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Review

A conceptual framework for measuring sustainability performance of supply chains

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ABSTRACT

Supply chains are critical driving forces behind business competitive advantages, hence their sustainability measurement and management is vital. Determining the sustainability performance of supply chains is challenging. It requires appropriate tools for capturing and analyzing data for every supply chain activity and for each sustainability aspect. This study analyzes measurement approaches that are used to assess sustainability performance of supply chains. Using Content, Context and Process framework, we have studied 104 peer-reviewed articles, published in the literature on sustainable supply chain management (SSCM) and green supply chain management (GSCM). The results show that various measurement approaches are used to assess sustainability in different sectors and supply chain echelons. The application of multi-criteria decision-making methods is increasing and several promising measurement frameworks have been proposed. The most used approaches include Life Cycle Assessment, Analytical Hierarchy Process, Fuzzy set approach, Balance Scorecard, and Data envelopment analysis. Additionally, this study proposes a novel conceptual framework and provides a concise guideline for assessing sustainability of supply chains. Key challenges that need to be solved by future measurement approaches include sustainability data collection and sharing, metrics standardization, and collaboration among supply chain members per se and stakeholders. This study creates better comprehension of how existing approaches evaluate sustainability of supply chains and provides new insights into sustainability performance measurement approaches, supply chain configuration, and metrics selection.

Contents

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1. Introduction

In today's competitive business environment, many corporations including IBM, Hewlett Packard, Xerox, Walmart, and BMW have started to integrate sustainability principles into their supply chains (SCs) (Rajeev et al., 2017). Because of serious misconducts related to sustainable practices, Walmart stopped working with suppliers in Uzbekistan and Bangladesh in 2008 and in 2011, respectively (Varsei et al., 2014). Walmart estimated that over 90 percent of its total emissions are related to SC operations (Birchall, 2010; Dubey et al., 2017). Likewise, Carbon Disclosure Project (2011) estimated that more than 20 percent of global greenhouse gases emissions are produced from 2500 largest global companies, and their SCs are responsible for a large proportion of emissions (Dubey et al., 2017).

In response to growing concerns about SCs environmental and social impacts, various stakeholders such as government regulators, consumers, non-governmental organizations (NGOs), the media, and community activists are putting pressure on organizations to reduce harmful impacts in their SCs (Delai and Takahashi, 2011; Hassini et al., 2012). Several authors (e.g., Seuring and Gold, 2013; Winter and Knemeyer, 2013) argue that sustainability extends beyond the boundaries of any single firm and harmful impacts occur across all stages of products lifecycle (Linton et al., 2007). Consequently, companies are now held responsible for their SCs and are increasingly obliged to measure, control, and disclose, their own sustainability performance as well as their entire SC sustainability performance (Rao, 2014; Taticchi et al., 2013).

Searcy (2017) notes that five out of six companies listed in the S&P 500 published a sustainability report in 2015. However, such sustainability reports often are uncompleted and uncoordinated due to missing standards (KPMG, 2011; Reefke and Sundaram, 2017). Likewise, Morali and Searcy (2013) emphasize that SC sustainability reporting needs to be refined. Furthermore, several authors (Bai and Sarkis, 2014; Taticchi et al., 2013) highlight that competition shifted from individual organizations competing against each other to SCs competing against each other.

To improve the competitive advantages, organizations need to measure and manage effectively and efficiently (Neely et al., 2002; Shepherd and Günter, 2006) their SC sustainability performance. Assessing and improving the performance requires the development of the SC performance measurement system. Performance metrics and measurement methods or tools are an integral part of the system. Thus, it is important to analyze performance measurement (PM) approaches that can support managers to focus on core SC sustainability-related decisions (Bai and Sarkis, 2014).

Some of the approaches that have been proposed for evaluating sustainability performance of the SC include Balanced Scorecard (BSC) and its modifications (Duarte and Cruz-Machado, 2015; Shafiee et al., 2014; Thanki and Thakkar, 2018), Life Cycle Assessment (LCA) and its modifications (Arcese et al., 2017; Cucchiella et al., 2014; Wang et al., 2016), Fuzzy set approaches (Chithambaranathan et al., 2015; Sabaghi et al., 2016; Uygun and Dede, 2016), Data Envelopment Analysis (DEA) (Mirhedayatian et al., 2014; Tajbakhsh and Hassini, 2015a), Supply Chain Operations Reference (SCOR) model (Bai et al., 2012; Taticchi et al., 2013), Analytic Hierarchy/Network Process (AHP/ANP) (Agrawal et al., 2016; Büyüközkan and Çifçi, 2012), and a few conceptual PM frameworks (Hassini et al., 2012; Schöggl et al., 2016; Sloan, 2010).

These methods have been criticized for not taking all three sustainability aspects into consideration (Hassini et al., 2012; Seuring, 2013) and most of them lack to incorporate all SC members (Ahi and Searcy, 2015). Another issue is the selection of metrics as there is a myriad of proposed metrics for SSCM or GSCM (Ahi and Searcy, 2015; Hassini et al., 2012). Additionally, the majority of PM approaches have been initially developed for evaluating performance within organizations and not across organizations. For these reasons various authors highlight the need for further research in assessment frameworks and analytical models that can integrate and measure sustainability performance of SCs (Bai and Sarkis, 2014; Björklund et al., 2012; Bulsara et al., 2016; Matos and Hall, 2007; Morali and Searcy, 2013; Reefke and Sundaram, 2017; Seuring, 2013; Taticchi et al., 2015; Varsei et al., 2014).

Given the importance of measuring sustainability performance of SCs and potential tools with their limitations, this study focuses on the call for investigation of PM systems for advancing GSCM and SSCM (Bai and Sarkis, 2014; Reefke and Sundaram, 2017). Therefore, the purpose of this study is to examine PM approaches that have been published in the peer-reviewed academic literature on SSCM and GSCM.

To fulfill this research objective, the authors analyzed, classified and synthesized PM approaches presented in 104 peer-reviewed articles published from 2005 to the end of March 2018, in the literature on GSCM and SSCM. The Content, Context, and Process framework was used for papers content analysis. This article makes the following contributions to GSCM and SSCM literature. First, by summarizing and categorizing an extensive number of studies on PM of SSCM and GSCM, this paper creates better comprehension of how existing studies assess sustainability of SCs. Second, a novel conceptual framework for measuring sustainability performance of SCs is proposed. The framework provides new insights into the relationships between sustainability PM approaches, SC design, and metrics selection. Third, it provides a concise guideline for measuring sustainability performance of SCs. Fourth, this paper highlights that standardization of metrics, data sharing, and collaboration among SC members are key challenges to current measurement approaches in SSCM and GSCM. Thus, this study extends understanding about methods and tools that have been used to assess sustainability performance of SCs and draws some conclusions that can inform practitioners and scholars.

Following the introduction, the study continues with a concise literature review (2) on sustainability PM of SCs. Next, the methodology (3) applied in the study is presented, followed by the section of results (4). The study ends with a discussion (5) of results, further research recommendations, and conclusions (6).

2. Sustainable supply chain performance measurement

The literature on PM of SCs is rich and have been researched extensively in last three decades (e.g., Beamon, 1999; Gunasekaran and Kobu, 2007; Neely et al., 2002; Shepherd and Günter, 2006). In contrast, literature on PM of SSCM and GSCM is fragmented (Taticchi et al., 2013) and limited, despite several contributions (e.g., Ahi et al., 2016a; Ahi and Searcy, 2015; Erol et al., 2011; Grosvold et al., 2014; Hassini et al., 2012; Izadikhah and Saen, 2017; Marconi et al., 2017; Varsei et al., 2014; Xing et al., 2016). Some of the contributions are literature reviews, which will be discussed in the following section.

2.1. Related reviews and the rationale for this study

To position this study in the literature we analyze previous literature reviews closely related to the aim of this study. In other words, only literature reviews on sustainability PM of SCs that cover at least two sustainability dimensions are considered. Interested readers on literature reviews focused only in economic sustainability of SCs are recommended to read following reviews (Akyuz and Erkan, 2010; Balfaqih et al., 2016; Gopal and Thakkar, 2012; Gunasekaran and Kobu, 2007; Maestrini et al., 2017; Shepherd and Günter, 2006).

