translate into various other strategic business objectives such as customer sensing capability and customer responding capability (Roberts & Grover, 2012), cost efficiency (Yang, 2014), information sharing capabilities (Tarafdar & Qrunfleh, 2017), customer service and differentiation (Um, 2017b), as well as external learning (Tse et al., 2016). In international contexts, agility impacts firm performance through enhanced knowledge about overseas markets environment, overseas markets experience, learning orientation and ambiguity tolerance (Nemkova, 2017).

Another group of studies specified the business performance types enabled by agility abilities, namely operational, market, and financial performances (Eckstein et al., 2015; Inman et al., 2011), operational performance (Blome et al., 2013; Eckstein et al., 2015; Shin et al., 2015), financial performance (Gligor et al., 2015), high sales, market share, speed to market, profitability, and customer satisfaction (DeGroote & Marx, 2013), market share, return on assets, average selling price, overall product quality, and overall customer service level (Yang, 2014), and customer retention rate (Shin et al., 2015). It should be mentioned that in Shin's (2015) study, the effect is correlational, not causal, and the authors did not find any impact on firm's financial performance.

On the mediating effect of agility, Power and Sohal (2001) described the extent to which the development of new products and improvement of productivity using the latest technologies in ASC, facilitates the fulfilment of changing customers' requirements and enhances customer-related performance, hence firm performance. In this line, Liu et al. (2013) defined that absorptive capacity along with ASC completely mediate the impacts of IT capabilities on organizational performance. Tse et al. (2016) used a survey-based methodology and contacted 266 Chinese's electronic firms. The survey results stressed that agility positively influences firm performance. In addition, agility fully mediates the effect of SC integration and external learning on firm performance.

In summary, the literature highlights that ASC can have a positive impact on a number of performance indicators: economic and financial performance (e.g., profit, sales growth, selling price, cost reduction, return on assets), market performance (e.g., market share, customer service quality, customer satisfaction, customer retention rate), technical performance (e.g., innovation, growth in core competence, productivity, flexibility technical, overall product quality) and operational performance (e.g., external partner and relationship, diffusion of new ideas, organizational agility, flexibility in resources utilization). Further agility enables the attainment of such performances through various processes: customer-related (e.g., customer sensing and customer responding capabilities, customer service, market knowledge, market experience), strategic (e.g., differentiation, ambiguity tolerance, learning), and informational (e.g., information sharing capabilities, knowledge). Yet, although some studies investigated how technology investments increase firm performance through agility (e.g., Liu et al., 2013; Power et al., 2001; Tse et al., 2016), several research gaps remain. First. it remains unclear to what extent these investments, especially most recent ones in digitization (e.g., Big Data, Internet of Things, artificial intelligence) contribute to the abovementioned underlying processes, mediating agility and performance. Second, it is also unclear which performance indicators they impact more specifically. Future research is crucially needed on this strategic topic. Third, although many studies investigated the underlying processes through which agility impacts firm performance, little research investigated the process underlying IT investments and capabilities on agility. Future research might seek to unveil the key success factors, best practices or criteria that spur agility from technological assets.

Additionally, as seen so far, given that successful implementation of agility depends tremendously on management/leadership and learning/competence, the human factor is at the core. Yet, this literature does not investigate the human performance factor underlying the link between technology investments in SC and agility, or between agility and underlying processes or performance indicators directly. In line with Yusuf et al. (1999) or Bottani (2010), on this topic, future research could focus on such concepts as creativity, entrepreneurial growth, staff performance, or staff satisfaction.

### 5.5. ASC performance measurement

Similarly to supplier selection methods, a number of methods and techniques were advanced to improve ASC performance measurement (e.g., Van Hoek, 2001; Sieger et al., 2000). These methods and techniques rely on mathematical models (Giachetti et al., 2003), AHP models (Agarwal et al., 2006), the balanced scorecard (Arteta & Giachetti, 2004), indices (Lin et al., 2006; Sahu et al., 2016) (e.g., Fuzzy Agile Manufacturing Index (Routroy et al., 2015), marketing, operational and financial metrics (Ganguly et al., 2009; Jüttner et al., 2007), metrics (Sahu et al., 2016), (in)tangible attributes (Jain et al., 2008), measurement models (Yauch, 2011), data envelopment analysis (DEA) models (Khalili-Damghani & Tavana, 2013), benchmarking (Sarkis, 2001), agility estimation methods (Yang & Li, 2002), knowledge-based frameworks (Tsourveloudis & Valavanis, 2002), hierarchical models (Weber, 2002), fuzzy logic (Potdar & Routroy, 2017; Routroy et al., 2015; Routroy & Shankar, 2015; Sahu et al., 2016; Tsourveloudis & Valavanis, 2002), performance value analysis (Potdar & Routroy, 2017; Routroy & Shankar, 2015), MADM appraisement modules (Sahu et al., 2016), systematic procedural framework (Samantra et al., 2013), or human perception-based model (Patel et al., 2017). Furthermore, Khalili-Damghani et al. (2011) proposed a method to evaluate the

efficiency of ASC capabilities and Khalili-Damghani and Taghavifard (2012) developed a model to evaluate the related efficiency of process and sub-processes.

It appears that few studies address how digitization may improve the measurement of agility. In light of the recent uptake in abundant (Monahan & Hu, 2015; Mussomeli et al., 2016), multidirectional and real-time information flows (Schoenherr & Speier-Pero, 2015), to advanced analytics techniques and algorithms (Richey et al. 2016), measurement could improve in many ways to better assess ASC performance. Past studies have called for the need for managers to understand big data business analytics on logistics and supply chain management into a broader framework called supply chain analytics (Wang et al., 2016). This is especially crucial in an information-centric environment such as SCA that relies on accurate data about customers, suppliers and other stakeholders to be successful (Christopher, 2000). Extant research already showed that big data analytics capabilities has a positive and significant effect on SCA, especially under higher levels of organizational flexibility (Dubey, Gunasekaran, & Childe, 2018). This research provides some preliminary hints at the extent to which big data contributes to agility especially through improved measurement processes such as the use of advanced tools (e.g., optimization, regression, simulation) for data analysis, the use of (un)structured data (e.g., reports, tweets, Instagram, Youtube) for data analysis, use of complex visualization techniques to assist in understanding complex information extracted from large-scale data, or connected dashboard applications which encompass useful information that is necessary for diagnosis (Akter et al., 2017; Srinivasan & Swink, 2018). Future research could provide new methods that harness the power of these descriptive, predictive and prescriptive analytics (Delen & Ram, 2018), in measuring agile capabilities in the supply chain.

