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Green supply chain management: a meta-analysis of recent reviews

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Abstract. This paper provides a meta-analysis of the review papers targeting the theme of green supply chain management (GSCM). The chosen topic is of central interest among researchers in supply chain and logistics, and a number of review papers have appeared on that theme. Using a combination of bibliographic and bibliometric analyses, this paper makes an attempt to delineate the most debated topics in GSCM, the most prominent themes and the need for future research in the field.

Keywords: meta-analysis; systematic literature review; green supply chain.

1 Introduction

Green supply chain management (GSCM) describes the concept of integrating sustainable environmental processes into the traditional supply chain management processes, such as product design, material sourcing and selection, manufacturing and production, operation, logistics, up to end-of-life management [1], [2]. It is therefore a holistic approach that incorporates environmental concerns in the supply chain [3] and aids firms to improve their footprint on sustainability [4]. Greening operations by reducing air, water and waste pollution, enhances firms’ performance in terms of less waste, reuse/recycling of products, decrease in manufacturing costs, enhanced assets efficiency, positive image, and higher customer satisfaction.

GSCM has recently gained increasing importance, as reducing air, water and environmental pollution is one of the key challenges of the 21st century [5]. GSCM also has a mediating role in achieving Sustainable Development Goals (SDGs) [6], [7], which is a main target of companies worldwide. This increased interest towards GSCM has led to many papers published on this topic, and, consequently, to the publication of review papers on GSCM as well. Starting from the pioneer state-of-the-art review on GSCM (i.e. [1]), many researchers have carried out reviews on specific topics of GSCM (e.g. [8], [9], [10] or [11]). In the light of the wide number of review papers available on GSCM and of the various topics that have been addressed in these reviews, this paper proposes a meta-analysis of the review papers on GSCM. This methodology has

been chosen as it typically allows researchers to arrive at conclusions that are more accurate and reliable than those presented in a single study or review paper [12].

The remainder of the paper is structured as follows: section 2 describes the methodology used in carrying out this study. Section 3 shows the main results of the meta-analysis. Section 4 highlights the conclusions, limitation and implications of the study.

2 Methodology

A meta-analysis is a quantitative statistical analysis grounded on the results of multiple scientific studies, all addressing the same topic, with each individual study reporting specific aspects or measurement [12]. The quantitative procedures of meta-analysis help to address some of the challenges introduced by the existence of multiple answers to a given research question. Meta-analyses allow combining numerical results from various studies, accurately estimating the resulting statistics [13] and explaining inconsistencies (if any) in the research findings. The meta-analysis carried out in this study targets review papers in the field of GSCM and, in particular, systematic literature reviews (SLRs). Being SRL a structured approach, this choice ensures that homogeneous data can be retrieved from the papers analyzed. Indeed, a requirement of SLRs is to follow a clearly defined and replicable protocol, where the criteria for reviewing the literature are clearly stated. Moreover, SLRs involve planning a well thought out search strategy which has a specific focus or answers a defined question [14].

For retrieving the pertinent studies, different queries were made on the Scopus database (www.scopus.com) on November 2020. The queries were made using search terms linked to the theme of GSCM, namely: “green supply chain management”, “green supply chain” and “sustainable supply chain”. These terms were searched for in the “abstract/title/keyword” (TITLE-ABS-KEY) of the document. Moreover, in line with the scope of this paper, the query results were limited to “review” as article type. The timespan of the studies was limited as well, and it was set from 2007 to 2020. Indeed, one of the first reviews on GSCM (i.e. [1]) was carried out exactly in 2007, which is a robust justification for starting in that year for retrieving the pertinent studies; moreover, at the time of the query, only a preliminary amount of studies of 2021 were available online, meaning that year 2021 could not be evaluated in full and this is why it was excluded from the analysis. Therefore, the query settings were PUBYEAR>2006 AND PUBYEAR<2021 AND (LIMIT-TO (DOCTYPE, "re")). The queries made returned 300 documents in total: 67 documents using "green supply chain management", 92 using "green supply chain" and 141 using "sustainable supply chain".

For the three groups of papers, some key pieces of information (i.e. the paper’s metadata, the number of citations and the author’s keywords) were directly downloaded in .csv file format using the “export” function of Scopus and imported in Microsoft Excel™ for creating the full dataset of useful studies. The database was thus used for removing papers for which the author name was not available (i.e. that returned “[No author name available]” or a blank cell in the corresponding field of Scopus). Despite the query settings, indeed, these papers typically are not scientific papers (nor review

papers): they could be editorials, prefaces of conferences, papers published in non-scientific magazines or something similar; in any case, these documents should be excluded from any elaboration. Four papers with this characteristic were thus removed from the database. Duplicated studies, i.e. studies that resulted from more than one query, were then identified, by simply comparing the articles' title using the "IF" function of Microsoft Excel™. This check involved 85 papers to be removed from the sample. The fulltexts of the remaining 211 papers were retrieved and checked to ensure that each study meets the criterion of being a SLR and not a mere review paper. This led to 106 documents that matched this criterion and were taken as the final sample of papers to be analyzed.