Existing reviews on sustainability PM of SCs examine different aspects but none of them study sustainability measurement approaches. Previous reviews are focused either on metrics identification (Ahi and Searcy, 2015; Cuthbertson and Piotrowicz, 2011; Hassini et al., 2012; Tajbakhsh and Hassini, 2015b); bibliometric and co-citation analysis (Taticchi et al., 2015, 2013); or on a broad overview on PM of SSCM and GSCM (Beske-Janssen et al., 2015; Björklund et al., 2012; Bulsara et al., 2016; Hervani et al., 2005). Table 1 presents previous literature reviews on sustainability PM of SCs. Some of the limitations of these reviews include (i) they review some papers that cover only economic dimension of sustainability; (ii) the majority of the studies focus on identification and discussion of metrics or measures and miss the SC context; (iii) article's selection criteria in some works are unclear; and (iv) methodology followed to develop the review is not explained or illustrated.

This study aims to overcome previous limitations by reviewing an extensive number of papers and explaining in detail the research methodology. Specifically, this study differs from previous reviews for the following reasons: (i) it is focused on sustainability measurement tools and not on indicators, measures or metrics; (ii) includes a comprehensive up-to-date list of studies that assess sustainability of SCs; and (iii) proposes a comprehensive framework for measuring sustainability performance of SCs.

Since, four previous literature reviews (Ahi and Searcy, 2015; Hassini et al., 2012; Hervani et al., 2005; Tajbakhsh and Hassini, 2015b) have proposed conceptual PM frameworks for measuring sustainability of SCs, it's important to analyze in greater detail elements of these frameworks. Specifically, the framework proposed by Hervani et al. (2005) does not explicitly mention SC members but it implies that, at least, can be used to measure economic and environmental sustainability between suppliers and manufacturers. A list of environmental metrics is provided and a short discussion about the influence of stakeholders is reported. There are no details how to select pertinent metrics and how these metrics can be aggregated into key performance indicators (KPIs). In the framework proposed by Hassini et al. (2012) all sustainability dimensions and SC members including suppliers, manufacturers, distributors, retailers, and consumers are considered. This framework is supplemented with metrics for each SC member by Tajbakhsh and Hassini (2015b). However, the aggregation of these measures into KPIs or composite indicators is scarcely discussed, and the influence of stakeholders is not considered. The conceptual framework proposed by Ahi and Searcy (2015) includes all sustainability dimensions and SC members but it lacks to discuss the aggregation of individual metrics into KPIs. In other words, it does not reveal how sustainability of SCs should be measured.

In sum, the main issues with previous sustainability PM

Table 1
Previous literature reviews on measuring sustainability performance of SCs.

Study	Time range	Number of papers	Article selection/Database	Sustainability dimensions	Outcome
Hervani et al. (2005)	Not specified	Not specified	Not specified	Environmental Economic	Hurdles related to PM of SCs are presented and a ***framework*** for planning PM system is proposed.
Cuthbertson and Piotrowicz (2011)	1998–2009	45	Keyword/database is not specified	Environmental Economic Social	Articles are classified according to their research methodology, a case study is discussed, and several metrics are listed.
Björklund et al. (2012)	1998–2008	17	Keyword/database is not specified	Environmental Economic	Studies are categorized based on stakeholder perspective, the purpose of measuring, managerial levels of measuring, measuring across SC, and the combination of measurements.
Hassini et al. (2012)	2000–2010	87	Keyword/Scopus	Environmental Economic Social	Papers are classified based on their research methodology, industry, SC drivers, and partners. A conceptual *PM* ***framework*** is provided.
Taticchi et al. (2013)	1970–2012	205	Keyword/Isi Web of Science	Environmental Economic Social	Articles are analyzed using citation and co-citation techniques and a research agenda is provided.
Tajbakhsh and Hassini (2015b)	1994–2013	140	Keyword/Google Scholar	Environmental Economic Social	Articles are classified based on their research methodology, industry, and sustainability dimensions. The study proposes *a* ***framework*** with focus on metrics.
Taticchi et al. (2015)	2000–2013	384	Keyword/Isi Web of Science	Environmental Economic Social	Bibliometric analysis such as analysis of publication, citations and research methods. The focus is in the intersection of decision support tools and performance measurement.
Ahi and Searcy (2015)	To the end of 2012	445	Keyword/Scopus	Environmental Economic Social	Frequency analysis of metrics used in the literature of SSCM or GSCM. A conceptual *PM* ***framework*** is proposed.
Beske-Janssen et al. (2015)	1995–2014	149	Keyword/EBSCO Business Source, Emerald, Science Direct, and Wiley	Environmental Economic Social	Bibliometric analysis and qualitative data covering what is measured; who is measuring; how is it measured. It is focused on the evolution of PM in SSCM.
Bulsara et al. (2016)	To the end of 2014	112	Keyword/Database is not specified	Environmental Economic Social	Articles are categorized into three groups: scope of the study, research methodology and the sustainability focus of the study.

frameworks are that they partly consider components of sustainability PM of SCs, and they lack to highlight the significance of relationships between SC members, sustainability metrics, and stakeholders. Furthermore, tools for aggregating individual sustainability metrics into KPIs are not provided. These tools are at the core of this study, and KPIs are critical elements on PM process because they help SC managers to focus on central activities (Bai and Sarkis, 2014). Therefore, this paper reviews relevant literature and proposes a novel conceptual framework for measuring sustainability performance of SCs. Next, we present the benefits and challenges of measuring sustainability performance of SC and discuss some relevant measurement approaches.

2.2. The advantages of measuring SC sustainability performance

Previous research reports important outcomes from assessing the SC sustainability performance. In their review, Beske-Janssen et al. (2015) emphasize that central elements of SSCM, such as collaboration, transparency, supplier evaluation are only feasible if related performance measurement and management tools are implemented. Additionally, measuring sustainability performance of SCs urges supply chain innovation (Schaltegger and Burritt, 2014).

On one hand, measuring and managing sustainability of SCs guides organizations towards eliminating and reducing risks and confirming compliance with standards and regulations (Bulsara et al., 2016; Seuring and Müller, 2008; Taticchi et al., 2013), on the other hand, PM signals organizations for opportunities and trade-offs (Schaltegger and Burritt, 2014).

Thus, measuring and managing sustainability of SCs is more than dealing with risk and compliance because organizations reduce costs, increase efficiency, strengthen competitive advantages, facilitate sustainability reporting, sharpen operational performance, and support the implementation of the SC strategy (Björklund et al., 2012; Chithambaranathan et al., 2015; Hervani et al., 2005; Shepherd and Günter, 2006).

2.3. The challenges of measuring SC sustainability performance

Evaluating sustainability performance of SCs across multiple members such as suppliers, manufacturers, distributors, and consumers is complex and challenging (Sloan, 2010). In a large set of existing sustainability metrics (e.g., Ahi and Searcy, 2015; Tajbakhsh and Hassini, 2015b), SC managers should select and aggregate metrics into KPIs, in a way that would facilitate decision making in all managerial levels. Social indicators sometimes are challenging to be quantified and are often prone to subjectivity (Schaltegger and Burritt, 2014). Other problems highlighted by Brewer and Speh (2000), Hervani et al. (2005), and Wong and Wong (2008) on PM systems in SCs include:

- Managers lack understanding of metrics applied in multi-organizational context.
- Managers and organizations lack the control of inter-organizational metrics.
- Different goals and objectives among organizations in the chain result with different measures.
- Incompleteness and inconsistencies on PM among SC partners.
- Information systems are incapable of gathering non-traditional information relating to SC performance.
- Lack of standardized performance measures in terms of units to use, structure, format etc.

Additionally, existing PM methods and tools should be adjusted to integrate environmental, social and economic measures (Olugu et al., 2011; Reefke and Trocchi, 2013) in a balanced way in order to create synergetic effects (Beske-Janssen et al., 2015) or triple win-win solutions (Seuring and Müller, 2008).