## 6. Conclusions and implications

Over the years, the agility philosophy has become a solution to many complications arising in today's changing and volatile networks that need ever more responsiveness. With 90 studies published on ASC, this study provides substantial advice for scholars and practitioners alike on the technological component in ASC. The consistent and positive relationship found between technology investments and agility through the attainment of multiple capabilities (e.g., customer sensing capabilities, customer responding capabilities, customer service, market knowledge, market experience, differentiation, ambiguity tolerance, learning, information sharing capabilities, and knowledge), provide strong evidence in favour of selecting and developing a (technology-driven) ASC. It appears that ASC is particularly well-suited for organizations that desire to achieve growth from the combination of networks, customer focus, process and technology such as digitization. However, both scholars and practitioners need to understand a few nuances about the centrality of technology in the particular context of ASC, and possibly in SC as a whole. Drawing on a co-citation analysis of articles, this study has identified three neat clusters of articles (i.e., *drivers of SC agility*, *organizational capabilities for achieving SC agility*, and *defining and measuring agile capabilities*") focusing on specific areas of ASC field, and constituting, therefore, its intellectual foundations. The first cluster, "*drivers of SC agility*" refers to ASC antecedents and consequences, operational collaboration, technological resources, and IT integration. Technology is addressed through operational lenses with a focus on hardware, software, human capital, systems and processes. The second cluster, "*organizational capabilities for achieving SC agility*" deals with ASC methodologies and frameworks, product exchange standards, flexibility measurement, and the development of ASC instrument. In this cluster, technology appears as a useful means to tackle measurement issues in ASC. Technology may also create new approaches and methodologies such as Big Data-related technology which enables more inductive or bottom-up perspectives in problem identification and solving. The research areas under cluster 3 - *defining and measuring agile capabilities* - include benchmarking for agility, formulating partners' selection criteria, and evaluation of partners' capability, and partners' performance. Technological aspects are less salient in this cluster but could be developed further in forthcoming research. In fact, technology might meaningfully assist in assessing the most relevant criteria for partner selection. Likewise, it could drastically improve benchmarking capabilities.

Two keywords groups emerged from the analysis. While the first is focused on strategic and managerial thinking in the ASC field, the second is more concerned with operational and practical issues. Both are important, yet both have been singled out as distinctive groups.

This three-cluster articles' categorization assists managers in identifying the theoretical roots of the ASC field. First, it enables to evaluate the present body-of-knowledge in term of antecedents of SC agility, different types of organizational capabilities, developing performance benchmarks and criteria for partners selection and their capacity evaluation. Second, the categorization underlines the future need within the appropriate clusters to make relevant decisions in light of the antecedents and barriers that have been reported to impact ASC implementation or not, and to take relevant decisions on which organizational capabilities would be more or less impactful. Third, the categorization assists managers in improving metrics and techniques to measure partners' capacity and performance. Further, an author co-citation also uncovers three neat clusters of authors that in greater extent match the articles' co-citation clusters.

As previously summarized, technology investments and capabilities have an indirect influence on organizational performance. Technological capabilities, in general, contribute to respond more quickly to short-term changes in demand and markets, and handle external disruptions more smoothly (Dubey et al., 2018). With such a dynamic, sensitive and integrated process in place, organizations attain technical (e.g., innovation, growth in core competence, productivity, flexibility, technicality, overall product quality), and operational (e.g., external partner and relationship, diffusion of new ideas, organizational agility, flexibility in resources utilization) performances, but also desirable market (e.g., market share, customer service quality, customer satisfaction, customer retention rate) and financial (e.g., profit, sales growth, selling price, cost reduction, return on assets) outcomes. Customers are better served by organizations and customer satisfaction leads to repeat purchases, which in turn, affect positively revenue growth and stock price. However, along with the various benefits and merits of technology and digitization of ASC, organizations need to be prepared to exert potentially stronger efforts in harnessing manpower at all levels, behind the technology.

Developing supporting leadership and management process as well ensuring adequate roles, competency and education counter the technological focus mantra. It takes an accurate description of employees' roles and detailed elaborations on their competencies especially in relation to technology and beyond, for ASC strategies to be successful (Bottani, 2010; Yusuf et al., 1999). This is not to deny the importance of technology but rather to emphasize that, because technology especially advanced technology is difficult to master, it requires continuous and deliberate practices to ensure the full harnessing of technological capabilities within ASC.

Further, this review suggests that, contrarily to intuitive thinking, the main barriers to implementing a tech-driven and information-centric strategy such as ASC, are not necessarily the blunt lack of technology or technical investments per se. Instead, lack of appropriate managerial processes such as planning and implementation methodologies or measurement (e.g., PDCA), which we termed managerial/leadership as well as lack of technical expertise which ties back to competency and roles, and which we thus termed competency/education, are more significant barriers to ASC. Similarly, although technology is an influential criterion for supplier selection and despite the fact that technology is a criterion for selecting suppliers in agile contexts vs, lean ones, technology is not the most important criterion in supplier section.

Rather, both human and managerial capabilities directly affect cultural and technological abilities of supplier selection instead of the reverse.