The analyses made on the 106 papers were of both bibliographic and bibliometric nature. Bibliographic analyses mainly aim at providing an overview of the sample of papers; examples of these analyses include the number of publications per year, the trend of publications in time or the publication outlet. Bibliometric analyses instead are more structured elaborations that apply quantitative tools to the evaluation of a sample of papers [15]. Among the possible elaborations, citation analyses and keyword analyses [16] were carried out in this study. All these analyses were made exploiting appropriate functions available on Microsoft Excel™.

3 Results

The first aspect investigated is the trend of publications in time (Fig.1). The first SLR on topics related to GSCM appeared in 2011, despite the fact that review papers on this theme were published even before that year. However, this outcome could be expected as SLR started gaining attention in engineering research in recent years only, while being a known methodology in medicine and social sciences since the late '90s [17]. This is also confirmed by the almost constant increase in the number of SLRs published since that date, with a peak of 30 papers in 2019; overall, 55 papers (51.8% of the sample) were published in the last two years of the timespan. The 106 SLRs of the sample were found to be published, overall, on 51 different sources. Looking at those journals that published at least two studies (Fig.2), the *Journal of Cleaner Production* emerges as the source in which the greatest number of studies has been published (19 out of 106, 17.9%), followed by *Sustainability* (12 out of 106, 11.3%) and *Supply chain management* (11 out of 206, 10.4%). This outcome is consonant with the theme under examination; indeed, both *Journal of Cleaner Production* and *Sustainability* target expressively the topics of green and environment, while *Supply chain management* has a broader focus, targeting, more in general, studies that investigate the supply chain under various perspectives.

A quite well-known tool for mapping the research trends on a given topic is the keywords analysis [16] by means of their frequency (i.e. the number of occurrences of a keyword) and persistency (i.e. the number of years elapsed since the keyword was used for the first time). This analysis was made using the "author's keywords" field of Scopus. In this respect, for four papers of the sample, the keywords were not available; therefore, these studies were excluded from the analysis, leading to a sample of 102

usable papers. The keywords of these papers were elaborated using Microsoft Excel™, with the aim first of all to identify terms which needed to be grouped into a single keyword. In fact, it is frequent that the different authors use slightly different terms with the same meaning; this is for instance the case of keywords written in full or using acronyms (e.g. supply chain management vs. SCM), or of the same terms written in singular or plural form (e.g. supply chain vs. supply chains). Some preliminary adjustments were therefore made to fix these small inconsistencies. The number of keywords resulting after these adjustments was 564. Because of the still high number of outcomes, each keyword was examined singularly to identify a macro-theme to which it could be associated. For example, “green” as a keyword can be easily associated to a macro-theme like “green supply chain”. Approximately 60 keywords could not be associated to any macro-theme, either because they represented terms appearing just once or because they expressed very specific concepts.

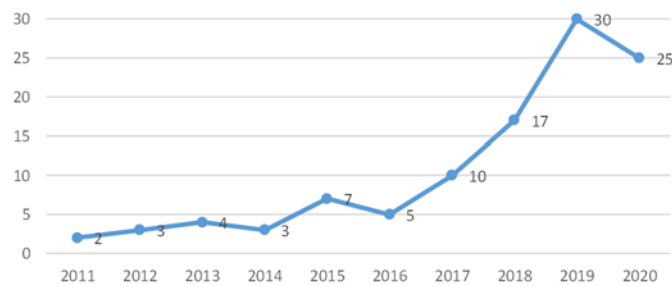


Fig. 1: trend of publications in time.

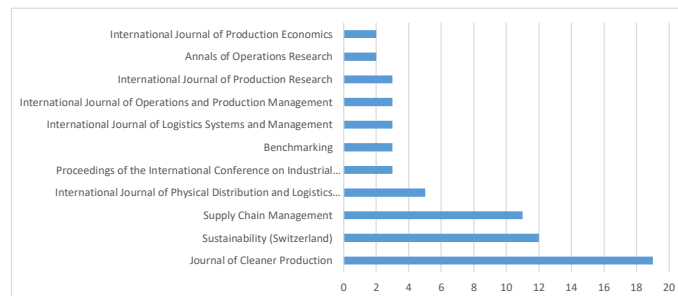


Fig. 2: top journals.