2.4. Performance measurement approaches in GSCM and SSCM

Sustainability PM approaches applied in SCs are diverse in nature. They include environmental management standards (e.g., ISO 14001), international reporting standard (e.g., GRI – Global Reporting Incentive), SCOR framework, BSC, LCA, multi-criteria decision making (MCDM) tools (e.g., AHP, ANP, DEA), Rough set theory, Fuzzy-set approach, Composite Indicators, and Conceptual Frameworks.

AHP is an easy and flexible multi-criteria decision-making technique that combines subjective managerial inputs and objective factors in multiple criteria decision-making. Selecting KPIs and ranking metrics in SC is a key to success (Gunasekaran and Kobu, 2007) and AHP can be a good tool to choose and prioritize metrics. It is a technique that helps managers to understand the trade-offs between sustainability aspects and allows the active participation of decision-makers in making rational decisions and reaching agreements (Schaltegger and Burritt, 2014). Dey and Cheffi (2013) developed an innovative green supply chain performance measurement framework by integrating SC processes with organizational decision levels employing AHP. Singh et al. (2007) proposed a conceptual PM framework using AHP.

LCA is widely used by different authors and often serves as a background for other modeling approaches (Seuring, 2013). Croes and Vermeulen (2015) extended LCA to measure product sustainability. In their work, they emphasized that LCA lacks a measuring standard, does not include the social aspect, is limited to a top-down approach, is based on complex impact data, and has difficulties with data maintenance. Matos and Hall (2007) proposed an analytical framework to analyze the appropriateness of LCA in the assessment of complex and novel technologies for sustainable development by considering a rugged landscape as an adequate approach for high performance. They applied a design structure matrix to identify parameters and interdependencies between sustainability dimensions. Simão et al. (2016) used European Platform on Life-Cycle Assessment of European Life-Cycle Database to evaluate performance postponement strategies in green supply chain design. Park et al. (2016) using an input-output-based ecological lifecycle assessment framework evaluated the ecological performance of the US agriculture and food sectors. Acquaye et al. (2014) developed a systematic benchmarking approach which combines the Multi-Regional Input–Output (MRIO) and LCA as a basis for developing supply chain maps for industrial-level carbon emissions performance measurement.

SCOR is not specifically designed for PM but is one of the most implemented frameworks across industries (Taticchi et al., 2013). The SCOR divides the supply chain into six phases – plan, source, make, deliver, return, and enable an added-in version. The generic performance metrics for every phase are cost, time, quality, flexibility, and innovation (Taticchi et al., 2013). Bai et al. (2012) introduced a seven-step methodology for joint environmental and business PM and they proposed a core set of essential measures for sustainable SCs. Two years later, Bai and Sarkis (2014) developed a methodology for determining and applying sustainable supplier key performance indicators. They utilized SCOR and neighborhood rough set theory to identify KPIs and data envelopment analysis to benchmark and evaluate the relative performance of KPIs.

BSC, developed by Kaplan and Norton (1992), initially was not designed for SC evaluation. BSC integrates financial and non-financial aspects in the PM process and provides feedback for continuous improvement. The scorecard measures organizational performance from the financial perspective, customer perspective, internal process perspective, and learning and growth perspective. Several authors have modified BSC to incorporate sustainability dimensions and to make it applicable in SCs. Reefke and Trocchi (2013) customized BSC for SSCM and provided six potential development steps for implementation in practice, but their model lacks measures, composite indicators or KPIs for each respective perspective. Shaw et al. (2010) proposed an aggregated strategic environmental supply chain performance index incorporated within BSC. Tseng et al. (2015) developed a hybrid quantitative BSC to evaluate SSCM in a closed-loop hierarchical structure using Fuzzy Delphi Method and ANP. They employed ANP to consider interdependences among measures and to assess the final performance score by integrating importance and performance weights.

Nawrocka et al. (2009) highlighted that ISO 14001 is often used as a proof of environmental performance in supplier selection. Vermeulen and Metselaar (2015) proposed a methodology for improving the sustainability performance of SCs by employing private certification standards. Tajbakhsh and Hassini (2015a) proposed a multi-stage DEA model that simultaneously assesses the sustainability performance of both the overall efficiency score of the SC and the individual efficiency score of its partners. Mirhedayatian et al. (2014) using DEA suggested an innovative model for assessing GSCM. Jakhar (2014) developed a model for green SC performance measures. The model combines the methodologies of structural equation modeling. AHP, and multi-objective linear programming. Hadiguna et al. (2011) discussed the failure to develop performance measures and metrics for a pan SC in the automotive industry using the system approach thinking. Zhang et al. (2016) analyzed green SC performance with cost learning and operational inefficiency effects and found that forward-looking behavior is preferred to myopic one for channel members of the SC. Likewise, Erol et al. (2011) developed a model for measuring sustainability performance of SCs based on fuzzy approach. Varsei et al. (2014) proposed a conceptual framework that can be used for initial sustainability assessment of SCs.

In sum, several researchers have tried to combine or modify existing tools (e.g., Badiezadeh et al., 2017; Bai and Sarkis, 2014; Bhattacharya et al., 2014; Fornasiero et al., 2017; Lau, 2011; Sahu et al., 2015; Yakovleva et al., 2012) while other researchers have proposed new frameworks (e.g., Azevedo et al., 2017, 2013; Goyal et al., 2018; Lee and Wu, 2014; Santiteerakul et al., 2015; Shokravi and Kurnia, 2014; Sloan, 2010) to measure sustainability performance of SCs. Next, the methodology of this study is presented, which describes how some of these articles are analyzed and classified into different categories.

3. Research methodology

The research methodology was adopted to provide a contemporary overview of the field and to identify articles on PM of sustainable and green SCs. In conducting a literature review, Tranfield et al. (2003) suggest to follow five methodological steps:

- identification of research aim
- selection of articles
- quality assessment of studies
- data extraction and
- synthesis of data and reporting

Based on this approach, a database of articles was created, which was examined to provide answers to the research objective. Similar approaches utilizing literature reviews have been used in other studies for data collection and evaluation of SSCM or GSCM (e.g., Ahi and Searcy, 2015; Beske-Janssen et al., 2015; Hassini et al., 2012; Tajbakhsh and Hassini, 2015b).

The review process was initiated by searching for titles and abstracts of documents in SCOPUS database using the following search string:

("Sustainable" OR "Sustainability" OR "Green" OR "Environmental" OR "Social") AND "Supply Chain" AND "Performance" AND ("Management" OR "Measurement" OR "Assessment" OR "Evaluation") AND ("Framework" OR "System" OR "Method" OR "Tool" OR "Concept" OR "Standard")

Inclusion criteria were used to narrow down the number of documents to those relating to the focus of this study and to papers published in the highest quality peer-reviewed academic journals. Conference papers, conference reviews, books and book chapters, sources not written in English, and documents categorized in subject areas other than business, management and accounting, and decision sciences were excluded. As most of the documents relating to sustainability performance measurement were published after 2004 (Ahi and Searcy, 2015; Tajbakhsh and Hassini, 2015b), the publishing period was limited from 2005 until the end of March 2018. The narrowed-down search resulted in 373 peer-reviewed journal articles.

The review process was continued by reading the abstract of each paper and skimming its content. Only, articles that cover at least two dimensions of sustainability and measure performance of SCs were selected for inclusion in the final sample. This procedure yielded 91 papers. Using snowballing technique or checking reference lists, we located another 13 relevant studies. Thus, the total number of reviewed studies is 104, which are marked with an asterisk symbol (*) in the reference list. To increase the reliability of the research, individual papers were checked for inclusion in the study by a second researcher as suggested by Tranfield et al. (2003).

The content, context, and process (CCP) framework which was first developed in strategic management (Pettigrew, 1985), is used for papers content analysis. The framework, presented in Fig. 1, has been used on PM of SC by Cuthbertson and Piotrowicz (2011). The framework considers the context in which measurement takes place. Examination of context is also suggested by GRI, which states that organizations should consider their performance in wider context of sustainability. Furthermore, Cuthbertson and Piotrowicz (2011) point out that the CCP framework incorporates the following elements:

- *Content* – metrics, their levels, categories, and dimensions.
- *Context* – factors that impact PM of SC, are separated into two groups:
  - organizational factors include strategy, structure, culture, company size management methods and philosophy, experience and
  - SC factors include industry, number of participants, maturity, products, stakeholders, geographical coverage, and strategic goals.
- *Process* – methods, tools, and frameworks used to measure SC performance; the way that data are captured, presented and used; as well as the development of the measurement system.