Building an efficient ASC requires a combination of devising appropriate roles, developing human competencies and expertise through education, combined with strong leadership and managerial supporting processes. Selection of the right suppliers on similar criteria is important since there is a strong interrelationship in ASC networks. For example, regardless of how technologically advanced a supplier is, it is unlikely that a poorly trained and inadequately managed workforce can be expected to contribute meaningfully to the strategic and competitive objectives of the supplier's agile requirements. Besides, as with almost any major organizational change, accompanying a supplier from an under-trained to a well-trained status will take several years to complete. Thus, organizations attempting to attain agility need to use the right criteria for selection beforehand and understand that advanced technology in the form of digitization or else is not panacea.

Incidentally, although the need for measures and right methodologies has been identified as a way to overcome ASC barriers, the review on ASC performance measurement, in particular, did not hint at a particular integration of digitization for the measurement of agility. Future research should devote more attention to the topic of supply chain analytics (Wang et al., 2016) in the particular area of ASC, i.e., agile supply chain analytics. Although some research has scratched upon the integration of business intelligence (BI) competence, agile capabilities and agile performance, they merely confirmed agile capabilities as mediator between BI and agile performance (Sangari & Razmi, 2015). Of particular interest, is the application of machine learning based methods or artificial intelligence such as deep learning, in order to improve the measurement, and hence, the planning and control of ASC.

In response to the increased interest in digitally enabled supply chain strategies (Coreynen, Matthyssens, & Van Bockhaven, 2017; Vendrell-Herrero, Bustinza, Parry, & Georgantzis, 2017) and the concomitant uptake in studies on a technology-centric strategy such as ASC, the contributions of this paper are fourfold. First, a systematic literature review was conducted to identify how technology was addressed within the ASC literature and offered both descriptive and more in-depth knowledge on the treatment of technology in the ASC literature. Second, we provided a preliminary discussion on the mapping of a nomological network of ASC research providing scholars an overview of the subject of research so far. Third, the combination of the topical literature leads to nuance the centrality of technology in the ASC from several viewpoints. Whether for implementing ASC, avoiding implementation hurdles, or selecting ASC suppliers, technology plays a necessary but non-sufficient role in spurring ASC performance. Instead, both managerial/leadership as well as education/competency play more fundamental roles in enabling the technology underpinning ASC. Conversely, the results suggest that technology should be better integrated in the measurement and metrics of ASC, possibly contributing to an agile supply chain analytics stream of research. Finally, a research agenda is proposed throughout the paper to suggest future research avenues to improve our understanding of how technology could better contribute to ASC performance.

## References


Abdollahi, M., Arvan, M., & Razmi, J. (2015). An integrated approach for supplier portfolio selection: Lean or agile? *Expert Systems with Applications, 42*, 679–690.

Agarwal, A., Shankar, R., & Tiwari, M. K. (2006). Modeling the metrics of lean, agile and leagile supply chain: An ANP-based approach. *European Journal of Operational Research, 173*(1), 211–225.

Agrawal, A. (2001). University-to-industry knowledge transfer: Literature review and unanswered questions. *International Journal of Management Reviews, 3*(4), 285–302.

Aitken, J., Christopher, M., & Towill, D. (2002). Understanding, implementing and exploiting agility and leanness. *International Journal of Logistics, 5*(1), 59–74.

Akter, S., Fosso Wamba, S., & Dewan, S. (2017). Why PLS-SEM is suitable for complex modelling? An empirical illustration in big data analytics quality. *Production Planning and Control, 28*(11 − 12), 1011–1021.

Alimardani, M., Rabbani, M., & Rafiei, H. (2014). A novel hybrid model based in DEMATEL, ANP and TOPSIS for supplier selection in agile supply chain. *International Journal of Services and Operations Management, 18*(2), 179–211.

Alimardani, M., Zolfani, S. H., Aghdaie, M. H., & Tamosaitiene, J. (2013). A novel hybrid SWARA and VIKOR methodology for supplier selection in an agile environment. *Technological and Economic Development of Economy, 19*(3), 533–548.

Arteta, B. M., & Giachetti, R. E. (2004). A measure of agility as the complexity of the enterprise system. *Robotics and Computer-Integrated Manufacturing, 20*(6), 495–503.

Baker, P. (2008). The design and operation of distribution centres within agile supply chains. *International Journal of Production Economics, 111*(1), 27–41.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99–120.

Barratt, M. (2004). Understanding the meaning of collaboration in the supply chain. *Supply Chain Management: an international journal, 9*(1), 30–42.

Battistella, C., De Toni, A. F., De Zan, G., & Pessot, E. (2017). Cultivating business model agility through focused capabilities: A multiple case study. *Journal of Business Research, 73*, 65–82. https://doi.org/10.1016/j.jbusres.2016.12.007.

Beikkhakhian, Y., Javanmardi, M., Karbasian, M., & Khayambashi, B. (2015). The application of ISM model in evaluating agile suppliers selection criteria and ranking suppliers using fuzzy TOPSIS-AHP methods. *Expert Systems with Applications, 42*, 6224–6236.

Benckendorff, P., & Zehrer, A. (2013). A network analysis of tourism research. *Annals of Tourism Research, 43*, 121–149.

Bidhandi, R. A., & Valmohammadi, C. (2017). Effects of supply chain agility on profitability. *Business Process Management Journal, 23*(5), 1064–1082 Retrieved from http://www.emeraldinsight.com/doi/abs/10.1108/BPMJ-05-2016-0089.

Blome, C., Schoenherr, T., & Rexhausen, D. (2013). Antecedents and enablers of supply chain agility and its effect on performance: A dynamic capabilities perspective. *International Journal of Production Research, 51*(4), 1295–1318.

Bottani, E. (2010). Profile and enablers of agile companies: An empirical investigation. *International Journal of Production Economics, 125*, 251–261.

Braunscheidel, M. J., & Suresh, M. J. (2009). The organizational antecedents of a firm's supply chain agility for risk mitigation and response. *Journal of Operations Management, 27*(2), 119–140.

Brettel, M., Friederichsen, N., Keller, M., & Rosenberg, M. (2014). How virtualization, decentralization and network building change the manufacturing landscape: An Industry 4.0 Perspective. *International journal of mechanical, industrial science and engineering, 8*(1), 37–44.

