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Sustainable supply chain modeling and analysis: Past debate, present problems and future challenges

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ABSTRACT

For the last two decades, the topic of sustainable supply chains has evoked considerable interest from academics and practitioners. Within this context, Resources, Conservation and Recycling (RCR) and its two predecessors (Resources and Conservation, and Conservation and Recycling) have provided a platform for the exchange of technological, economic, institutional and policy aspects to help societies transition toward sustainability. The current article analyses the published research works in the RCR literature within the context of sustainable supply chain modeling by employing a content analysis literature review technique. Using the body of available literature in RCR, the articles on sustainable supply chain are analyzed in terms of the following: (1) publication per year, (2) top-cited papers across time, (3) most productive and influential authors, institutions and countries (4) supply chain related topical themes, (5) research methodologies applied, (6) illustration types and (7) industries addressed. The analysis revealed that the call for incorporating sustainability (i.e., economic, social, and environmental pillars) into supply chain operations has increased in recent years in RCR publications. Finally, the comprehensive findings and interpretations are presented, as well as the primary current trends, future challenges, directions and opportunities.

1. Introduction

Sustainability, which is the integration of environmental and social aspects with economic consideration, has become a popular buzzword among academic researchers and industrial practitioners (Brandenburg et al., 2014; Seuring and Müller, 2008). It has received increasing attention since the release of *Our Common Future* by Brundtland (1987) over two decades ago. Researchers and corporate managers have devoted many efforts toward sustainability integration, i.e., creating a culture of sustainability mindset (Galpin et al., 2015) and revisiting business models (Bocken et al., 2014; França et al., 2017). It has become apparent that it is vital for organizations to move forward and address not only sustainability issues internally (within the organization), but externally as well (Berning and Venter, 2015). Therefore, managing supply chains in a sustainable manner plays a vital role in addressing sustainability concerns in firms of all sizes and across a broad spectrum of industries.

Consequently, many researchers have studied sustainable supply chain (SSC) in recent decades (Beske et al., 2014; Brandenburg et al., 2014; Craig and Easton, 2011; Ghadimi et al., 2016; Seuring, 2013; Seuring and Müller, 2008). Before discussing these issues in more detail, it is necessary to present the various definitions related to SSC that are included in the current literature (see Table 1). SSC is a concept that has evolved from the convergence of the perspectives of sustainability and supply chain (Seuring and Müller, 2008). Pagell and Shevchenko (2014) stated that a truly SSC had "no harm on social or environmental systems while maintaining economic viability." An SSC requires awareness about sustainable practices such as ethical sourcing, green purchasing, environmental purchasing, and logistics social responsibility (Agrawal et al., 2015; Ghadimi et al., 2017a; Sarkis and Zhu, 2017).

This paper conducts a systematic literature review of SSCs with the

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Table 1
Definitions related to sustainable supply chains.

Term	Definition	References
Sustainable supply chain (SSC)	A supply chain that not only simultaneously makes profit and achieves its potential, but also is one that is responsible to its consumers, suppliers, societies, and environments by innovative strategic, tactics and management technologies.	Kim et al. (2014)
Supply chain sustainability (SCS)	Management of environmental, social and economic impacts, and the encouragement of good governance practices, throughout the lifecycles of goods and services.	United Nations Global Compact (2011)
Sustainable supply chain management (SSCM)	The management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements.	Seuring and Müller (2008)

goal of identifying related works on sustainable supply chain modeling and analysis in the Resources, Conservation and Recycling (RCR) publications. Thereafter, the related identified articles are analyzed to identify gaps, issues and opportunities for further research and development. Several theoretical analyses and reviews have been published over the years that examine various aspect of the SSC-related research, such as the conceptual framework of SSCM (Ahi and Searcy, 2013; Carter and Rogers, 2008; Pagell and Wu, 2009; Seuring and Müller, 2008; Svensson, 2007) and SSC practices/empirical examples (Beske et al., 2014). Among these identified papers in the related research, only two articles are modeling based reviews. Seuring (2013) performed a review of SSCM covering quantitative models on forward supply chains by reviewing 36 publications. Brandenburg et al. (2014) provided a review on quantitative, formal models that address sustainability aspects in the forward supply chain, which was based on 134 publications.

Our research study distinguishes itself from the previous two modeling-based literature reviews by (a) including reverse logistics (RL) and supply chain management articles, as RCR is one of the main venues to publish papers on societal, economic and technological change for improved recovery and reuse of materials and (b) reviewing articles solely from RCR dedicated to the legacy of RCR to celebrate its 30th anniversary. Although the published RCR research on this topic contains a relatively small proportion compared with the SSC studies published in other journals, RCR's published articles provide a small-scale version of how academic researchers within this domain have contributed. In addition, we will use this opportunity to share our own perspectives with regard to the addressed SSC-related themes in RCR and will provide suggestions regarding future enhancements that are needed in this research field.

The rest of this paper is structured as follows. Section 2 presents the motivation for conducting this study. Section 3 describes an overview of the research methodology in preparing this review article. Section 4 provides the details of various analyzed and discussed taxonomies together with the results of the analysis. The current trends, challenges and future directions gained after analyzing various articles with respect to various categories are discussed in Section 5. Finally, Section 6 presents the study's conclusions and outlines several limitations.

2. Motivation

In parallel to the increasing publications on SSC in logistics and supply chain management journals, this topic has shown a strong and continuous growth in RCR as well. In 2018, RCR will reach its 30th anniversary (or 43 years tracing back to the inception of Resource Recovery and Conservation), making it one the oldest journals in the sustainable management and conservation of resources field. The impact factor of RCR has shown a steady increase in recent years, which may coincide with increased global attention to environmental problems. In the literature, a series of special activities may be organized when the journal reaches an important milestone in the journal's development, such as a call for papers of an editorial (Dolgui, 2012), review articles (Sarkis and Zhu, 2017; Zou et al., 2017) or a bibliometric (Cancino et al., 2017). To celebrate its 30th anniversary, RCR has organized a special issue calling for review papers specially regarding the four following topics.

a) Resource efficiency and environmental impact analysis
b) Resource recovery and waste utilization technologies and policies
c) Environmental behavior studies
d) Sustainable supply chain modeling and analysis

This paper seeks to contribute to the SSC modeling and analysis topic by reviewing and analyzing the related articles published in RCR over the past 43 years (1975–2017). Historically, the notion of a supply chain first appeared in RCR in 1993, when Pearce and Turner (1993) introduced the "dual system," which involved mandatory waste collection and recovery systems across the SC that were established by the industrial sector and the normal municipal system. Phillips et al. (1999) studied the barriers to carrying out waste minimization initiatives in the East Midlands of England, and it was predicated that the current lowly ranked barrier was likely to become a more prominent issue in the years ahead. However, these two works focus on waste management, not directly on the management of the supply chain. In 2002, RCR published the first paper related to sustainable/green supply chains. Tsoulfas et al. (2002) investigated the used starting, lighting and ignition (SLI) batteries sector and analyzed the different stages of the reverse supply chain of used SLI batteries, presenting the environment impact using a life cycle analysis methodology. Following those studies, the excellent work of authors, reviewers, and editors over the past 16 years have resulted in 61 research papers on the topic of SSC modeling and analysis in RCR.

3. Methodology

To identify the relevant publications for this review, the titles and abstracts of all published studies in RCR and its three predecessors, i.e., Conservation and Recycling, Resource Recovery and Conservation, and Resources and Conservation, have been reviewed. More specifically, the actual contents of the papers and their primary focus has been considered rather than using a keyword search approach. To prevent the exclusion of any publications, all the published papers from Volume 1, Issue 1 in Resource Recovery and Conservation (May 1975) to Volume 125 and articles in press in Resources, Conservation and Recycling (October 2017) have been reviewed carefully based on a pre-determined coding process (see Sub-section 3.2) and the SSC related articles have been included in the articles database.