In line with the aim of this study, the research focus is on the ***process*** component of CCP framework. The selected papers are analyzed and classified according to the publication year and source, sustainability aspects studied, the industry investigated and the measurement approach used or proposed.

The classification was implemented in the following way. First, out of the 104 articles, eight studies are excluded from analysis of sustainability aspects, industry and measurement approach

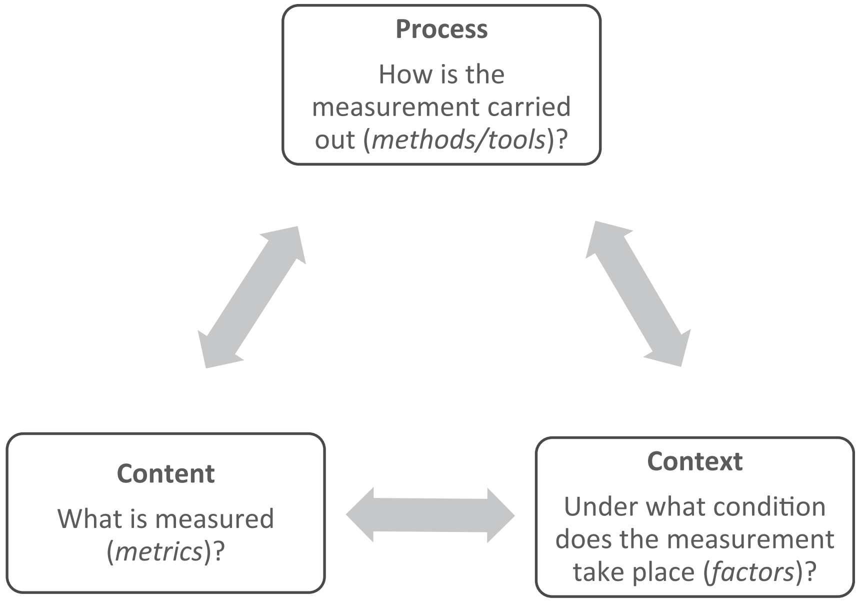

Fig. 1. The Content, Context, and Process framework for performance measurement in supply chain.
Source: Adapted from Cuthbertson and Piotrowicz (2011).

because six are literature reviews (see Table 1) that do not propose a framework and two other works (Grosvold et al., 2014; Schaltegger and Burritt, 2014) are more theoretical in nature. Second, articles that measure economic and environmental dimensions together are classified under the *Environmental* category, while papers that measure social and economic aspects are classified under the *Social* category. Third, papers that measure all three sustainability aspects are classified under the *TBL (triple-bottom-line)* category. When considering the industry covered, papers that do not state the specific industry are classified under the *General* category. Finally, in the measurement approach classification, articles are classified based on the main method used to measure sustainability of SCs.

4. Results

4.1. Descriptive analysis

The growing interest of scholars on PM of SSCM and GSCM is evident by the number of publications on a yearly basis, illustrated in Fig. 2. It is worth noting that increasing trend is steeper in the last five years.

Fig. 3 presents the distribution of papers by journal, where three or more articles are published. The top five journals contribute with 44 percent or 46 papers, while 31 other studies are published in 31 different journals, and 27 remaining articles are published in nine different journals. Thus, 104 papers included in our sample are published in 46 journals. This indicates the heterogeneity and distribution of the research on measuring sustainability performance of SCs.

4.2. Analysis of studies by industry and sustainability dimension

Table 2 shows the classification of papers by industry and sustainability aspect. Each paper is classified in one industry and in one sustainability aspect. We believe that classification by industry is important because SC activities and SC configurations are different among industries. Therefore, the measurement approach differs, both in tools and sustainability metrics used. Around one-third of the reviewed papers do not specify the industry and we found only

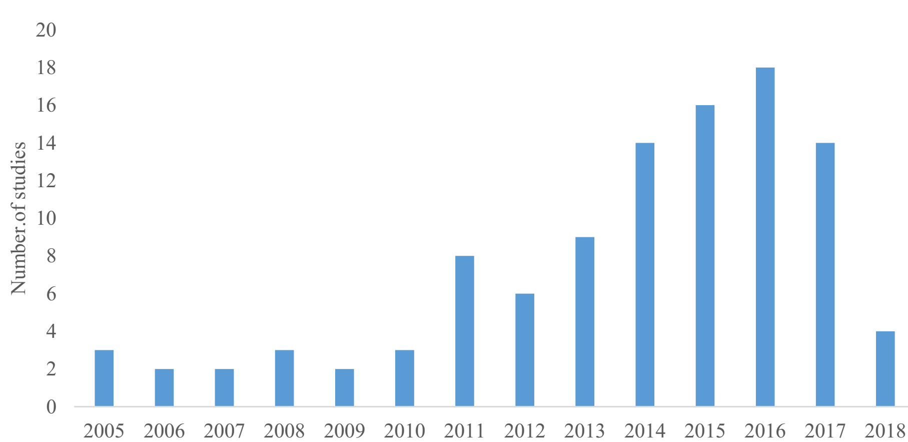

Fig. 2. Distributions of papers by publication year (n = 104).

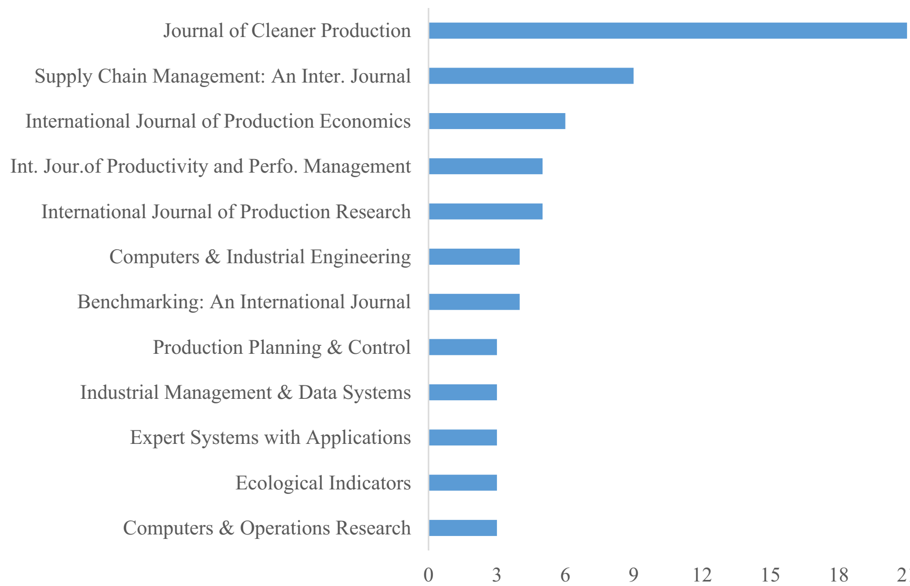

Fig. 3. Journals where three or more articles are published (n = 104).

Table 2
Distribution of studies by industry and sustainability dimensions.

	Environmental[a]	Social[b]	TBL[c]	Total
Retail	1		1	**2**
Steel	3		1	**4**
Service	1		3	**4**
Agriculture	2	1	2	**5**
Textile-footwear	4		1	**5**
Automotive	8		1	**9**
Food and Beverage	6		4	**10**
Electro-electronic	4	2	6	**12**
Manufacturing	8		6	**14**
General	14	2	15	**31**
Total	**51**	**5**	**40**	**96**

Notes.
[a] Articles that measure economic and environmental dimensions together.
[b] Articles that measure economic and social dimensions together.
[c] Articles that measure economic, social and environmental dimensions.

four studies (Chithambaranathan et al., 2015; Jauhar et al., 2017; Tajbakhsh and Hassini, 2015a; Tseng et al., 2018) that cover service sectors including Banking and Education. Regarding sustainability aspects, environmental is still leading, followed by TBL. We note also that in the reviewed literature there is no paper that studies only social and environmental dimension of sustainability.