Brusset, X. (2016). Does supply chain visibility enhance agility? *International Journal of Production Economics, 171*, 46–59.

Burgess, T. F. (1994). Making the leap to agility: defining and achieving agile manufacturing through business process redesign and business network redesign. *International Journal of Operations & Production Management, 14*(11), 23–34.

Callon, M., Courtial, J. P., Turner, W. A., & Bauin, S. (1983). From translations to problematic networks: An introduction to co-word analysis. *Social Science Information, 22*(2), 191–235.

Cegarra-Navarro, J.-G., Soto-Acosta, P., & Wensley, A. K. P. (2016). Structured knowledge processes and firm performance: The role of organizational agility. *Journal of Business Research, 69*(5), 1544–1549.

Sharifi, H., & Zhang, Z. (1999). A methodology for achieving agility in a manufacturing organisation: an introduction. *International Journal of Production Economics, 62*, 7–22.

Shashi Centobelli, P., Cerchione, R., & Ertz, M. (2020). Managing supply chain resilience to pursue business and environmental strategies. *Business Strategy and the Environment, 29*(3), 1215–1246.

Cerruti, C., Mena, C., Skipworth, H., & Ernesto, T. (2016). Characterizing agile supply partnerships in the fashion industry. *International Journal of Operations & Production Management, 36*(8), 923–947.

Chakravarty, A., Grewal, R., & Sambamurthy, V. (2013). Information technology competencies, organizational agility, and firm performance: Enabling and facilitating roles. *Information Systems Research, 24*(4), 976–997.

Chan, A. T. L., Ngai, E. W. T., & Moon, K. K. L. (2017). The effects of strategic and manufacturing flexibilities and supply chain agility on firm performance in the fashion industry. *European Journal of Operational Research, 259*, 486–499.

Chiang, C., Kocabasoglu-Hillmer, C., & Suresh, N. (2012). An empirical investigation of the impact of strategic sourcing and flexibility on firm's supply chain agility. *International Journal of Operations & Production Management, 32*(1), 49–78.

Christopher, M. (2000). The agile supply chain: Competing in volatile markets. *Industrial Marketing Management, 29*, 37–44.

Coreynen, W., Matthyssens, P., & Van Bockhaven, W. (2017). Boosting servitization through digitization: Pathways and dynamic resource configurations for manufacturers. *Industrial Marketing Management, 60*, 42–53.

Costantino, N., Dotoli, M., Falagario, M., Fanti, M. P., & Mangini, A. M. (2012). A model for supply management of agile manufacturing supply chains. *International Journal of Production Economics, 135*(1), 451–457.

Day, G. S. (1994). The capabilities of market-driven organizations. *Journal of Marketing, 58*(4), 37–52.

DeGroote, S. E., & Marx, T. G. (2013). The impact of IT on supply chain agility and firm performance: An empirical investigation. *International Journal of Information Management, 33*, 909–916.

Delen, D., & Ram, S. (2018). Research challenges and opportunities in business analytics. *Journal of Business Analytics, 1*(1), 2–12.

Dingsøyr, T., Nerur, S., Balijepally, V., & Moe, N. B. (2012). A decade of agile methodologies: Towards explaining agile software development. *Journal of Systems and Software, 85*(6), 1213–1221.

Droge, C., Vickery, S. K., & Jacobs, M. A. (2012). Does supply chain integration mediate the relationships between product/process strategy and service performance? An