The results of this analysis, limited to those keywords that appeared at least twice and excluding the keyword that were not classified, are proposed in Table 1. From Table 1 it can be seen that the most recurrent macro-theme is the wide topic of “sustainable supply chain management” (SSCM, frequency: 65), which includes 4 keywords that appeared at least twice. The next most recurrent macro-themes are “Systematic literature review” (frequency: 48), “sustainability” (frequency: 46) and “green supply chain” (frequency: 45), which are all in line with the focus of the sample of papers reviewed. It should be mentioned that keywords related to “literature review” (as opposed to SLR) occur a significant lower number of times (frequency: 19), which once again denotes

appropriateness of the sample of papers. Interestingly, a macro-theme relating to the usage of specific tools for “bibliometric analyses” has also been found (frequency: 11).

It is also interesting to see that “supply chain management” and “logistics” are quite recurrent as well (frequencies: 38 and 20, respectively), suggesting that these themes are often investigated in GSCM literature. The three pillars of sustainability, i.e. the economic, social and environmental ones [18], are all covered among the macro-themes identified; the most frequent one is environmental sustainability (frequency: 18), followed by social sustainability (frequency: 9) and economic sustainability (frequency: 5). Various themes related to sustainability have also been identified, including sustainable development, circular economy or corporate social responsibility.

Table 1. Frequency of keywords and macro-themes.

Macro-theme	Frequency	Appearance	Keywords	Frequency
<i>SSCM</i>	65	2011	Sustainable supply chain management	31
			Sustainable supply chain	20
			Supply chain sustainability	3
			Sustainable operations	2
<i>Systematic literature review</i>	48	2012	Systematic literature review	40
			Systematic review	3
			PRISMA	2
			Structured literature review	2
<i>Sustainability</i>	46	2012	Sustainability	30
			Triple bottom line	2
			Sustainability performance	2
<i>Green supply chain</i>	45	2013	Green supply chain management	20
			Green supply chain	6
			Green	2
<i>Supply chain management</i>	38	2011	Supply chain management	13
			Supply chain	13
			Multi-tier supply chain	2
<i>Logistics</i>	20	2012	Logistics service provider (LSP)	3
			Logistics	2
			Freight transport	2
			Vehicle routing	2
<i>Performance measurement</i>	19	2015	Performance measurement	4
			Performance measures	2
			Supply chain performance measurement	2
			Green supply chain performance measurement	2
			Performance	2
<i>Literature review</i>	19	2013	Literature review	16
<i>Environmental sustainability</i>	18	2011	Environment	5
			Environmental sustainability	4
			Environmental management	3
<i>Supplier selection</i>	14	2011	Supplier selection	4
			Third-party logistics (3PL)	3
			Sustainable sourcing	2
			Partner selection	2
<i>Circular economy</i>	14	2017	Circular economy	9
<i>Corporate social responsibility</i>	12	2011	Corporate social responsibility	5
			Social responsibility	2
<i>Bibliometric analysis</i>	11	2016	Content analysis	4
			Bibliometric analysis	3
			Quantitative methods	2
<i>Industry 4.0</i>	11	2018	Industry 4.0	3
			Big data analytics	2
			Blockchain	2
<i>Developing countries</i>	11	2017	Developing countries	4

			Guanxi	2
			Asian emerging economies	2
<i>MCDM</i>	10	2011	Multi criteria decision making	3
			AHP	3
			Topsis	2
<i>Social sustainability</i>	9	2014	Social sustainability	3
<i>Sustainable development</i>	7	2012	Sustainable development	6
<i>Innovation</i>	6	2017	Innovation	3
<i>Framework</i>	6	2015	Conceptual framework	2
<i>Collaboration</i>	5	2019	Collaboration	3
<i>Closed-loop supply chain</i>	5	2017	Closed-loop supply chain	5
<i>Economic sustainability</i>	5	2011	Economic performance	3
			Economic sustainability	2
<i>Reverse logistics</i>	5	2011	Recycling	2
<i>Research methodology</i>	4	2012	Interpretive structural modeling	2
<i>Agility/leanness</i>	4	2018	Lean	2
<i>Electronic</i>	4	2012	Electrics and electronics industry	2
<i>Construction industry</i>	3	2019	Construction industry	3
<i>Knowledge</i>	2	2019	Knowledge	2
<i>Fuzzy</i>	2	2011	Fuzzy	2
<i>Manufacturing sector</i>	2	2017	Manufacturing sector	2

A second interesting aspect is the persistency of keywords, which allows for identifying the new themes *vs.* the well-established ones. As the first SLR about GSCM appeared in 2011, the persistency of the keywords can range from 1 for a keyword appearing in 2020, to 10 for a keyword appearing in 2011. Because of the high number of keywords found, the macro-themes were used for the determination of the persistency (all data can be seen in columns 2 and 3 of Table 1). The results are shown in Fig.3, which correlates the persistence (*y*-axis) and the frequency (*x*-axis) of each macro-theme. To be more effective, the graph in Fig.3 was divided into 4 quadrants, obtained by distinguishing high *vs.* low values of persistency and frequency. As persistency is computed on a range of 10 years, it is quite immediate to label the resulting values as “high” if they range from 6 to 10 (corresponding to a study published between 2011 and 2015) or “low” if they range from 1 to 5 (corresponding to a study published after 2015). For frequencies, the median value (*i.e.* 5) was taken as the boundary to separate the “high” and “low” values.