Sustainability dimensions studied on yearly basis in reviewed papers are presented in Fig. 4. The results indicate that the number of papers that measure TBL and environmental aspects increased in last five years. It is worth noting that, in 2015, the number of papers that cover all three sustainability aspects is higher than the number of papers that cover environmental and economic aspects.

4.3. Analysis of SC sustainability measurement approaches

Classification of the papers based on the measurement approach

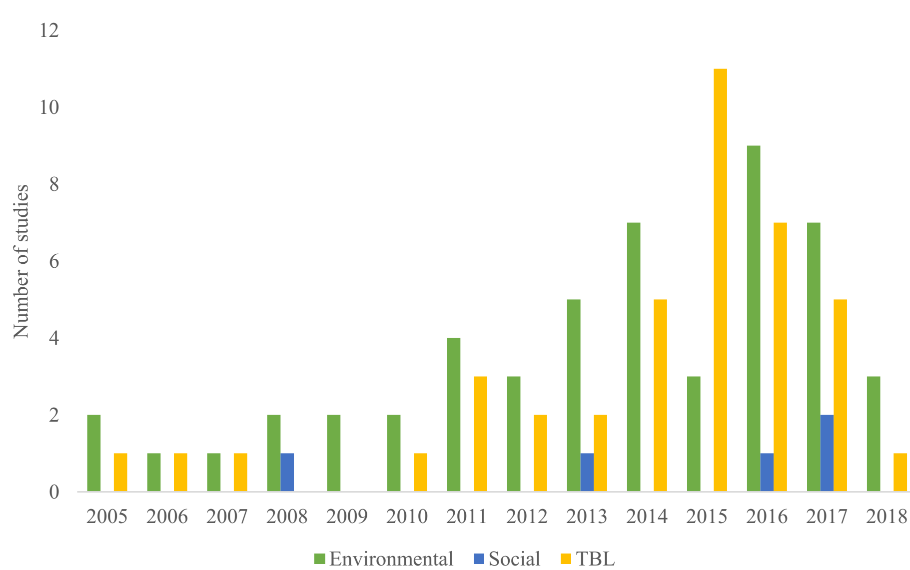

Fig. 4. Distribution of sustainability aspects covered in the reviewed articles by year (n = 96).

Table 3
Distribution of reviewed studies by measurement approach and sustainability aspects.

	Environmental[a]	Social[b]	TBL[c]	Total
SCOR and Rough set theory	1		1	**2**
Multi-objective and Goal Programming	1		2	**3**
Multi-Regional Input-Output (MRIO)	2		1	**3**
ISO Standards, Surveys, and Interviews	1		3	**4**
Composite performance index	3		4	**7**
Data envelopment analysis (DEA)	5		4	**9**
Fuzzy-set approach	7		3	**10**
Balanced Scorecard (BSC)	6		4	**10**
Analytical Hierarchy/Network Process (AHP/ANP)	4		7	**11**
Life Cycle Assessment (LCA)	11	4	1	**16**
General performance measurement framework	10	1	10	**21**
Total	**51**	**5**	**40**	**96**

Notes:
[a] Articles that measure economic and environmental dimensions together.
[b] Articles that measure economic and social dimensions together.
[c] Articles that measure economic, social and environmental dimensions.

and sustainability aspects is shown in Table 3. Majority of papers propose or develop a performance measurement framework, but the proposed approaches are seldom implemented in real cases. However, it is interesting to note, the equal number of studies (10) of proposed PM frameworks that consider all three sustainability aspects and studies that consider environmental and economic dimensions. The results also reveal that in the reviewed literature all PM approaches have been tailored to measure all three sustainability aspects.

Fig. 5 presents the distribution of measurement methods by year. To improve clarity, AHP and ANP, Composite performance index, DEA, Fuzzy-set approach, MRIO, Rough set theory, SCOR, Multi-objective and Goal Programming have been grouped together under '*Math focused*' category; BSC, Standards, and Surveys are grouped under one category; and other measurement approaches are presented individually. SCOR has been grouped under '*Math focused*' since is often used with other multi-criteria methods.

Methods grouped under '*Math focused*' are used in 47 percent of the reviewed papers (e.g., Acquaye et al., 2017, 2014; Agrawal et al., 2016; Büyüközkan and Çifçi, 2012; Harik et al., 2015; Jakhar, 2015, 2014; Kazancoglu et al., 2018; Rodríguez-Serrano et al., 2017; Schmidt and Schwegler, 2008; Tsoulfas and Pappis, 2008; Zhang, 2017) and, since 2011, the usage and development of these methods is rising. In 2005, two works (Hervani et al., 2005; Labuschagne et al., 2005) proposed conceptual frameworks to measure sustainability of SCs. After 2005, in the reviewed literature we did not find any framework proposed, until in 2010, when a framework was proposed by Sloan (2010). However, since 2010, the interest of scholars To develop such PM frameworks is growing. From 2005 to 2014, LCA is used in six studies (e.g., Balkau and Sonnemann, 2010; Brent, 2005; Hutchins and Sutherland, 2008; Kainuma and Tawara, 2006), whereas from 2015 until 2018 is used in ten studies (e.g., Egilmez et al., 2016; Kulak et al., 2016; Park et al., 2016; Tsalis et al., 2017).

Categorization of articles by measurement approach and type of industry are presented in Table 4. In two studies (Bai et al., 2012; Bai and Sarkis, 2014) the industry is not specified, where SCOR with Rough-set theory are combined to measure sustainability of SCs. Multi-objective and Goal Programming is used in manufacturing (Yousefi et al., 2017), agriculture (Boukherroub et al., 2015), and in electronic industry (Tsai and Hung, 2009). Based on MRIO analysis three studies (Acquaye et al., 2017, 2014; Rodríguez-Serrano et al., 2017) measure the environmental performance of electro-electronic and steel industries. Several studies combined standard 14001 with interviews or surveys and such studies are applied in agriculture industry (Vermeulen and Metselaar, 2015), food and beverages (Vasileiou and Morris, 2006), and in two studies (Nawrocka et al., 2009; Piotrowicz and Cuthbertson, 2015) the industry was not specified. The logic of composite performance index is used in food and beverage (Manning and Soon, 2016), in manufacturing (Lau, 2011), and in four studies (e.g., Azevedo et al., 2017; Tsoulfas and Pappis, 2008) the industry was not specified. DEA is used in service industries (Jauhar et al., 2017; Tajbakhsh and Hassini, 2015a), in food and beverage industries (e.g., Kahi et al., 2017; Mirhedayatian et al., 2014), in electro-electronic industry (Tavana et al., 2013), in manufacturing (Izadikhah and Saen, 2016), and in one study (Amini et al., 2016) the industry is not specified. Fuzzy-set approach is used in automotive industry (Olugu and Wong, 2012), in manufacturing (Kazancoglu et al., 2018; Sabaghi et al., 2016; Sahu et al., 2013), in service industries

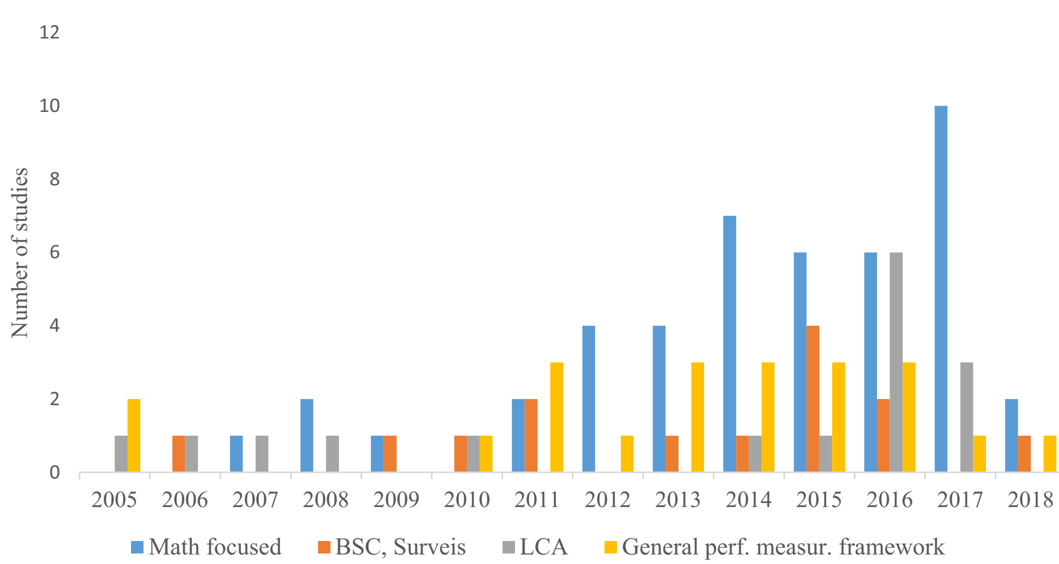

Fig. 5. Distribution of measurement approaches by year ("Math focused" groups AHP/ANP, Composite performance index, DEA, Fuzzy set approach, Rough set theory, Multi-objective and goal programming).