empirical study. *International Journal of Production Economics, 137*(2), 250–262.
Dubey, R., Gunasekaran, A., & Childe, S. J. (2018). Big data analytics capability in supply chain agility: the moderating effect of organizational flexibility. *Management Decision*. https://doi.org/10.1108/MD-01-2018-0119.
Easterby-Smith, M., Thorpe, R., & Jackson, P. (2012). *Management Research.* London, England: SAGE Publications.
Urciuoli, L., & Hintsa, J. (2017). Adapting supply chain management strategies to security–an analysis of existing gaps and recommendations for improvement. *International Journal of Logistics Research and Applications, 20*(3), 276–295.
van Eck, N. J., & Waltman, L. (2014). CitNetExplorer: A new software tool for analysing and visualizing citation networks. *Journal of Informetrics, 8*(4), 802–823.
van Eck, N. J., Waltman, L., Dekker, R., & van den Berg, J. (2010). A comparison of two techniques for bibliometric mapping: Multidimensional scaling and VOS. *Journal of the American Society for Information Science and Technology, 61*(12), 2405–2416.
Eckstein, D., Goellner, M., Blome, C., & Henke, M. (2015). The performance impact of supply chain agility and supply chain adaptability: The moderating effect of product complexity. *International Journal of Production Research, 53*(10), 3028–3046.
Eisenhardt, K. M., & Martin, J. A. (2000). Dynamic capabilities: what are they? *Strategic Management Journal, 21*(10－11), 1105–1121.
Elnagar, S., Weistroffer, H., & Thomas, M. (2018, October). *Agile Requirement Engineering Maturity Framework for Industry 4.0. In European, Mediterranean, and Middle Eastern Conference on Information Systems.* Cham: Springer405–418.
Ertz, M., & Leblanc-Proulx, S. (2018). Sustainability in the collaborative economy: A bibliometric analysis reveals emerging interest. *Journal of Cleaner Production, 196*, 1073–1085.
Felipe, C. M., Roldán, J. L., & Leal-Rodríguez, A. L. (2016). An explanatory and predictive model for organizational agility. *Journal of Business Research, 69*(10), 4624–4631.
Fisher, M. L. (1997). What is the right supply chain for your product? *Harvard Business Review, 75*(2), 105–116.
Galvagno, M., & Dalli, D. (2014). Theory of value co-creation: a systematic literature review. *Managing Service Quality, 24*(6), 643–683.
Ganguly, A., Nilchiani, R., & Farr, J. V. (2009). Evaluating agility in corporate enterprises. *International Journal of Production Economics, 118*, 410–423.
Geng, D., Feng, Y., & Zhu, Q. (2020). Sustainable design for users: a literature review and bibliometric analysis. *Environmental Science and Pollution Research, 27*, 29824–29836.
Giachetti, R. E., Martinez, L. D., Saenz, O. A., & Chen, C. S. (2003). Analysis of the structural measures of flexibility and agility using a measurement theoretical framework. *International Journal of Production Economics, 86*(1), 47–62.
Gligor, D. M. (2014). The role of demand management in achieving supply chain agility. *Supply Chain Management: An International Journal, 19*(5/6), 577–591.
Gligor, D. M., Esmark, C. L., & Holcomb, M. C. (2015). Performance outcomes of supply chain agility: When should you be agile? *Journal of Operations Management, 33–34*, 71–82.
Gligor, D. M., & Holcomb, M. (2014). The road to supply chain agility: an RBV perspective on the role of logistics capabilities. *The International Journal of Logistics Management, 25*(1), 160–179.
Gligor, D. M., & Holcomb, M. C. (2012). Understanding the role of logistics capabilities in achieving supply chain agility: A systematic literature review. *Supply Chain Management: An International Journal, 17*(4), 438–453.
Gligor, D. M., Holcomb, M. C., & Feizabadi, J. (2016). An exploration of the strategic antecedents of firm supply chain agility: The role of a firm's orientations. *International Journal of Production Economics, 179*, 24–34.
Gligor, D. M., Holcomb, M. C., & Stank, T. P. (2013). A multidisciplinary approach to supply chain agility: Conceptualization and scale development. *Journal of Business Logistics, 34*(2), 94–108.
Goldman, S. L., & Nagel, R. N. (1993). Management, technology and agility: the emergence of a new era in manufacturing. *International Journal of Technology Management, 8*(1–2), 18–38.
Goldman, S. L., Nagel, R. N., & Preiss, K. (1995). *Agile Competitors and Virtual Organizations.* New York, NY: vanNostr and Reinhold.
Grönroos, C. (2004). The relationship marketing process: communication, interaction, dialogue, value. *Journal of Business & Industrial Marketing, 19*(2), 99–113.
Gunasekaran, A. (1998). Agile Manufacturing: Enablers and an Implementation Framework. *International Journal of Production Research, 26*(5), 1223–1247.
Hasan, M. A., Shankar, R., & Sarkis, J. (2007). A study of barriers to agile manufacturing. *International Journal of Agile Systems and Management, 2*(1), 1–21.
Hazen, B. T., Bradley, R. V., Bell, J. E., In, J., & Byrd, T. A. (2017). Enterprise architecture: A competence-based approach to achieving agility and firm performance. *International Journal of Production Economics, 193*, 566–577.
Hillebrand, B., & Biemans, W. G. (2003). The relationship between internal and external cooperation: Literature review and propositions. *Journal of Business Research, 56*(9), 735–743.
van Hoek, R. I., Harrison, A., & Christopher, M. (2001). Measuring agile capabilities in the supply chain. *International Journal of Operations & Production Management, 21*(1), 126–148.
Huang, P., Ouyang, T. H., Pan, S. L., & Chou, T. (2012). The role of IT in achieving operational agility: A case study of Haier, China. *International Journal of Information Management, 32*, 294–298.
Inman, R. A., Sale, R. S., Jr, K. W. G., & Whitten, D. (2011). Agile manufacturing: Relation to JIT, operational performance and firm performance. *Journal of Operations Management, 29*, 343–355.
Ismail, H. S., & Sharifi, H. (2006). A balanced approach to building agile supply chains. *International Journal of Physical Distribution and Logistics Management, 36*(6), 431–444.
Jain, V., Benyoucef, L., & Deshmukh, S. G. (2008). A new approach for evaluating agility in supply chains using Fuzzy Association Rules Mining. *Engineering Applications of Artificial Intelligence, 21*, 367–385.