3.1. Article database

The SSC modeling and analysis research started somewhat slowly in RCR and its predecessors. However, this trend also occurred in many other supply chain and industrial engineering journals. Relatively few articles with a focus on sustainable/green supply chain, production and operations were found between 1975–2002. A general overview of these papers is provided in Section 2. From 2002–2017, 61 published

articles were identified as having some form of sustainability, green, social and ecological connections with various supply chain operations, including 59 research articles and 2 review articles. The analyses and discussions in this article (see Section 5) are based on these 59 research articles. These articles also provide the data for the descriptive analysis and content analysis presented in Section 4.

3.2. Coding process

Based on the coding process model developed by Mayring (2004), four structural dimensions, namely, supply chain related topical themes, research methodologies applied, illustration types and industries addressed were defined and categorized. The database derived from the coding process facilitates the analyses presented in Sections 4 and 5. The works presented in Govindan et al. (2009) and Tseng et al. (2017) are used as two samples to demonstrate the employed coding process. The first paper developed a multi-criteria group decision making (MCGDM) model in a fuzzy environment to guide the selection process of the best third-party reverse logistics provider. (1) For the supply chain related topical themes dimension, it is placed into "decisions at functional interfaces" due to the reverse logistics supplier selection theme. (2) For the research methodologies applied dimension, this paper proposed a hybrid approach using interpretive structural modeling (ISM) and a fuzzy technique for order preference by similarity to the ideal solution (TOPSIS), which falls into the "multi-criteria decision modeling" sub-category. (3) For the illustration types dimension, the model was validated by a case in India, so it clearly falls into the category of "case study/real-world applications." (4) For the industries addressed dimension, the case is about the battery manufacturing industry, so it obviously belongs to the "electrical equipment and appliance manufacturing" category.

The second paper developed a converged interval-valued triangular fuzzy numbers-gray relation analysis (IVTFN-GRA) to enhance green supply chain management. (1) For the supply chain related topical themes dimension, it falls into the "strategic consideration" category because this paper obtained the important green supply chain management (GSCM) attributes and assisted the firm in GSCM performance. (2) For the research methodologies applied dimension, it proposed an IVTFN-GRA approach to solve the multi-criteria evaluation problem, which is placed into the "multi-criteria decision modeling" sub-category. (3) For the illustration types dimension, the model was validated by a case study, so it clearly falls into the category of "case study/real-world applications." (4) For the industries addressed category, a Taiwanese electronic manufacturing focal firm was used to evaluate the GSCM measurement, so it belongs to the "computer and electronic product manufacturing" category.

3.3. Rigor of the coding process

The process of coding for each category has a subjectivity limitation. To ensure the objectivity of the research process, the double-check guidelines proposed by Seuring and Müller (2008) were used. The coding process was performed by both the first author and the second author independently. If there existed disagreement or an author was uncertain about how to best to code an article, the third author would step in, and a collaborative decision was made. The inter-coder reliability is calculated based on the proportion of total pairwise agreements between the coders, which is proposed by Cronbach (1951). The Cronbach coefficient alpha was calculated to be 0.85, which is well above the acceptable threshold of 0.70. It must be recognized that there is an intrinsic limitation in content analysis wherever there are multiple topics from which to choose (Taylor and Taylor, 2009).

4. Sustainable supply chain growth in RCR

In this section, a descriptive and content analysis of contemporary research themes is presented regarding publications per year, top-cited articles across the time, supply chain operations related topical themes, research methodologies applied, illustration types and industries involved. As mentioned in the previous sections, the notation of sustainable or green supply chain management in RCR first appeared in 2002. Therefore, only the articles published after this year have been considered within the descriptive and content analysis processes.

4.1. Publication per year

Fig. 1 depicts the frequency of the publications per year, contextualizing the SSC knowledge production over time in RCR. The articles published have increased in recent years, mainly from 2011 onwards. This period includes 91.53% of all the publications, with an average of 7.7 publications per year from 2009 to 2017. It should be noted that eight papers have the "in press" status and are citable using the DOI. Therefore, their online publication date is used to count them in a specific year. For example, an article from Tseng et al. (2017) was

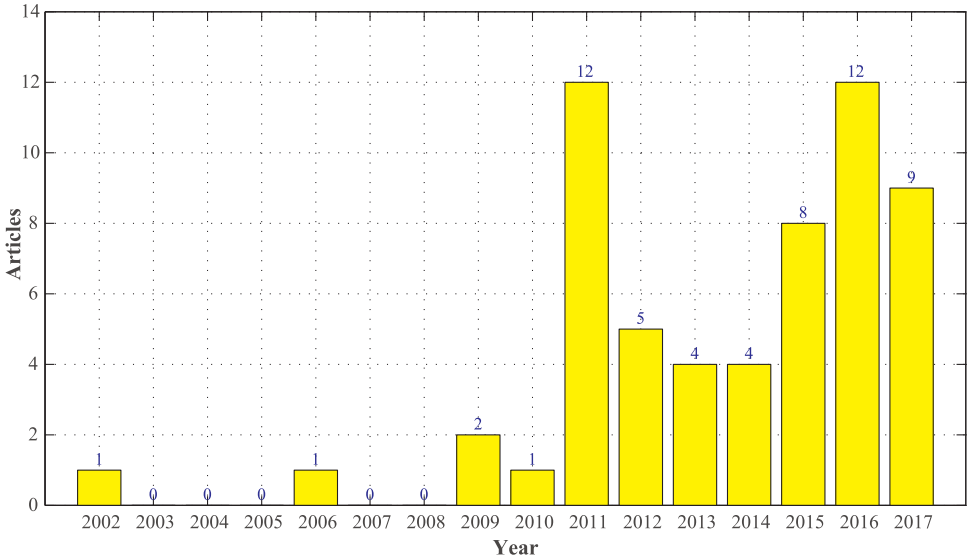

Fig. 1. Number of publications per year across the period studied.
Note: There is a dip in 2017 as data was collected only up to 11 October 2017.

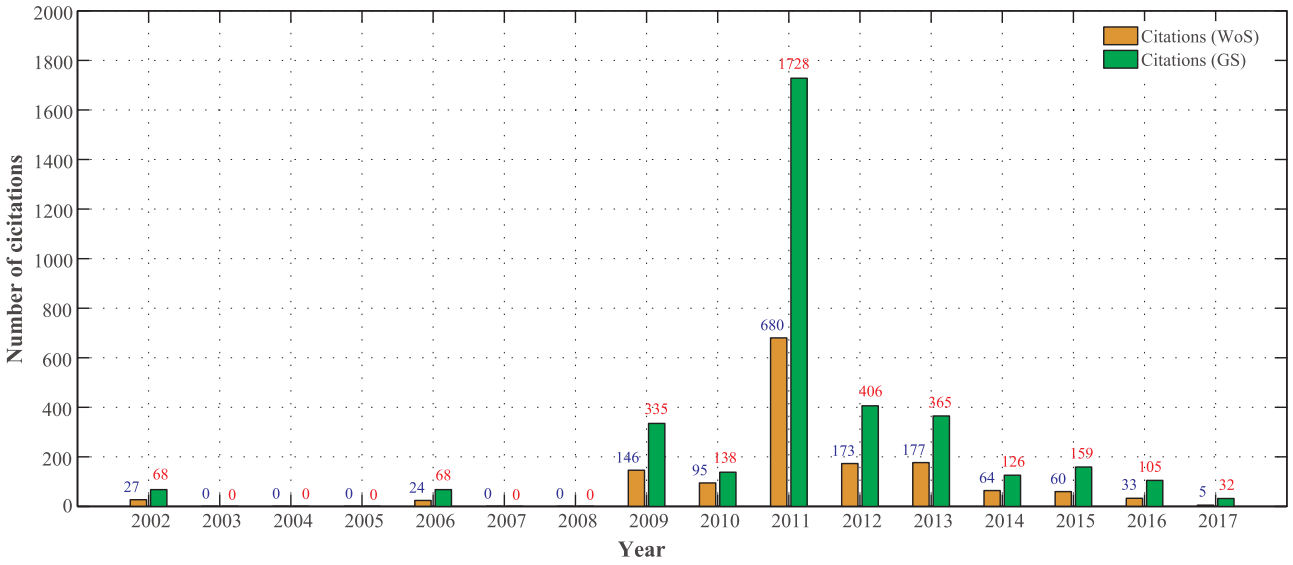

Fig. 2. Number of citations for the articles per year (Access date: 2017.10.11).

available online on 31 January 2017 but still had the "in press" status; therefore, this article was counted among the 2017 publications.