Table 4
Distribution of studies by measurement approach and industry.

	Retail	Steel	Service	Agriculture	Textile-footwear	Automotive	Food and Beverage	Electro-electronic	Manufacturing	General
SCOR and Rough set theory										2
Multi-objective and Goal Programming				1				1	1	
Multi-Regional Input-Output (MRIO)		1						2		
ISO Standards, Surveys, and Interviews				1			1			2
Composite performance index							1		1	5
Data envelopment analysis (DEA)			2				4	1	1	1
Fuzzy-set approach	1	1	2			1			3	2
Balanced Scorecard (BSC)					1	1	1	2		5
Analytic Hierarchy/Network Process (AHP/ANP)		1			2	1	1	2	4	
Life Cycle Assessment (LCA)				3	1	2	1	2	3	4
General performance measurement framework	1	1			1	4	1	2	1	10
Total	**2**	**4**	**4**	**5**	**5**	**9**	**10**	**12**	**14**	**31**

(Chithambaranathan et al., 2015; Tseng et al., 2018), in retail industry (Erol et al., 2011), in steel industry (Zhang, 2017), and in two papers (Sahu et al., 2015; Uygun and Dede, 2016) the industry is not specified. BSC is used in electro-electronic industries (Hsu et al., 2011; Tseng et al., 2015), automotive (Ferreira et al., 2016), food and beverage (Shafiee et al., 2014), textile and footwear (Thanki and Thakkar, 2018), and in five studies (Duarte and Cruz-Machado, 2015; Haghighi et al., 2016; Naini et al., 2011; Reefke and Trocchi, 2013; Shaw et al., 2010) the industry is not specified. AHP or ANP is used in electro-electronic industry (Felice et al., 2013), in manufacturing (e.g., Bhattacharya et al., 2014; Sari, 2017) and in few other industries. LCA is applied in agriculture (e.g., Park et al., 2016), textile and footwear (Fornasiero et al., 2017), automotive (Brent, 2005; Simão et al., 2016), food and beverage (Kulak et al., 2016), electro-electronic (Tsalis et al., 2017; Wang et al., 2016), manufacturing (e.g., Xing et al., 2016), and in four articles the industry is not specified (e.g., Hutchins and Sutherland, 2008). Finally, ten studies (e.g., El Saadany et al., 2011; Hassini et al., 2012; Nikolaou et al., 2013; Schöggl et al., 2016) propose PM frameworks for not a specific industry, four studies (Azevedo et al., 2013; Hadiguna et al., 2011; Lee and Wu, 2014; Olugu et al., 2011) propose frameworks in automotive industry, two studies in electro-electronic industries (Hassini et al., 2012; Rao, 2014), one study in manufacturing (Labuschagne et al., 2005), one in retail (Zhang et al., 2016), one in food and beverages (Manzini and Accorsi, 2013), one in steel (Goyal et al., 2018), and one study (Marconi et al., 2017) proposed a framework for textile and footwear industries.

Table 5 reveals the categorization of articles by measurement approach and SC level, stakeholders, categories of metrics, data collection, and implementation of the measurement approach. For simplicity of illustration, the SC has been divided in upstream echelon – PM of suppliers and manufacturers, and in downstream echelon – PM from manufacturers to the reverse logistics (Olugu et al., 2011). Metrics are classified into metric categories and in specific metrics. The difference between these two groups is that the first category does not provide specific measures while articles classified in the second category list specific metrics. It is important to point out that, although, two third of the reviewed studies apply the measurement approach used in the study, the implementation is done only for illustrative purposes. Note that each number in Table 5 shows the number of times a measurement approach is used in a specific category and a single study might have been classified in more than one category as they are mutually exclusive.

5. Discussion

The objective of this study was to analyze PM approaches published in peer-reviewed academic literature on SSCM and GSCM. By categorizing and synthesizing previous articles, this paper has provided a thorough overview of PM methods and tools used to assess sustainability of SCs. The findings thus contribute to a better understanding of PM approaches applied in SSCM and GSCM both in theory and in practice.

Results presented in Fig. 2 and in Fig. 3, indicate that literature on sustainability PM of SCs is flourishing but is fragmented, limited and scattered in many journals. Similar results are reported by Taticchi et al. (2013) and Beske-Janssen et al. (2015). Searcy (2017) notes that more than 80 percent of companies listed in the S&P 500 published a sustainability report in 2015. However, results (see Table 2) show that industry-specific studies are sparsely present in

Table 5
Distribution of studies by measurement approach and SC echelon, stakeholders, categories of metrics, data collection, and implementation.

	Upstream	Downstream	Stakeholders	Categories of metrics	Specific metrics	Data collection and sharing	Implemented
SCOR and Rough set theory	2[a]			2	1		
Multi-objective and Goal Programming	3	2		2	1	1	2
Multi-Regional Input-Output (MRIO)	3	1	2	2	3	2	3
ISO 14000 Standards, Surveys, and Interviews	4	2	1	4	3	1	4
Composite performance index	7	3	1	6	4	3	1
Data envelopment analysis (DEA)	6	7	1	5	4	2	8
Fuzzy-set approach	8	5	3	10	6	1	8
Balanced Scorecard (BSC)	10	5	6	10	8	2	7
Analytic Hierarchy/Network Process (AHP/ANP)	10	9	4	10	8	2	10
Life Cycle Assessment (LCA)	15	7	5	14	9	6	11
General performance measurement framework	18	14	8	17	13	5	11
Total	**86**	**55**	**31**	**82**	**60**	**25**	**65**

Note.
[a] It shows how many times a measurement approach is used in a specific category.

the literature reviewed. This is in contradiction with a large number of sustainability reports. One explanation might be that practitioners are leading with sustainability reports while scholars are focused on developing general frameworks to assess SC sustainability performance (see Table 3). Another explanation might be that sustainability reports published by companies present only partial information about their companies, and not for their entire SC. This is supported by KPMG (2011) and Morali and Searcy (2013) who found that sustainability reports often are uncompleted.

Even though studies that incorporate all three sustainability dimensions are increasing (see Fig. 4), still the social dimension lacks behind environmental and economic aspects. Similar results have been observed at least a decade ago (e.g., Seuring and Müller, 2008). One reason that explains this issue might be that social indicators sometimes are missing and often are challenging to be quantified as well as are often prone to subjectivity (Schaltegger and Burritt, 2014). Another reason is that, in past, there has been higher attention devoted to environmental aspect by governments and other stakeholders. However, recent studies (e.g., Popovic et al., 2018) have proposed specific measures for assessing social sustainability of supply chains.

5.1. Performance measurement approaches used to assess sustainability of SCs

PM tools used to evaluate sustainability of SCs are diverse (see Table 3). To help SC managers and scholars, this study has presented and synthesized several methods (e.g., AHP, ANP, DEA, Goal programming, Fuzzy set approach, Rough sets theory, LCA) with related articles that measure sustainability performance of SCs. In planning and designing a PM system, a good starting point is to read existing publications that are in the same or similar industry, in which the SC exist. In this direction, this study has classified PM methods and tools, both by sustainability dimension and industry. Thus, interested readers can refer to Tables 3 and 4 for specific results. Furthermore, Fig. 5 illustrates the trend that '*Math focused*' methods and tools used to measure sustainability of SCs, is sharply increasing. Likewise, a considerable attention of scholars is also on the development of conceptual PM frameworks.