Jüttner, U., Christopher, M., & Baker, S. (2007). Demand chain management-integrating marketing and supply chain management. *Industrial Marketing Management, 36*(3), 377–392.
Katayama, H., & Bennett, D. (1999). Agility, adaptability and leanness: A comparison of concepts and a study of practice. *International Journal of Production Economics, 60*, 43–51.
Khalili-Damghani, K., & Taghavifard, M. (2012). A three-stage fuzzy DEA approach to measure performance of a serial process including JIT practices, agility indices, and goals in supply chains. *International Journal of Services and Operations Management, 13*(2), 147–188.
Khalili-Damghani, K., Taghavifard, M., Olfat, L., & Feizi, K. (2011). A hybrid approach based on fuzzy DEA and simulation to measure the efficiency of agility in supply chain: Real case of dairy industry. *International Journal of Management Science and Engineering Management, 6*, 163–172.
Khalili-Damghani, K., & Tavana, M. (2013). A new fuzzy network data envelopment analysis model for measuring the performance of agility in supply chains. *International Journal of Advanced Manufacturing Technology, 69*, 291–318.
Khan, A. K., Bakkappa, B., Metri, B. A., & Sahay, B. S. (2009). Impact of agile supply chains' delivery practices on firms' performance: cluster analysis and validation. *Supply Chain Management: An International Journal, 14*(1), 41–48.
Khan, A. K., & Pillania, R. K. (2008). Strategic sourcing for supply chain agility and firms' performance: A study of Indian manufacturing sector. *Management Decision, 46*(10), 1508–1530.
Kidd, P. T. (1994). *Agile Manufacturing – Forging New Frontiers.* Wokingham: Addison-Wesley.
Kim, M., & Chai, S. (2017). The impact of supplier innovativeness, information sharing and strategic sourcing on improving supply chain agility: Global supply chain perspective. *International Journal of Production Economics, 187*, 42–52.
Koufteros, X. A., Rawski, G. E., & Rupak, R. (2010). Organizational integration for product development: the effects on glitches, on-time execution of engineering change orders, and market success. *Decision Sciences, 41*(1), 49–80.
Kumar, A., & Motwani, J. (1995). A methodology for assessing time-based competitive advantage of manufacturing firms. *International Journal of Operations & Production Management, 15*(2), 36–53.
Larson, D., & Chang, V. (2016). A review and future direction of agile, business intelligence, analytics and data science. *International Journal of Information Management, 36*(5), 700–710.
Le, J. (2016). *The 10 algorithms machine learning engineers need to know.* Retrieved from https://www.kdnuggets.com/2016/08/10-algorithms-machine-learning-engineers.html (accessed on 08/08/2019) .
Lee, H. L. (2004). The triple-A supply chain. *Harvard Business Review, 82*(10), 102–113.
Lee, J., Cho, H., & Kim, Y. S. (2015). Assessing business impacts of agility criterion and order allocation strategy in multi-criteria supplier selection. *Expert Systems with Applications, 42*, 1136–1148.
Li, G., Lin, Y., & Wang, S. (2006). Enhancing agility by timely sharing of supply information. *Supply Chain Management: An International Journal, 11*(5), 425–435.
Lim, M. K., & Zhang, Z. (2012). A multi-agent system using iterative bidding mechanism to enhance manufacturing agility. *Expert Systems with Applications, 39*(9), 8259–8273.
Lin, C., Chiu, H., & Chu, P. (2006). Agility index in the supply chain. *International Journal of Production Economics, 100*, 285–299.
Liu, H., Ke, W., Wei, K. K., & Hua, Z. (2013). The impact of IT capabilities on firm performance: The mediating roles of absorptive capacity and supply chain agility. *Decision Support Systems, 54*, 1452–1462.
Liu, Z., Yin, Y., Liu, W., & Dunford, M. (2015). Visualizing the intellectual structure and evolution of innovation systems research: A bibliometric analysis. *Scientometrics, 103*, 135–158.
Lowry, P. B., & Wilson, D. (2016). Creating agile organizations through IT: The influence of internal IT service perceptions on IT service quality and IT agility. *Journal of Strategic Information Systems, 25*, 211–226.
Lu, Y. (2017). Industry 4.0: A survey on technologies, applications and open research issues. *Journal of Industrial Information Integration, 6*, 1–10.
Luo, X., Wu, C., Rosenberg, D., & Barnes (2009). Supplier selection in agile supply chains: An information-processing model and an illustration. *Journal of Purchasing and Supply Management, 15*(4), 249–262.
Mason-Jones, R., & Towill, D. R. (1997). Information enrichment: designing the supply chain for competitive advantage. *Supply Chain Management: An International Journal, 2*(4), 137–148.
Mason-Jones, R., & Towill, D. R. (1999). Total cycle time compression and the agile supply chain. *International Journal of Production Economics, 62*, 61–73.
Masson, R., Losif, L., Mackerron, G., & Fernie, J. (2007). Managing complexity in agile global fashion industry supply chains. *The International Journal of Logistics Management, 18*(2), 238–254.
Matawale, C. R., Datta, S., & Mahapatra, S. S. (2013). Agility appraisement and identification of agile barriers in a supply chain. *International Journal of Services and Operations Management, 16*(4), 478–505.
Matawale, C. R., Datta, S. S., & Mahapatra, S. S. (2016). Supplier/partner selection in agile supply chain: Application of vague set as a decision making tool. *Benchmarking: An International Journal, 23*(4), 866–892.
Mishra, S., Mahapatra, S. S., & Datta, S. (2014). Agility evaluation in fuzzy context: Influence of decision-makers' risk bearing attitude. *Benchmarking: An International Journal, 21*(6), 1084–1119.
Mishra, S., Sahu, A. K., Datta, S., & Mahapatra, S. S. (2015). Application of fuzzy integrated MULTIMOORA method towards supplier/partner selection in agile supply chain. *International Journal of Operational Research, 22*, 466–514.
Mokadem, M. E. (2017). The classification of supplier selection criteria with respect to lean or agile manufacturing strategies. *Journal of Manufacturing Technology*