Overall, the general pattern indicates a growth in SSC focused publications. Apparently, there is increased interest, but some of this interest could be attributed to the general growth in the quantity of RCR publications. A total of 65 articles were published in 2002 by RCR; this number dramatically increased to more than four times that amount, reaching 275 articles in 2017. The sample of 59 articles considered is not a considerable population compared to the total numbers of publications in RCR. They represent less than 3% of the total of approximately 2170 published articles in RCR during the years 2002–2017.

In fact, year 2011 has the largest number of published SSC oriented articles (i.e., 12 articles) but represented only approximately 8.8% (137 articles in 2011) of the published articles in RCR for the year. Using the Web of Science (WoS) citation database, at the time when this current paper was prepared, these 12 articles published in 2011 had 680 total citations with an average of 56.7 citations per article. The total citation count for all 2011 RCR articles was 3635, with an average of 26.53 citations/article. Thus, the identified SSC-oriented articles represented approximately 18.7% of the total citations. These results show that the SSC research domain is being cited more than average (regarding year 2011), although it has not been considered as a main stream publication theme in RCR. The citation count frequency is discussed in more detail in Section 4.2.

4.2. Top-cited papers across the time

There are numerous ways to measure the influence and impact of papers; one of the more straightforward approaches is to determine the number of times a manuscript has been cited. However, there are limitations to this approach. It is likely that older papers have been cited more often and their electronic accessibility also plays a role. Given these initial limitations, it was decided to evaluate the identified papers based on citation count. Fig. 2 shows the number of citations of research articles classified per year. As depicted, most citations occurred from 2009 to 2016; totaling 96% in WoS and 95% in Google Scholar (GS) of all citations since 2002 and with an average of 179 (WoS) and 420 (GS) citations per year.

At the time of this study, ten research papers had more than 100 citations on the GS, and nine papers had more than 50 citations on the WoS. The WoS database and citation index typically has fewer citations per article due to the more restrictive inclusion of publications within its database. Moreover, Table 2 presents the top ten research papers in terms of citations based on the WoS and GS. The most cited RCR paper in the SSC domain was published by Diabat and Govindan (2011), with 188 WoS citations. The authors of this paper identified the influential drivers of a successful implementation of GSCM. Govindan et al. (2009) published the second most cited paper focusing on reverse logistics provider selection, which received over one hundred citations in WoS.

Table 2
Publications with the greatest number of citations.

Authors (year)	No. Citations (WoS)	Rank	No. Citations (G-S)	Rank
Diabat and Govindan (2011)	188	1	472	1
Govindan et al. (2009)	124	2	309	2
Eltayeb et al. (2011)	98	3	288	3
Lam et al. (2010)	95	4	138	8
Shen et al. (2013)	83	5	182	5
Olugu et al. (2011)	79	6	200	4
Mena et al. (2011)	70	7	161	6
Devika et al. (2012)	66	8	144	7
Hsu et al. (2012)	64	9	125	9
Muduli et al. (2013)	48	10	86	14
Lai et al. (2011)	44	11	108	10

Note: Access date on 2017.10.11 from WoS and GS.

4.3. Most productive and influential authors, institutions and countries

Table 3 presents a list of the top three authors with the greatest number of publications focused on the SSC domain in RCR. The ranking is based on the author's total number of publications and not on authorship order. Prof. Kannan Govindan (from Denmark) is the most productive author in the SSC domain in RCR, with 11 articles (18.6% of total).

Table 4 tabulates the size of the author team in the identified articles. It was most common for an article to have three authors (52.54%). Many papers had five or less authors (98.31%). Considering the increasing number of cross-national collaborations in the field, it is likely that many future studies published in RCR will involve multiple investigators and the number of co-authors will continue to increase.

Regarding the influential institutions, the University of Southern Denmark was the most productive institution in terms of SSC in RCR due to the contributions from Prof. Kannan Govindan and his colleagues. In terms of countries involved, a total of 29 countries from North

Table 3
The most productive and influential authors focused on SSC in RCR.

Rank	Author	Affiliation	Country	TP	TC	TC/TP
1	Govindan K	University of Southern Denmark	Denmark	11	572	52.00
2	Kannan, D	Indian Institute of Industrial Engineering	India	6	145	24.17
		Aalborg University	Denmark			
		University of Southern Denmark	Denmark			
3	Diabat A	Masdar Institute of Science and Technology	United Arab Emirates	4	338	84.50

Note: TP means total publication, TC means total citation and TC/TP means citations per publication.

Table 4
Size of the author team of the identified research articles.

Number of Authors	Count	Percentage (%)
1	1	1.69
2	6	10.17
3	31	52.54
4	11	18.64
5	9	15.25
6	1	1.69
Total	59	100

America, South America, Europe, Asia, Africa and Oceania were involved in producing these 59 papers. China (37 authors) appears as the most productive country, followed by India (28 authors), Denmark (18 authors), the UK (12 authors), Malaysia (12 authors) and Taiwan (12 authors), which is quite reasonable considering the large populations in China and India. In terms of European economies, per capita, scientists in the Denmark, the UK and Portugal contribute significantly to RCR. It also shows that environmental issues have become a continuous public concern in the developed countries and recently in developing economies as well. Supply chain sustainability has attracted more attention in India compared to the other countries, with six articles (6/59) investigating SSCs in practice.

4.4. Supply chain related topical themes

To form a sustainable value chain, researchers and practitioners require that sustainability be considered with respect to different aspects. Table 5 shows a classification of the papers within the five major themes. These thematic classifications were extracted from Sarkis and Zhu (2017) and were utilized to cluster the identified 59 articles within the defined categories as follows:

- Strategic consideration. Strategy delivers road maps required by an individual or organization to pursue a target or goal. From the strategic scope, a supply chain is viewed in terms of the corporation's sustainable competitive advantage, which includes the organizational mission statement, initiatives, value proposition, strategic decision making, managerial evaluation criteria (performance metrics), triggers (drivers or pressure), corporate social responsibility, and legislative concerns.
- Operational level. Operation represents supply chain level activities, which is the integration of decisions across the supply chain (Meixell and Gargeya, 2005). Integrating business processes is one of the practices in SCM that involves the SC model design, the design of a logistics network, business operations performance measurement and risk analysis.
- Decisions at functional interfaces. Function can be viewed as a series of activities in a supply chain, i.e., supplier selection and development, manufacturing, purchasing, delivery of products and services, waste treatment, and recycling.
- Green product. Product is viewed in product and material level investigations including product design, innovation, production, recycling and packaging.
- Energy perspective. Energy relates to the energy consumption, efficiency, and environmental impact.

Since business to business competition is extended to the supply chain level, it is critical for companies to align the supply chain and the firm's strategy to improve their organizational performance. The firm's focus is not only on profits or economic performance but also on the "triple bottom line (TBL)," which integrates environmental and social performance with economical business performance (Mani et al., 2016). This shows that if firms adopt a more environmentally friendly attitude (Andiç et al., 2012) and move toward SSCM (Tseng et al., 2017), this will ultimately lead to generating economic benefits for organizations (Eltayeb et al., 2011) as well as enhancing their sustainable performance (Jabbour et al., 2015). The strategy category also presents the pressures (Govindan et al., 2016; Xu et al., 2013), drivers (Diabat and Govindan, 2011) and various factors (Jabbour et al., 2014; Zhu et al., 2011) for adopting a green or environmental SCM strategy.