The majority of the studies measure the SC sustainability performance between suppliers and manufacturers (e.g., Brent, 2005; Lee and Wu, 2014; Singh et al., 2007) while few PM frameworks (e.g., Ahi and Searcy, 2015; Chardine-Baumann and Botta-Genoulaz, 2014; Hassini et al., 2012; Olugu et al., 2011; Santiteerakul et al., 2015) have wider focus by including suppliers, manufacturers, retailers, and consumers. Surprisingly, less than one -third of studies (e.g., Hervani et al., 2005; Labuschagne et al., 2005; Varsei et al., 2014) incorporate stakeholders (see Table 5) in their measurement approach and even fewer studies list sustainability metrics per SC member (e.g., Olugu et al., 2011; Tajbakhsh and Hassini, 2015b). Likewise, the reviewed literature barely discuss how inter-organizational metrics should be developed and selected as well as how pertinent data should be collected. Furthermore, a discussion of the relationships between SC configuration and sustainability metrics as well as stakeholder participation are very sparsely present in the reviewed literature.

However, among many existing methods, a practitioner might ask "What is the best tool to use?" The answer to this question is tricky because there is no best method. For a classic discussion related to the best MCDM method, we recommend reading (Ignizio, 1983). The manager should choose the tool s/he knows the best and is the most suitable for the characteristics of the problem. In the case of sustainability PM of SCs, features of the problem include number of stakeholders, number of SC members and their related activities, the number of indicators, and the data required for indicator calculation. In principle, if the manager is in a situation where the interactions between decision factors are high, he should choose ANP over AHP. Likewise, if uncertainty and vagueness of decision factors are high, then the chosen method (AHP, ANP, DEA etc.) should be combined with fuzzy set theory. Usually, when measuring sustainability performance of SCs, both, the interactions among decision factors and level of uncertainty are high. Therefore, there is a need to combine the chosen tool(s) with fuzzy logic to increase the accuracy of the measurement system.

Overall, this study highlights that the selected PM approach must be compatible with the measurement systems both at the company level and at the SC level. The selected inter-organizational metrics must capture sustainability performance data across the entire SC and any measurement approach should take into account relationships between SC design, metrics selection, and SC context. In an attempt to clarify these issues, in next section, this study proposes a novel framework for evaluating sustainability performance of SCs.

5.2. A conceptual framework for measuring sustainability performance of SCs

Measuring sustainability performance of SCs is inherently complex and multi-dimensional (Sloan, 2010). Previous frameworks and tools proposed to measure sustainability performance of SCs do not consider all elements and complexity of this issue. Therefore, this study proposes a novel and comprehensive framework to assess SC sustainability. The proposed framework illustrated in Fig. 6, represents an overview of elements and their interactions that should be considered when developing a PM system for evaluating sustainability of SCs. In contrast, with the focus of the majority of the reviewed studies, represented by the dotted line, the proposed framework has a broader view by incorporating all three dimensions of sustainability, SC members, and stakeholders.

The first element of the framework represents SC members including raw material extractors, suppliers, focal company, distributors, retailers, consumers and reverse logistics. Each member has its own goals which influence and are influenced by internal stakeholders such as workers, investors, owners and managers and external stakeholders such as governments, regulators, competitors, media, and NGOs. The double-headed arrows between SC members indicate forward and reverse flows. Since all members belong to the same SC, they should cooperate and share their goals to formulate SC strategy. In the SC strategy managers need to define what is understood by sustainability performance and what has to be measured (Hervani et al., 2005; Wong and Wong, 2008). The SC strategy is mostly shaped by the focal company or manufacturer which usually has higher influence on other SC members. Thus, the proposed framework connects sustainability PM with SC strategy and overcomes this issue identified by Brewer and Speh (2000) and Shepherd and Günter (2006).

"What should be measured?" is represented by the second element of the framework. The double-headed arrow connects this element with the SC strategy, from where sustainability inter-organizational metrics should be derived. On one hand, measures should include environmental, social and economic dimensions of sustainability, on the other hand, measures should be able to overcome existing hurdles (see section 2.3). One way to overcome obstacles is to select metrics by incorporating a so-called "twin approach" (Beske-Janssen et al., 2015) which combines an outside-in approach and inside-out approach (Schaltegger and Wagner, 2006). Both approaches are represented in the framework by the hierarchy of measures. SC strategy should align goals with respective metrics from different SC members (inside-out) and metrics

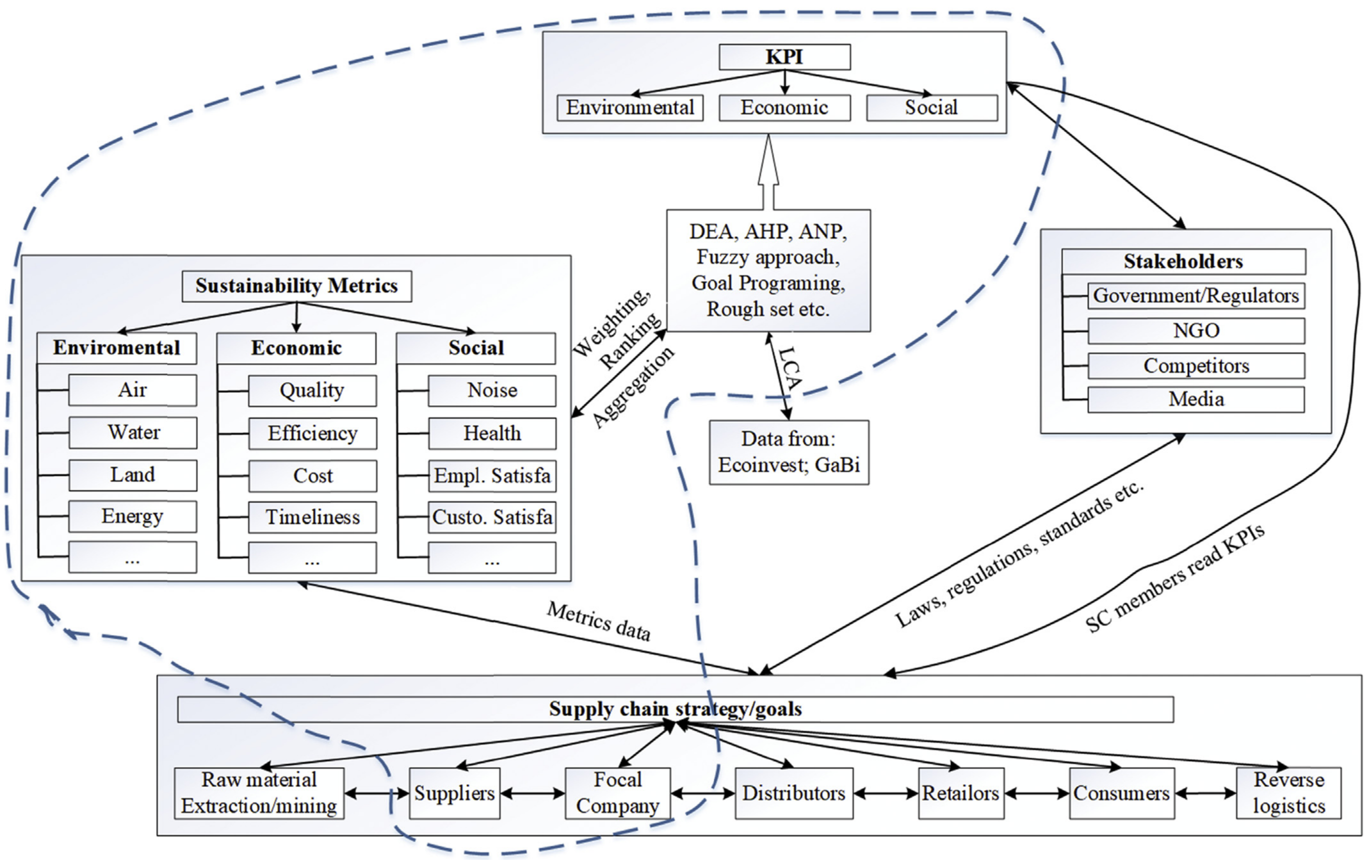

Fig. 6. A conceptual framework for measuring sustainability performance of SCs.

resulted from requirements of external stakeholders (outside-in). When selecting metrics, practitioners and scholars (e.g., Matos and Hall, 2007; Varsei et al., 2014) are also interested in the interdependencies between environmental, economic and social dimensions to overcome trade-offs and create win-win solutions (Beske-Janssen et al., 2015; Seuring and Müller, 2008). This is supported by the broadly integrated approach of the framework. Thus, the standardization and consistency of inter-organizational sustainability metrics are ensured, at least to an acceptable degree, which is a necessary requirement for aggregation or conversion of individual metrics into KPIs.