The outcomes show that macro-themes such as Industry 4.0, agility/leanness, circular economy, or innovation started being explored in review papers concerning GSCM in recent times only. On the contrary, the first SLRs about GSCM have targeted themes like performance measurement, environmental sustainability, sustainable development, corporate social responsibility, supplier selection or reverse logistics. This outcome highlights the maturity of these themes compared to the more recent ones. Moreover, for a SLR to be carried out on a given topic, it is evident that a relevant amount of studies on that topic should have been published; for newer themes, such as Industry 4.0 or circular economy, it is reasonable to suppose that the number of studies useful for a review has been reached in recent years only.

The last analysis presented tries to evaluate the relevance of the macro-themes by taking into account the average number of citations received by the papers falling into that macro-theme. The number of citations per year (instead of the absolute number of citations) was used in carrying out the analysis, to normalize the resulting values. Table 2 shows the results obtained, limited to those macro-themes that received more than 10

citations/year on average. As Table 2 and Figure 3 show, macro-themes that appeared in early studies are also the most cited in literature, suggesting that over the years they have become well-established topics on which many authors are working. It is interesting to see, nonetheless, that some more recent topics (e.g. sustainable development or research methodologies) have also received a relevant number of citations, meaning that are attracting the attention of researchers.

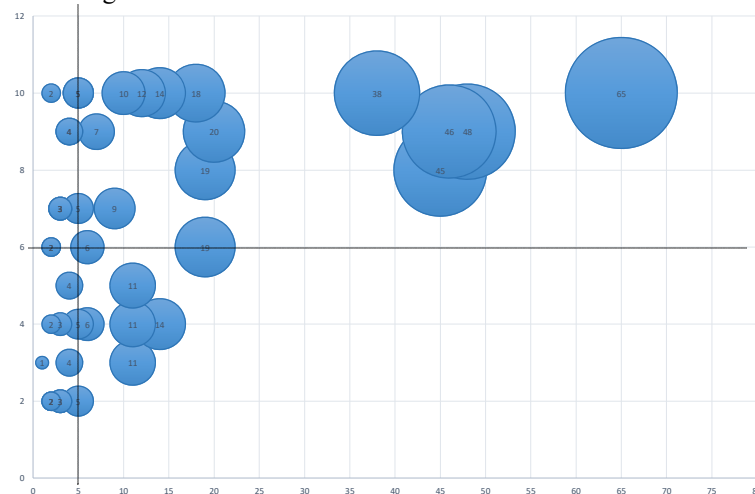


Fig. 3: frequency vs. persistency of keywords.

Table 2. Average number of citations per year vs. macro-theme.

Macro-Theme	Citations/year	Macro-Theme	Citations/year
Economic sustainability	31.6	Research methodology	13.0
Manufacturing Sector	26.0	Developing countries	12.2
Processes	21.3	Supplier selection	12.1
Organization	18.5	Sustainable development	11.6
Closed-Loop Supply Chain	18.5	Electronic	11.4
Corporate social responsibility	17.5	Supply chain management	11.2
Circular economy	16.8	Environmental sustainability	11.1
Literature review	15.0	SSCM	10.5
Decision science	13.5	Agility/leannes	10.3

4 Conclusions

This paper has presented a meta-analysis of systematic literature reviews focusing on the topic of GSCM. A set of 106 papers was retrieved from the Scopus database and the relevant pieces of information were exported to allow their elaboration on Microsoft Excel™. Out of the numerous analyses that can be made on a set of papers using bibliographic and bibliometric tools, this paper has focused on some descriptive statistics, keyword analysis and citation analysis. These analyses were used to provide a preliminary investigation of the topic and to identify the most prominent themes. For sure, the analyses presented could be deepened and complemented by additional elaborations

intended to confirm the results obtained and highlight further specific facets. As an example, all the data relating to the systematic literature reviews (e.g. the number of papers examined, the timespan of the review, the database used etc.) could be retrieved from the set of papers and compared. The correlation between the number of papers reviewed and the specific topic of the review is a further point worth of investigation.

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