The operational category is more focused on supply chain level activities. Operations management improves the sustainability aspects

Table 5
Number of published articles in RCR.

Thematic categories	References
Strategic consideration (14)	Zhu et al. (2011), Eltayeb et al. (2011), Diabat and Govindan (2011); Andiç et al. (2012), Xu et al. (2013), Jabbour et al. (2014), 2015; Balaji and Arshinder (2016), Mani et al. (2016), Govindan et al. (2016), Gong et al. (2016), Mathivathanan et al. (2017), Shi et al. (2017), Tseng et al. (2017)
Operational level (13)	Wan Alwi et al. (2009), Krikke (2011), Jalali Naini and Aliahmadi (2011), Olugu et al. (2011), Egilmez et al. (2014), Hong et al. (2014); Tao et al. (2015), Mangla et al. (2015), Alhaj et al. (2016), Zhang et al. (2016), Badri Ahmadi et al. (2017), Carvalho et al. (2017) and Luthra et al. (2017)
Decisions at functional interfaces (23)	Tsoulfas et al. (2002), Logožar et al. (2006), Govindan et al. (2009), Lai et al. (2011), Yuan et al. (2011), Coelho et al. (2011), Mena et al. (2011), Shi et al. (2011), Lee et al. (2012), Devika et al. (2012), Hsu et al. (2012), Styles et al. (2012), Shen et al. (2013), Kumar et al. (2014); Ayvaz et al. (2015), Haji Vahabzadeh et al. (2015), Seo et al. (2015); Zhou and Zhou (2015), Bouzon et al. (2016), Prakash and Barua (2016), Agrawal et al. (2016), Steuer et al. (2017), Trochu et al. (2017)
Green product (4)	Ilgin and Gupta (2011), Khor and Udin (2013), Martinho et al. (2015); Sinha et al. (2016)
Energy perspective (5)	Lam et al. (2010), Muduli et al. (2013), Peng et al. (2016), Ye et al. (2016); Zhang et al. (2017)

Note: the number in the parentheses presents the frequency of articles published on each theme.

Table 6
Total number of published articles on each theme.

Themes	Publications
Eco-design, design for environment, corporate SD (2)	Ilgin and Gupta (2011), Shi et al. (2017)
Environmental supply chain management (9)	Zhu et al. (2011), Ilgin and Gupta (2011), Jalali Naini and Aliahmadi (2011), Lee et al. (2012), Styles et al. (2012), Seo et al. (2015), Tao et al. (2015), Alhaj et al. (2016), Peng et al. (2016)
Green supplier/vendor/logistics provider selection/ evaluation (5)	Govindan et al. (2009), Hsu et al. (2012), Shen et al. (2013), Kumar et al. (2014), Prakash and Barua (2016)
Green supply chain management (15)	Diabat and Govindan (2011), Eltayeb et al. (2011), Olugu et al. (2011), Andiç et al. (2012), Khor and Udin (2013), Xu et al. (2013), Shen et al. (2013), Muduli et al. (2013); Jabbour et al. (2014); Mangla et al. (2015); Jabbour et al. (2015), Balaji and Arshinder (2016), Govindan et al. (2016); Carvalho et al. (2017), Tseng et al. (2017)
Green (Eco) efficiency (2)	Carvalho et al. (2017), Zhang et al. (2017)
Energy supply chain (2)	Lam et al. (2010), Ye et al. (2016)
Waste management (10)	Coelho et al. (2011), Yuan et al. (2011), Mena et al. (2011), Andiç et al. (2012), Lee et al. (2012), Ayvaz et al. (2015), Govindan et al. (2016), Sinha et al. (2016), Steuer et al. (2017), Trochu et al. (2017)
Recycle for sustainability (5)	Logožar et al. (2006), Coelho et al. (2011), Hsu et al. (2012), Hong et al. (2014), Steuer et al. (2017)
Carbon footprint (4)	Lam et al. (2010), Krikke (2011), Devika et al. (2012), Seo et al. (2015)
Green network structure analysis and design (8)	Wan Alwi et al. (2009), Krikke (2011); Devika et al. (2012); Ayvaz et al. (2015), Zhou and Zhou (2015), Shi et al. (2017), Steuer et al. (2017), Trochu et al. (2017)
Green product (2)	Ilgin and Gupta (2011), Khor and Udin (2013)
Reverse logistics, closed-loop supply chain (17)	Tsoulfas et al. (2002), Logožar et al. (2006), Govindan et al. (2009), Coelho et al. (2011), Shi et al. (2011), Devika et al. (2012), Khor and Udin (2013), Hong et al. (2014), Ayvaz et al. (2015), Haji Vahabzadeh et al. (2015), Zhou and Zhou (2015); Tao et al. (2015), Agrawal et al. (2016), Bouzon et al. (2016); Prakash and Barua (2016), Sinha et al. (2016); Trochu et al. (2017)
Sustainable supply chain management (4)	Egilmez et al. (2014), Luthra et al. (2017), Mathivathanan et al. (2017), Zhang et al. (2016)
Social supply chain management (2)	Mani et al. (2016), Badri Ahmadi et al. (2017)
Green logistics (2)	Lai et al. (2011), Martinho et al. (2015)
Life cycle assessment (4)	Tsoulfas et al. (2002), Egilmez et al. (2014), Seo et al. (2015); Sinha et al. (2016)
Environmental performance measurement/ improvement (4)	Jalali Naini and Aliahmadi (2011), Ilgin and Gupta (2011); Styles et al. (2012),Gong et al. (2016)

Note: the number in the parentheses presents the frequency of articles published on each theme.

in the supply chain scenario. The publications in RCR discuss the green supply network model design (Krikke, 2011; Tao et al., 2015; Wan Alwi et al., 2009), supply chain modeling for management practices (Alhaj et al., 2016; Carvalho et al., 2017; Luthra et al., 2017), performance measurement for the sustainability of the supply chain (Badri Ahmadi et al., 2017; Egilmez et al., 2014; Jalali Naini and Aliahmadi, 2011; Olugu et al., 2011; Zhang et al., 2016), as well as management activities for supporting green activities across the supply chain (Hong et al., 2014; Mangla et al., 2015; Tao et al., 2015).

The functional category is focused on activities concerning SSCM that are implemented either individually or cross-functionally. It includes supplier selection (Kumar et al., 2014), green/sustainable performance evaluation (Shen et al., 2013; Styles et al., 2012), economic production and low carbon production (Seo et al., 2015; Shi et al., 2011), green shipping (Lai et al., 2011), waste treatment (Lee et al., 2012; Yuan et al., 2011) and recycling (Coelho et al., 2011; Hsu et al., 2012; Steuer et al., 2017). It is worth mentioning that RL related research represents the vast majority of publications within the function category, such as the following: reverse logistics networks (Ayvaz et al., 2015; Devika et al., 2012; Trochu et al., 2017; Zhou and Zhou, 2015), reverse logistics models (Haji Vahabzadeh et al., 2015; Logožar et al., 2006; Tsoulfas et al., 2002), reverse logistics provider selection (Govindan et al., 2009; Hsu et al., 2012; Prakash and Barua, 2016), outsourcing in reverse logistics (Agrawal et al., 2016) as well as reverse logistics barriers (Bouzon et al., 2016).

Green products refers to products that consider environmental principles in the design and manufacturing of the products, i.e., incorporating recycling strategies into the design phase, products produced with recycled materials and that use fewer toxic materials (Chen and Chai, 2010). In the green product category, some studies focused on designing products for disassembly at the end of its life cycle (Khor and Udin, 2013) and developing sensor embedded products (Ilgin and Gupta, 2011) to cope with the uncertainty associated with the disassembly operation. In addition, other researchers employed eco-design tools (Martinho et al., 2015) and eco-cycle principles (Martinho et al., 2015) to design a green product.