*Management, 28*(2), 232–249.
Monahan, S. T., & Hu, M. (2015). Sharing supply chain data in the digital era. *MIT Sloan Management Review, 57*(1), 95.
Moon, K., Lee, J., & Lai, S. (2017). Key drivers of an agile, collaborative fast fashion supply chain: Dongdaemun fashion market. *Journal of Fashion Marketing and Management: An International Journal, 21*(3), 278–297.
Mostaghel, R. (2016). Innovation and technology for the elderly: Systematic literature review. *Journal of Business Research, 69*(11), 4896–4900.
Mussomeli, A., Gish, D., & Laaper, S. (2016). The rise of the digital supply network: Industry 4.0 enables the digital transformation of supply chains. *Deloitte Insights* (December, 1).
Naylor, J. B., Naim, M. M., & Berry, D. (1999). Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain. *International Journal of Production Economics, 62*(1–2), 107–118.
Nemkova, E. (2017). The impact of agility on the market performance of born-global firms: An exploratory study of the "Tech City" innovation cluster. *Journal of Business Research, 80*, 257–265.
Overby, E., Bharadwaj, A., & Sambamurthy, V. (2006). Enterprise agility and the enabling role of information technology. *European Journal of Information Systems, 15*(2), 120–131.
Patel, B. S., Samuel, C., & Sharma, S. K. (2017). Evaluation of agility in supply chains: A case study of an Indian manufacturing organization. *Journal of Manufacturing Technology Management, 28*(2), 212–231.
Perkmann, M., & Walsh, K. (2007). University-industry relationships and open innovation: Towards a research agenda. *International Journal of Management Reviews, 9*(4), 259–280.
Petticrew, M., & Roberts, H. (2006). *Systematic Reviews in the Social Sciences.* Malden: Blackwell Publishing.
Pittaway, L., Robertson, R., Munir, K., Denyer, D., & Neely, D. (2004). Networking and innovation: a systematic review of the evidence. *International Journal of Management Reviews, 5-6*(3–4), 137–168.
Potdar, P. K., & Routroy, S. (2017). Performance analysis of agile manufacturing: A case study on an Indian auto component manufacturer. *Measuring Business Excellence, 21*(2), 117–135.
Power, D. J., Sohal, A. S., & Rahman, S. (2001). Critical success factors in agile supply chain management: An empirical study. *International Journal of Physical Distribution and Logistics Management, 31*(4), 247–265.
Prater, E., Biehl, M., & Smith, M. A. (2001). International supply chain agility-Tradeoffs between flexibility and uncertainty. *International Journal of Operations & Production Management, 21*(5/6), 823–839.
Qin, J., Liu, Y., & Grosvenor, R. (2016). A categorical framework of manufacturing for industry 4.0 and beyond. *Procedia Cirp, 52*, 173–178.
Qrunfleh, S., & Tarafdar, M. (2013). Lean and agile supply chain strategies and supply chain responsiveness: The role of strategic supplier partnership and postponement. *Supply Chain Management: An International Journal, 18*(6), 571–582.
Radicchi, F., Castellano, C., Cecconi, F., Loreto, V., & Paris, D. (2004). Defining and identifying communities in networks. *Proceedings of the National Academy of Sciences of the United States of America, 101*(9), 2658–2663.
Ralston, P. M., Blackhurst, J., Cantor, D. E., & Crum, M. R. (2015). A structure–conduct–performance perspective of how strategic supply chain integration affects firm performance. *Journal of Supply Chain Management, 51*(2), 47–64.
Ravald, A., & Grönroos, C. (1996). The value concept and relationship marketing. *European Journal of Marketing, 30*(2), 19–30.
Ren, J., Yusuf, Y. Y., & Burns, N. D. (2009). A decision-support framework for agile enterprise partnering. *International Journal of Advanced Manufacturing Technology, 41*, 180–192.
Richey, R. G., Jr., Morgan, T. R., Lindsey-Hall, K., & Adams, F. G. (2016). A global exploration of big data in the supply chain. *International Journal of Physical Distribution and Logistics Management, 46*(8), 710–739.
Roberts, N., & Grover, V. (2012). Investigating firm's customer agility and firm performance: The importance of aligning sense and respond capabilities. *Journal of Business Research, 65*, 579–585.
Routroy, S., Potdar, P. K., & Shankar, A. (2015). Measurement of manufacturing agility: A case study. *Measuring Business Excellence, 19*(2), 1–22.
Routroy, S., & Shankar, A. (2015). Performance analysis of agile supply chain. *International Journal of Manufacturing Technology and Management, 29*(3/4), 180–209.
Sahu, A. K., Sahu, A. K., & Sahu, N. K. (2016). Appraisal of partner enterprises under GTFNS environment: Agile supply chain. *International Journal of Decision Support System Technology, 8*(3), 1–19.
Samantra, C., Datta, S., Mishra, S., & Mahapatra, S. S. (2013). Agility appraisal for integrated supply chain using generalized trapezoidal fuzzy numbers set. *International Journal of Advanced Manufacturing Technology, 68*, 1491–1503.
Sambamurthy, V., Bharadwaj, A., & Grover, V. (2003). Shaping agility through digital options: Reconceptualizing the role of information technology in contemporary firms. *MIS Quarterly, 24*(2), 237–263.
Samdantsoodol, A., Cang, S., Yu, H., Eardley, A., & Buyantsogt, A. (2017). Predicting the relationships between virtual enterprises and agility in supply chains. *Expert Systems with Applications, 84*, 58–73.
Sangari, M. S., & Razmi, J. (2015). Business intelligence competence, agile capabilities, and agile performance in supply chain: An empirical study. *The International Journal of Logistics Management, 26*(2), 356–380.
Sangari, M. S., Razmi, J., & Zolfaghari, S. (2015). Developing a practical evaluation framework for identifying critical factors to achieve supply chain agility. *Measurement, 62*, 205–214.
Sarkis, J. (2001). Benchmarking for agility. *Benchmarking: An International Journal, 8*(2), 88–107.
Sarkis, J., Talluri, S., & Gunasekaran, A. (2007). A strategic model for agile virtual enterprise partner selection. *International Journal of Operations & Production Management, 27*(11), 1213–1234.
Schoenherr, T., & Speier-Pero, C. (2015). Data science, predictive analytics, and big data in supply chain management: Current state and future potential. *Journal of Business Logistics, 36*(1), 120–132.
Shams, S. M. R. (2016). Capacity building for sustained competitive advantage: a conceptual Framework. *Marketing Intelligence & Planning, 34*(5), 671–691.
Shin, H., Lee, J., Kim, D., & Rhim, H. (2015). Strategic agility of Korean small and medium enterprises and its influence on operational and firm performance. *International Journal of Production Economics, 168*, 181–196.
Siddhartha, & Sachan, A. (2016). Review of agile supply chain implementation frameworks. *International Journal of Business Performance and Supply Chain Modelling, 8*(1), https://doi.org/10.1504/IJBPSCM.2016.075999.
Sieger, D. B., Badiru, A. B., & Milatovic, M. (2000). A metric for agility measurement in product development. *IISE Transactions, 32*(7), 637–645.
Slater, S. F., & Narver, J. C. (1995). Market orientation and the learning organization. *Journal of Marketing, 59*(3), 63–74.
Srinivasan, R., & Swink, M. (2018). An investigation of visibility and flexibility as complements to supply chain analytics: An organizational information processing theory perspective. *Production and Operations Management, 27*(10), 1849–1867.
Storey, J., Emberson, C., & Reade, D. (2005). The barriers to customer responsive supply chain management. *International Journal of Operations & Production Management, 25*(3), 242–260.
Swafford, P. M., Ghosh, S., & Murthy, N. (2006). The antecedents of supply chain agility of a firm: Scale development and model testing. *Journal of Operations Management, 24*, 170–188.
Swafford, P. M., Ghosh, S., & Murthy, N. (2008). Achieving supply chain agility through IT integration and flexibility. *International Journal of Production Economics, 116*, 288–297.
Tarafdar, M., & Qrunfleh, S. (2017). Agile supply chain strategy and supply chain performance: Complementary roles of supply chain practices and information systems capability for agility. *International Journal of Production Research, 55*(4), 925–938.
Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*(7), 509–533.
Tse, Y. K., Zhang, M., Akhtar, P., & Macbryde, J. (2016). Embracing supply chain agility: An investigation in the electronics industry. *Supply Chain Management: An International Journal, 21*(1), 140–156.
Tsourveloudis, N. C., & Valavanis, K. P. (2002). On the measurement of enterprise agility. *Journal of Intelligent and Robotic Systems, 33*, 329–342.
Um, J. (2017a). Improving supply chain flexibility and agility through variety management. *The International Journal of Logistics Management, 28*(2), 464–487.
Um, J. (2017b). The impact of supply chain agility on business performance in a high level customization environment. *International Journal of Operational Research, 10*, 10–19.
Vargo, S. L., & Lusch, R. F. (2008). Service-dominant logic: continuing the evolution. *Journal of the Academy of Marketing Science, 36*(1), 1–10.
Vendrell-Herrero, F., Bustinza, O. F., Parry, G., & Georgantzis, N. (2017). Servitization, digitization and supply chain interdependency. *Industrial Marketing Management, 60*, 69–81.
Vickery, S. K., Drogea, C., Setiab, P., & Sambamurthya, V. (2010). Supply chain information technologies and organisational initiatives: Complementary versus independent effects on agility and firm performance. *International Journal of Production Research, 48*(23), 7025–7042.
Vogel, B., Reichard, R. J., Batistič, S., & Černe, M. (2020). A bibliometric review of the leadership development field: How we got here, where we are, and where we are headed. *The Leadership Quarterly* (Article in Press).
Waller, M. A., & 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, 34*(2), 77–84.
Wang, G., Gunasekaran, A., Ngai, E. W., & Papadopoulos, T. (2016). Big data analytics in logistics and supply chain management: Certain investigations for research and applications. *International Journal of Production Economics, 176*, 98–110.
Weber, M. M. (2002). Measuring supply chain agility in the virtual organization. *International Journal of Physical Distribution and Logistics Management, 32*(7), 577–590.
Wu, C., & Barnes, D. (2009). A model for continuous improvement in supplier selection in agile supply chains. *Knowledge and Process Management, 16*(3), 85–110.
Wu, C., & Barnes, D. (2010). Formulating partner selection criteria for agile supply chains: A Dempster–Shafer belief acceptability optimisation approach. *International Journal of Production Economics, 125*, 284–293.
Wu, C., & Barnes, D. (2011). A literature review of decision-making models and approaches for partner selection in agile supply chains. *Journal of Purchasing and Supply Management, 17*(4), 256–274.
Wu, C., & Barnes, D. (2012). A dynamic feedback model for partner selection in agile supply chains. *International Journal of Operations & Production Management, 32*(1), 79–103.
Wu, C., & Barnes, D. (2014). Partner selection in agile supply chains: A fuzzy intelligent approach. *Production Planning and Control, 25*(10), 821–839.
Wu, C., Barnes, D., Rosenberg, D., & Luo, X. (2009). An analytic network process-mixed integer multi-objective programming model for partner selection in agile supply chains. *Production Planning and Control, 20*(3), 254–275.
Wu, K. J., Tseng, M., Chiu, A. S. F., & Lim, M. K. (2017). Achieving competitive advantage through supply chain agility under uncertainty: A novel multi-criteria decision-making structure. *International Journal of Production Economics, 190*, 96–107.
Wu, L., Yue, X., Jin, A., & Yen, D. C. (2016). Smart supply chain management: a review and implications for future research. *The International Journal of Logistics Management,*