Energy consumption has not received much attention in business and management although it might be a well-established domain within some branches of engineering sciences including transportation research (Halldórsson and Kovács, 2010). Within this category, Zhang et al. (2017) discussed energy efficiency and Peng et al. (2016) focused on the energy-related CO_2 emissions topic. The other three papers discussed the biomass (biofuel) supply chain (Lam et al., 2010; Ye et al., 2016) and human behavior in the mining industry (Muduli et al., 2013).

The thematic categories are broken down into additional subthemes in terms of dynamic topics under investigation across supply chain activities and functions. Table 6 shows the breakdown of specific themes (rather than categories) associated with each publication. Fig. 3 provides further information regarding the number of published articles within each theme. Since each article might fit in multiple themes, the number of articles adds up to more than 59. Table 6 shows that the RL theme has received growing attention in RCR. Due to the nature of RCR, 28.81% of the studied works were related to extending the traditional forward supply chains to a closed-looped one where RL practices were taken into consideration. In the identified two review articles (Agrawal et al., 2015; Pokharel and Mutha, 2009), both investigated the current development in research and practice in RL. This topic is relatively highly considered in RCR.

Overall, it seems that the reviewed articles in RCR are focused on greening the supply chains. Interestingly, the term “green” appeared more frequently in most themes compared with term “sustainability.” This result indicates the substantial consideration of environmental sustainability over social sustainability in the RCR literature. For instance, corporate social responsibility related matters seem to be receiving limited attention (see Sub-section 5.1).

4.5. Research methodologies applied

Three main categories, i.e., modeling, conceptual and empirical, are adopted here to provide more insights on the methodologies applied within the published research in the RCR journal. Table 7 tabulates these based on the reviewed articles, and the “modeling” category has been further divided into four sub-categories, i.e., multi-criteria

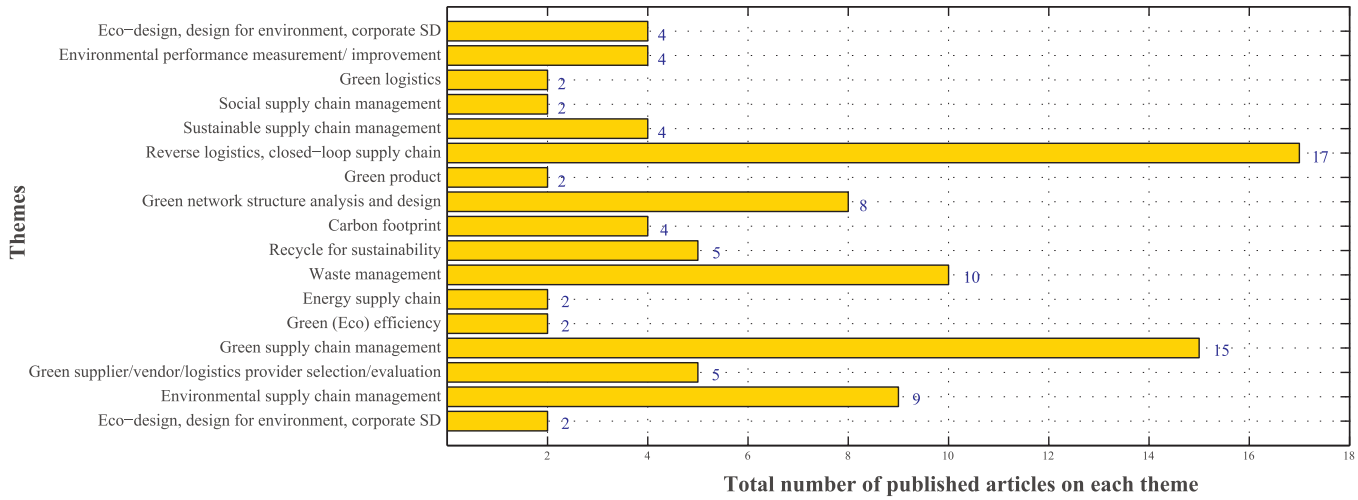

Fig. 3. Themes of published articles.

decision modeling, mathematical modeling, simulation modeling and analytical tools. 64.4% of the reviewed articles published in the RCR journal developed and applied modeling approaches to address the problems under study. More specifically, 23.7% of the articles applied multi-criteria decision modeling methodologies. Most of these methodologies are comprised of the commonly used multi-criteria decision making (MCDM) approaches, such as, the analytical network process (ANP), analytical hierarchy process (AHP), TOPSIS, decision-making

Table 7
Detailed categorization of the applied methodologies.

Method category	Sub-category	Methodology approach	Reference
Modeling (38)	Multi-criteria decision modeling (15)	Fuzzy Delphi – ANP (1)	Shi et al. (2017)
		FAHP – Fuzzy TOPSIS (1)	Prakash and Barua (2016)
		DEMATEL (2)	Govindan et al. (2016); Mathivathanan et al. (2017)
		Fuzzy TOPSIS (1)	Shen et al. (2013)
		FAHP (1)	Mangla et al. (2015)
		Fuzzy Delphi and AHP (1)	Bouzon et al. (2016)
		Fuzzy Delphi and IVTFN-GRA (1)	Tseng et al. (2017)
		Grey based DEMATEL (1)	Luthra et al. (2017)
		DEMATEL-ANP (DANP) and VIKOR (1)	Hsu et al. (2012)
		Fuzzy VIKOR (1)	Haji Vahabzadeh et al. (2015)
		Best Worst Method (1)	Badri Ahmadi et al. (2017)
		Evolutionary game theory and balanced scorecard (1)	Jalali Naini and Aliahmadi (2011)
		ISM and Fuzzy TOPSIS (1)	Govindan et al. (2009)
		Sustainable balanced scorecard – Graph theory (1)	Agrawal et al. (2016)
	Mathematical modeling (13)	Linear programming (3)	Logožar et al. (2006), Lam et al. (2010), Ayvaz et al. (2015)
		Mixed integer programming (4)	Krikke (2011); Devika et al. (2012); Alhaj et al. (2016); Trochu et al. (2017)
		Binary integer programming (1)	Carvalho et al. (2017)
		Non-linear programing (5)	Shi et al. (2011), Hong et al. (2014),Tao et al. (2015), Zhou and Zhou (2015), Ye et al. (2016)
	Simulation modeling (3)	Discrete event simulation based Design of experiments (1)	Ilgin and Gupta (2011)
		System dynamics (2)	Yuan et al. (2011), Sinha et al. (2016)
	Other tools (7)	Input-output analysis (IOA) (2)	Lee et al. (2012), Zhang et al. (2016)
		IOA – structural path analysis (1)	Peng et al. (2016)
		Life cycle assessment (LCA) (2)	Tsoulfas et al. (2002), Seo et al. (2015)
		IOA - LCA - Data Envelopment Analysis (DEA) (1)	Egilmez et al. (2014)
		Network Allocation Diagram (1)	Wan Alwi et al. (2009)
Empirical (17)		Questionnaire surveys/semi-structured interviews (12)	Eltayeb et al. (2011), Mena et al. (2011), Olugu et al. (2011), Zhu et al. (2011), Andiç et al. (2012), Xu et al. (2013); Khor and Udin (2013), Jabbour et al. (2015), Martinho et al. (2015), Mani et al. (2016), Zhang et al. (2016); Steuer et al. (2017)
		Survey - structural equation modeling (1)	Jabbour et al. (2014)
		Interpretive structural modeling (ISM) (3)	Diabat and Govindan (2011); Muduli et al. (2013), Kumar et al. (2014)
		Fuzzy MICMAC and total interpretive structural modeling (1)	Balaji and Arshinder (2016)
Conceptual (4)		Theoretical/literature reviews (4)	Coelho et al. (2011); Lai et al. (2011); Styles et al. (2012); Gong et al. (2016)

Note: the number in the parentheses presents the frequency of articles published on each applied methodology.

trial and evaluation laboratory (DEMATEL), and Visekriterijumska Optimizacija I Kompromisno Resenje (VIKOR). The merits and drawbacks of these approaches separately or combined with fuzzy logic are presented in Ghadimi et al. (2016). RL selection (Prakash and Barua, 2016), sustainable/green supply chain management practices adoption (Mathivathanan et al., 2017), RL barriers identification (Bouzon et al., 2016) and prioritizing the recovery options in RL (Haji Vahabzadeh et al., 2015) are among the addressed multi-criteria decision problems. The multi criteria/objective nature of sustainability operations is regarded as the main reason for utilizing MCDM approaches in SSC.

Unlike the "modeling" category of applied methodologies that encompasses most the published articles, the "empirical" and "conceptual" methodology approaches account for only 28.8% and 6.8% of the total reviewed articles. Questionnaire surveys and interviews were mostly utilized to gather empirical data associated with topics such as investigating the consumers' behavior regarding using environmentally friendly packaging (Martinho et al., 2015), elaborating relationships between green sourcing and organizational environmental performance indicators (Jabbour et al., 2015), characterizing the hierarchical structure of SSCM (Zhang et al., 2016) and investigating recent developments in socially responsive supply chains (Mani et al., 2016). The articles categorized within the "conceptual" research methodology category mostly used literature reviews and theoretical concepts to address the considered problem. Gong et al. (2016) provided a literature review on performance metrics affecting the sustainable decision-making procedures of firms. Styles et al. (2012) studied the challenges faced by private retailers regarding the consideration of environmental improvements within their supply chain by reviewing the best practice actions of 25 European retailers. Less focus on empirical and conceptual approaches is not surprising, as incorporating sustainability in traditional supply chain management at the operational and functional levels requires more modeling and applied case studies.

4.6. Illustration types

The main purpose for including this section in our analysis is to provide insights regarding the extent to which the developed methodological approaches presented in Section 4.5, which are aimed to narrow various gaps in the literature, have been validated. As shown in Table 8, four illustration types are used to validate the theoretical gaps and empirical claims made by various authors among the published literature in RCR. There are many papers that used "case study/real-world applications" to demonstrate the competence and usefulness of the suggested method (49.15%). These 29 papers studied and validated their theoretical claims by adopting real case applications of both SMEs and large enterprises (LEs).

Authors in 16 papers (27.12%) used statistical analysis to make inferences regarding either their empirical or theoretical claims. In some of these papers, empirical type methodologies might have been utilized to gather empirical data but the research gaps were finally confirmed or rejected (validated) using statistical approaches. Eltayeb et al. (2011) statistically measured the impact of green supply chain initiatives on an organization's performance. They confirmed that the external initiatives, for instance, green purchasing and reverse logistics would have indirect and minor effects on a firm's internal performance. The direct effect of such initiatives would impact the other actors in a supply chain, such as suppliers. Zhang et al. (2016) provided a set of statistically validated scales for measuring the successful implementation of SSCM and practices.

In 15.25% of the research articles reviewed, only numerical examples were utilized where the competence of the developed approach was studied. Although numerical demonstration of advantages of a proposed approach can be valuable (Carvalho et al., 2017), real-life application of a proposed methodology would highlight its deployment issues and deficiencies (Diabat and Govindan, 2011). Within the context of SSCM, Ghadimi et al. (2016) emphasized that a real-life examined methodology would provide more valuable theoretical and managerial insights towards incorporating sustainability into a typical SC. Additionally, a real-world application of a developed methodology will result in identifying potential drivers and barriers of its implementation procedure. Upon implementation, the actual willingness of the case company to integrate sustainability into their SC operations at the strategic, operational and functional levels can also be tested.

4.7. Industries addressed

In RCR, SSC practices appear to be applied in a handful of firms involved in various industries. Applications to design SSC models are mostly for in industries such as metal, electrical and electronic, and automobile manufacturing. The reviewed articles are classified based on the industries in which their proposed approach has been tested in to improve our understanding of the sectorial influences of SSCs.

The North American Industry Classification System (United States Census Bureau, 2017) was used for this purpose. Table 9 shows that there has been a large focus on the manufacturing industry, especially the computer and electronic product manufacturing industry and the transportation equipment manufacturing industry. The computer and electronic product manufacturing industry was often chosen because these types of products are used in almost all the other industrial and service sectors (Jabbour et al., 2014). The computer and electronic industry sector play a significant role toward elevating flexibility, increasing the efficient utilization of several types of energy, increasing productivity and ultimately contributing towards the sustainability levels of organizations. The transportation equipment manufacturing industry is the second most considered industry, mainly due to its large carbon footprint. In addition, chemical manufacturing and aluminum related manufacturing can be ranked as the third industry most often considered among the published articles in RCR.

Table 8
Validation approaches of the identified research articles.

Validation approach	Reference
Case Study/real-world applications (29)	Tsoulfas et al. (2002), Logožar et al. (2006), Govindan et al. (2009), Lam et al. (2010), Diabat and Govindan (2011), Krikke (2011), Jalali Naini and Aliahmadi (2011), Yuan et al. (2011), Hsu et al. (2012), Devika et al. (2012), Muduli et al. (2013), Egilmez et al. (2014), Kumar et al. (2014), Ayvaz et al. (2015), Jabbour et al. (2015), Mangla et al. (2015), Seo et al. (2015), Zhou and Zhou (2015), Balaji and Arshinder (2016), Bouzon et al. (2016), Govindan et al. (2016), Prakash and Barua (2016), Ye et al. (2016), Badri Ahmadi et al. (2017), Luthra et al. (2017), Mathivathanan et al. (2017), Trochu et al. (2017), Shi et al. (2017); Tseng et al. (2017)
Statistical (16)	Olugu et al. (2011), Ilgin and Gupta (2011), Eltayeb et al. (2011), Mena et al. (2011), Zhu et al. (2011), Andiç et al. (2012), Lee et al. (2012), Khor and Udin (2013), Xu et al. (2013), Jabbour et al. (2014), Martinho et al. (2015), Mani et al. (2016), Peng et al. (2016), Zhang et al. (2016), Steuer et al. (2017), Eltayeb et al. (2011), Zhang et al. (2017)
Numerical example (9)	Wan Alwi et al. (2009), Shi et al. (2011), Shen et al. (2013), Hong et al. (2014), Tao et al. (2015), Haji Vahabzadeh et al. (2015), Agrawal et al. (2016), Alhaj et al. (2016), Carvalho et al. (2017)
Theoretical (5)	Coelho et al. (2011), Lai et al. (2011), Styles et al. (2012), Gong et al. (2016), Sinha et al. (2016)

Note: the number in the parentheses presents the frequency of articles published on each validation approaches.

Table 9
Detailed categorization of the industries addressed.