*27*(2), 395–417.
Yang, C., & Liu, H. (2012). Boosting firm performance via enterprise agility and network structure. *Management Decision, 50*(6), 1022–1044.
Yang, J. (2014). Supply chain agility: Securing performance for Chinese manufacturers. *International Journal of Production Economics, 150*, 104–113.
Yang, S. L., & Li, T. F. (2002). Agility evaluation of mass customization product manufacturing. *Journal of Material Processing Technology, 129*(1–3), 640–644.
Yauch, C. A. (2011). Measuring agility as a performance outcome. *Journal of Manufacturing Technology Management, 22*(3), 384–404.
Yli-Ojanperä, M., Sierla, S., Papakonstantinou, N., & Vyatkin, V. (2018). Adapting an agile manufacturing concept to the reference architecture model industry 4.0: A survey and case study. *Journal of Industrial Information Integration*. https://doi.org/10.1016/j.jii.2018.12.002.
Yusuf, Y. Y., Gunasekaran, A., Adeleye, E. O., & Sivayoganathan, K. (2004). Agile supply chain capabilities: Determinants of competitive objectives. *European Journal of Operational Research, 159*(2) 379–39.
Yusuf, Y. Y., Gunasekaran, A., Musa, A., Dauda, M., Eli-Beroshy, N. M., & Cang, S. (2014). A relational study of supply chain agility, competitiveness and business performance in the oil and gas industry. *International Journal of Production Economics, 147*, 531–543.
Yusuf, Y. Y., Musa, A., Dauda, M., El-Berishy, N., Kovvuri, D., & Abubakar, T. (2014). A study of the diffusion of agility and cluster competitiveness in the oil and gas supply chains. *International Journal of Production Economics, 147*(PART B), 498–513.
Yusuf, Y. Y., Sarhadi, M., & Gunasekaran, A. (1999). Agile manufacturing: The drivers, concepts and attributes. *International Journal of Production Economics, 62*(1/2), 33–43.
Zhang, D. Z. (2011). Towards theory building in agile manufacturing strategies - Case studies of an agility taxonomy. *International Journal of Production Economics, 131*(1), 303–312.
Zhang, Z., & Sharifi, H. (2000). A methodology for achieving agility in manufacturing organisations. *International Journal of Operations and Production Management, 20*(4), 496–513.