Industry category	Sub-industry	Reference	Remark
Agriculture, forestry, fishing and hunting (3)	Crop production (3)	Mena et al. (2011), Egilmez et al. (2014), Balaji and Arshinder (2016)	Agri-food
Retail trade (1)		Styles et al. (2012)	Retailers across private-label food, textile, furniture and household chemical products
Manufacturing (50)	Textile mills (1)	Xu et al. (2013)	
	Primary metal manufacturing (3)	Logožar et al. (2006), Diabat and Govindan (2011)	Alumina and aluminum production and processing
		Peng et al. (2016)	Iron and steel
	Fabricated metal product manufacturing (6)	Diabat and Govindan (2011)	Kitchenware products
		Hsu et al. (2012); Hong et al. (2014)	Aluminum composite panel
		Eltayeb et al. (2011), Seo et al. (2015)	Aluminum window
		Kumar et al. (2014)	Fireworks
	Computer and electronic product manufacturing (16)	Eltayeb et al. (2011), Ilgin and Gupta (2011), Krikke (2011), Zhu et al. (2011), Andiç et al. (2012), Lee et al. (2012), Khor and Udin (2013), Xu et al. (2013), Hong et al. (2014); Jabbour et al. (2014), Ayvaz et al. (2015), Agrawal et al. (2016), Bouzon et al. (2016); Prakash and Barua (2016); Badri Ahmadi et al. (2017), Tseng et al. (2017),	Semi-conductors (SC), optoelectronic materials and components (OMC); printed circuit board assemblies (PCBA); electronic components and parts (ECP), electrical materials (EM); electrical and electronic equipment (EEE)
	Electrical equipment and appliance manufacturing (1)	Tsoulfas et al. (2002), Govindan et al. (2009)	Battery manufacturing
	Transportation equipment manufacturing (9)	Jalali Naini and Aliahmadi (2011), Olugu et al. (2011); Zhu et al. (2011), Xu et al. (2013), Jabbour et al. (2015), Badri Ahmadi et al. (2017), Carvalho et al. (2017); Luthra et al. (2017), Mathivathanan et al. (2017);	Automotive, motorcycle manufacturing companies
	Plastics and rubber products manufacturing (4)	Coelho et al. (2011), Eltayeb et al. (2011); Devika et al. (2012), Mangla et al. (2015)	Plastic
	Paper manufacturing (1)	Zhou and Zhou (2015)	
	Chemical manufacturing (4)	Eltayeb et al. (2011), Zhu et al. (2011); Jabbour et al. (2015), Badri Ahmadi et al. (2017)	
		Xu et al. (2013)	Furniture and household chemical products
	Machinery manufacturing (2)	Eltayeb et al. (2011), Zhu et al. (2011)	
	Nonmetallic mineral product manufacturing (1)	Badri Ahmadi et al. (2017)	Cement and concrete product manufacturing
	Miscellaneous manufacturing (1)	Shi et al. (2017)	Sporting and athletic goods manufacturing
Mining (2)		Muduli et al. (2013), Govindan et al. (2016)	Iron ore extracting mining
Utilities (2)	Electric power generation, Transmission and Distribution (2)	Lam et al. (2010), Ye et al. (2016)	Biomass electric power generation
Construction (2)	Heavy and civil engineering construction (2)	Yuan et al. (2011), Trochu et al. (2017)	
Others (1)		Zhang et al. (2017)	37 industry sectors

Note: the number in the parentheses presents the frequency of articles published on each industry category.

In addition to the sustainability studies on the supply chains of certain industries, several researchers studied supply chain sustainability across multiple industries (Badri Ahmadi et al., 2017; Diabat and Govindan, 2011; Eltayeb et al., 2011; Jabbour et al., 2015; Lee et al., 2012; Styles et al., 2012; Xu et al., 2013; Zhang et al., 2017; Zhu et al., 2011). A multiple industry design has three additional benefits. First, focusing on one industry might not provide a full spectrum of SSCs in practice. Second, considering more than one industry for implementing their research activity results in an increase in external validation and generalization of the findings and result implications. Lastly, there are few, if any, industries with large numbers of exemplars, which would have limited the sample sizes and further limited the applicability of the results (Pagell and Wu, 2009).

5. Current trends and future challenges and directions in SSC modeling and analysis – RCR focus

5.1. Overlooked topics in SSC modeling and analysis in RCR

The social dimension of SSC is receiving less attentions in comparisons with the environmental and economic aspects of SC in RCR. As tabulated in Table 6, only two publications were found that exclusively concentrated on the social aspect. Such a comparatively low consideration of the social dimension is not surprising and has already been mentioned in the existing sustainability literature (Beske et al., 2014; Ghadimi et al., 2016, 2013; Seuring and Müller, 2008; Zhang et al., 2016). Social dimension criteria, e.g., human rights abuses, child labor and irresponsible investment need to be incorporated into traditional/green supply chains to have a TBL consideration of sustainability (Ghadimi et al., 2016). Globally, social issues, such as human rights, and workers' health and safety issues are being increasingly acknowledged by manufacturing organizations. However, its consideration in an organization's sustainability performance metrics in combination with environmental and economic criteria is still at early stage and is often neglected. This is mainly due to the inherent difficulties associated with assessing the social performance of an SSC where the available tools for social indicators are limited and are often prone to subjectivity (Badri Ahmadi et al., 2017).

In a socially responsible supply chain, not considering social factors can affect an organization's reputation and long-term success. This is because organizations are held responsible for paying constant attention to their workers' health and safety issues together with some other important social criteria such as stakeholder engagement, e.g., manufacturers, distributors and/or retailers (Ghadimi et al., 2017b; Wang et al., 2015). Most companies' social considerations and efforts have not been as productive as they should be, and this is mainly because of

considering corporate social responsibility in a generic form, which is mis-aligned with the strategic supply chain decisions. This manner of consideration results in conflicting environmental, economic and social strategic goals (Craig and Easton, 2011). In contrast, these organizations should relate to the social aspects of their supply chain operations with the environmental and economic aspect in a broader corporate strategic perspective to ensure an economically sound supply chain with simultaneous and effective consideration of the TBL. Considering social sustainability might not have a direct impact on increasing the profitability of their operations (Hollos et al., 2012), but it has been proven in a few works that it can eventually be a driver for widening a company's profit margin (Thornton et al., 2013). Unfortunately, most SMEs are more willing to be forced to comply with environmental regulations and laws and skip social practices.

In addition, in terms of the energy related topic, there is an increasing awareness about the future diminution of fossil energy resources. Therefore, renewable energy sources have received wider interest in recent decades (Mele et al., 2011). Table 6 presents that only two publications that are identified related to the energy related topic dealing with the biomass (biofuel) supply chain (Lam et al., 2010; Ye et al., 2016). Future trends in sustainable supply chains call for more research to develop advanced modeling frameworks and solution methods in tackling the challenges in the renewable fuel supply chain, such as biodiesel supply chains and biogas supply chains.

5.2. Supply chain stages and the modeling perspective

Table 7 in Section 4.5 presents that a great portion of the developed methodologies in the articles published in RCR are modeling approaches. This is an inevitable result (64.4%) given the inherent complexity in a supply chain itself. In an SSC setting, this complexity would be even more highlighted with the incorporation of sustainability related practices in a typical SC. Therefore, pure modeling approaches are required for more understanding of the topic. Within this context, 36.8% of the reviewed articles within the "modeling" category developed multi-criteria decision making approaches to addressed topics such as the choice of sustainable development criteria in corporate sustainability (Shi et al., 2017), identifying barriers (Bouzon et al., 2016) and drivers of successful implementation of green SCM (Govindan et al., 2016) and identifying the most dominant SSCM practices (Mathivathanan et al., 2017). Further analysis of the literature shows that there is a gap between the body of literature (at least from RCR perspective) identifying several drivers and barriers of the successful implementation of green and sustainable SCM with the actual utilization of these research outputs in a real-world incorporation of sustainability in an organization's SC configuration. While challenging, an essential link between the results of these types of strategic studies and the mathematical and simulation modeling type approaches is required.

Based on the results in Section 4.4, 13 articles considered the entire supply chain as their analysis scope categorized within operational level schematic themes. Tools such as questionnaire surveys and semi-structured interviews help to build the related theory on SSC at an operational level with a concurrent consideration of sustainability and the entire SC. However, it is also essential to test these theories using qualitative modeling approaches such as mathematical and simulation modeling tools. Surprisingly, among those 13 papers, only five papers applied mathematical modeling approaches such as mixed integer modeling, non-linear programming and binary integer programming. This signifies a strong gap in the literature published in RCR in which mathematical modeling methods can play a significant role in addressing the SSC from a holistic perspective. Moreover, there are no links in the considered SSC literature regarding the utilization of discrete event simulation (DES) models at an operational level. The main reason for this gap in RCR's published papers can be attributed to the journal's scope, which mostly focuses on publishing environmental modeling and management with considering decisions at functional interfaces rather than for the entire SC (see Section 4.4). With links to MCDM approaches, stochastic or discrete multi-objective mathematical models and agent-based simulation approaches need to be developed and investigated due to the uncertainty in customer demand, availability of sustainable products and consumers' sustainable purchasing behaviors associated with sustainability integration with a typical SC (Ghadimi and Heavey, 2014; Ghadimi et al., 2018). Lastly, Seuring (2013) discussed the role of LCA-based data as a background for other modeling papers. In RCR, this finding cannot be confirmed due to the lack of LCA-based methodologies integrated with other modeling approaches.

5.3. Sustainable supply chain modeling and analysis: academic theory and industrial practice

Academics in RCR produced theoretical results in 59 identified articles in the SSC field. Table 8 presents the four illustration types used to validate the theoretical gaps and empirical claims. Almost 50% of the considered articles validate their theoretical claims through a real-world case study adoption and illustrate its applicability and capability in a real-world organizational setting. This type of empirical method is widely accepted in the international operations management research community (Taylor and Taylor, 2009). These studies contributed to both the academic and professional communities. For researchers, these studies provided the current knowledge in the SSC field and some directions for extending the current theory in the field. Additionally, valuable implications are often presented for industrial practitioners and decision makers inside an organization who are responsible for making effective strategic, operational, functional, product and energy related decisions to enhance the sustainability practices at a corporate level. However, does SSC oriented research affect firm/industry practice? Are the developed models effective in industry or does industry have its own agenda? Which SSC articles have had a dual impact on both science and practice? Gong et al. (2016) answered the questions in the sustainable performance metrics domain and highlighted the need for further research in this area to find the gap between the desirability of sustainability results and its actual implementation to improve business decision making. However, the related research activities are in the minority by far.

Approximately 15% of the articles attempted to validate their theoretical claims using numerical examples, and 9% of the articles only made theoretical claims without validation. Would these types of research works provide useful guidance for management practices? This is the key question that needs to be addressed in further research. As far back as 1964, Kaplan criticized the behavior scientists who "give the impression that they do not much care what they do if only they do it right" (Kaplan, 1964). Unlike physics-based models, the theoretical claims in social science are sometimes "only remotely related to the real world of practicing managers" (Susman and Evered, 1978) and far from practical guidance (Panda and Gupta, 2014). Rigby (2001) conducted a survey on utilized management tools and techniques in 15 countries to evaluate the performances of 25 tools and techniques, which consisted of a set of theories, concepts, processes, exercises, and analytic frameworks. It was found that only 7 of the 25 tools and techniques, were proposed and designed by academic scholars and they had low user satisfaction rates. To avoid these issues, Panda and Gupta (2014) strongly argued that the gap between rigor and relevance needs to be bridged to make academic research more relevant to practice, and provided some suggestions to enhance the relevance. Pagell and Shevchenko (2014) encouraged managers to participate in the academic research. They presented that participatory research would, at least in the supply chain field, be a way for supply chain researchers to improve the odds of innovations moving from the laboratory to practice and, hence, to lead practice.

5.4. Neglected focus on SMEs

Section 4.6 presents that among the 59 identified research articles, many articles studied and validated their theoretical claims in the SSC research domain through adopting a case study or pilot case from LEs. However, only two articles focused on SMEs. This reveals that sustainability in large firms has been well researched and SMEs have been the focus less often in terms of sustainability in RCR. The results are in line with the findings from prior studies (Brammer et al., 2012; Revell et al., 2010). It is not surprising studies on adopting sustainability are predominately aimed at LEs because individual large firms are naturally larger and have a greater impact on the environment than do SMEs.

SMEs constitute the majority of companies in all industrialized and developing nations, and the collective ecological and social impacts of countless SMEs are overwhelming. For example, it is estimated that SMEs account for up to 70% of industrial pollution worldwide (Revell et al., 2010). Given the significant scale of small businesses in nearly every economy, their cumulative achievements have a major effect worldwide. In addition, LEs usually work with large networks of suppliers - mostly SMEs (Gelinas and Bigras, 2004). Therefore, the goal of developing an SSC will not be achieved in practice unless SMEs are actively engaged.

However, it is believed that SMEs can benefit from applying some of the best practices of LEs. The previous results and conclusion in the SSC research domain of LEs cannot be directly applied to SMEs, because SMEs are not simply scaled-down versions of LEs but organizations with unique characteristics. Del Brìo and Junquera (2003) identified nine different characteristics of SMEs with respect to their environmental strategy, including aspects such as financial resources, organizational structure, management style and production capabilities.

In brief, SMEs differ from LEs in terms of circumstances and competencies. The indifferences between SMEs and LEs spur a growing body of literature to specifically highlight the SMEs' participation in environmental practices. However, the literature on the adoption of SSC principles for SMEs is still in its infancy (Ghadimi et al., 2016). Due to the importance of this research topic, there are many questions that can be regarded as future research directions on this topic, i.e., (1) what are the fundamental differences in the barriers and drivers in SSC management from the perspective of SMEs and LEs? (2) what are the differences in the adoption of SSC principles in SMEs and LEs?

5.5. More industry setting and broader opinions in the data collection procedure

While diverse types of industries have been explored in the identified 59 research articles, very few studies have investigated service related industries, which are relatively new areas of sustainability research. Table 9 shows that manufacturing (tangible products) industries constitute a large proportion of the previous research, such as the computer & electronic product manufacturing industry and the transportation equipment manufacturing industry. One of the reasons is that most successful manufacturing organizations have an opportunity to achieve higher performance in pursuit of SSCM, which is a common practice across manufacturing industries (Chow, 2015; Ghadimi et al., 2018; Wang et al., 2018). Recent decades have seen the rapid economy evolution from a manufacturing base to a service orientation. Servitization is even predicted as being a future significant research area within operations management (Taylor and Taylor, 2009). However, the literature in RCR with regards to service supply chains and sustainability considerations is still at the early stages.

To conduct research in industrial practice, questionnaire surveys were designed and interviews were conducted with experts to collect data from academia and industry in parts of the 59 identified articles. Most articles selected experts only from industry (Agrawal et al., 2016; Govindan et al., 2016; Khor and Udin, 2013; Ye et al., 2016; Zhang et al., 2016). Some articles selected respondents from both academia and industry (Carvalho et al., 2017; Olugu et al., 2011; Shi et al., 2017) and customers (Martinho et al., 2015). These respondents represent the interests of different stakeholders and have different perspectives. From the managers' point of view, the profitability of an SC is always the priority and the environmental and social performances come next (Carter and Rogers, 2008). From NGOs, governments, or communities, greater emphasis is given towards the impact of SC operations on society or the environment. Future research needs to build the SSC considering the various opinions from broader stakeholders, dealing with win-win or trade-offs among the economic, environmental and social elements of the TBL.

6. Concluding remarks and limitations

This study provides both retrospective and futuristic views of the research contributions in the field of SSC modeling and analysis in the RCR journal together with more generic implications, as well. A systematic and comprehensive content analysis has been conducted in this paper. A seven-dimensional taxonomy was designed for the review to analyze the published literature in RCR in terms of (1) the publication per year, (2) top-cited papers across time, (3) most productive and influential authors, institutions and countries (4) supply chain related topical themes, (5) research methodologies applied, (6) illustration types and (7) industries addressed. Based on these seven taxonomies, various types of analyses were conducted based on the 59 identified articles that were published in RCR regarding SSC modeling and analysis. The reported results and findings prove the emerging role of RCR within the SSC modeling and analysis literature. The future challenges and directions are addressed in Section 5, which are drawn from the statistical results in Section 4 coupled with our own perspectives and experiences.

This study has certain limitations, and it is important to articulate them here. One of the primary limitations of this paper is the scope of the review, which is limited to the published papers within RCR. Wherever appropriate, a more generic analysis has been provided to tackle this limitation. Another limitation of this work is related to the small sample size of 59 articles, as only the published papers in RCR and its precedents were considered within the review process.

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