Data required for each metric and who should measure these metrics are not explicitly mentioned in the reviewed literature. Beske-Janssen et al. (2015) highlight that the majority of existing tools imply that the focal company assesses sustainability performance of its SC. Challenges with this approach include difficulties in collecting data from the second or third tier of suppliers as the influence of focal company decreases and the reliability of data is hard to be insured. Another possible approach is that all SC members measure for themselves sustainability performance and then pass to the next tier. A challenge with this approach is that the meaning of sustainability for different SC members is not the same and as a result, different members measure and report different sustainability aspects and metrics. Consequently, aggregation of these metrics is difficult or even impossible. A third possible approach to measure sustainability is by involving an organization which is not part of the SC. Examples of this approach include the Sustainable Apparel Coalition for apparel industry, and the Business Social Compliance Initiative for textile industry (Beske-Janssen et al., 2015).

All these three possible approaches are supported by the framework. However, this study emphasizes that first, there is a need to align intra-organizational metrics within the company, and then inter-organizational sustainability metrics across SC members by considering requirements from SC stakeholders. Then every SC member individually collects related data on intra-organizational and inter-organizational sustainability metrics. Thus, the collected data would be standardized. Next, this data should be sent to a Sustainability Metrics database which might be owned by the focal company or a third party organization specialized in measuring sustainability performance. This database might also get data from existing LCA based database such as *Ecoinvent* and *Gabi*. Finally, these data would be calculated in relevant metrics and aggregated into KPIs or Composite Indicators. KPIs should be accessible to every SC member. Consequently, every member can check and improve its sustainability performance and in turn, the sustainability of entire SC would also be improved.

Methods and tools reviewed in this study including AHP/ANP, DEA, Goal Programming, Rough Sets and Fuzzy approaches can be used for weighting, ranking and aggregating individual metrics into KPIs. The necessity of aggregating individual metrics into KPIs or composite indicators has also been highlighted by earlier researchers (Bai and Sarkis, 2014; Hassini et al., 2012; Sloan, 2010). However, in contrast with several authors (e.g., Hassini et al., 2012) who propose to aggregate all three dimension into a single composite indicator, the framework proposes to have at least one KPI or a composite indicator per sustainability dimension and one per SC member. A larger number of KPIs would enable the focal firm to have a broader view and a better understanding of its SC. This would help manufacturers to identify and to take necessary actions towards SC members which are causing higher negative and positive impacts. Measuring positive impacts would guide focal companies to intensify collaboration with the 'best' suppliers, distributors and so on. However, a larger number of KPIs would make it harder to benchmark SCs.

The proposed framework systematically integrates three major components of the SC sustainability performance assessment – SC members, sustainability metrics, and stakeholders. A unique feature of the framework is that explicitly depicts relationships between these components at a macro level, and provides the variety of PM tools that have been developed to date. It can be used as a decision-supporting tool and as a design structure at the early development stages of the sustainability PM system in SCs. Although the framework does not provide specific sustainability metrics, it serves as guidance on how and what needs to be measured and, thus, can also be used as an initial point for inter-organizational sustainability metrics development.

In sum, as Matos and Hall (2007) and Varsei et al. (2014) emphasize that having a broad integrated approach to examine interactions among environmental, economic and social dimensions is better than applying deep, but disconnected expertise in each one. Likewise, this study hopes that the proposed framework, despite its abstraction level, would help practitioners and scholars to structure thinking and to "provide lens" (Sloan, 2010) on measuring sustainability performance of SCs.

5.3. A concise guideline for developing the SC sustainability performance measurement system

The starting point for the PM process is to analyze existing PM systems inside organizations which are members of the SC. During this phase, managers should determine what metrics are already in use and by which department as well as supplement and modify existing PM systems with environmental and social metrics. Next, SC practitioners should develop a sustainability policy and determine the scope of measurement, identify major performance processes and decompose them into sub-processes and activities, set objectives, select sustainability measures, use tools presented in this paper to aggregate individual metrics into KPIs, measure and track sustainability performance, report results, and finally review and improve sustainability PM system.

Process decomposition can be divided into further sub-steps (Chan and Qi, 2003; Cuthbertson et al., 2011, pp. 75–76):

1. Identification and linkage of all inter- and intra-organizational processes
2. Definition of core processes
3. Derivation of missions, responsibilities, and functions of core processes
4. Sub-processes decomposition
5. Derivation of responsibilities and functions of sub-processes
6. Identification and decomposition of main activities
7. Create links between processes, activities and their goals

After this step is finished for the focal company, the same process can be repeated for other SC members to identify sustainability measures for the inter-organizational processes by considering requirements of SC stakeholders (Cuthbertson et al., 2011). The proposed framework can serve as a design structure for at least several steps including sustainability metrics development and selection, creating KPIs, reporting and reviewing PM results. Furthermore, the framework highlights that all these steps should be in accordance with SC stakeholders.

Finally, since, measuring SC sustainability performance is inherently challenging (Sloan, 2010), these steps should be implemented in a software according to the proposed framework and the above listed steps.

5.4. Limitations

There are some limitations to this study that must be borne in mind. First, the authors only considered peer-reviewed journals in the SCOPUS database. Important and relevant knowledge may be found in other sources such as conference papers, books or PhD dissertations. Second, although the authors tried their best to use accurate search terms in the search string, there might be other important terms that were not included. Sometimes articles might address the topic of this study using different keywords. Third, although SCOPUS covers a wide range of peer-reviewed journals in the scientific, technical, and social sciences, it does not include all reputable peer-reviewed journals. Fourth, the study period of 13 years was considered valid for this study but other authors may investigate the field over a time-scale longer than a decade. Finally, the selection of the articles included in the database for review could be considered subjective, although the papers were reviewed by two researchers independently.

5.5. Future research recommendations

The main drawback of the proposed framework is that it does not provide specific inter-organizational sustainability metrics, but it highlights that these metrics should incorporate all sustainability dimensions and their interdependencies, as well as metrics should be developed and selected by involving SC stakeholders. In this direction, although, various authors (e.g., Ahi and Searcy, 2015; Bai et al., 2012; Bai and Sarkis, 2014; Hervani et al., 2005; Tajbakhsh and Hassini, 2015b) have listed sustainability performance measurement metrics, there is, however, still a lack of consensus on which metrics should be used in specific industries and SCs. In other words, standardized SC sustainability metrics need to be proposed by future research. Hints on this significant component of PM system can be found in these papers (Ahi et al., 2016b; Delai and Takahashi, 2011; Piotrowicz and Cuthbertson, 2015; Santiteerakul et al., 2015; Tajbakhsh and Hassini, 2015b).

Thresholds or limits for specific sustainability metrics are also rarely or not present in the reviewed literature. However, GRI guidelines are probably the best approach to follow (Beske-Janssen et al., 2015). Likewise, we also found that there is a lack of studies in the service sectors such as banking, educations or medical services and the majority of the proposed measurement frameworks are not tailored to a specific industry. Therefore, there is a need for more research on sector-specific sustainability measures together with their thresholds, and the validation of the proposed framework.

Future research should also investigate the possibilities to integrate different measurement tools under a single framework, in such a way that aggregation of individual metrics into KPIs to be as precise as possible. Another important aspect when considering the measurement approach is the configuration of SC itself. However, the majority of the papers reviewed in this study surprisingly do not discuss the SC design. This is in line with Pagell and Wu (2009) who highlight that the design structure and function of the SC are rarely taken into account when measuring sustainability performance. Thus, future research should investigate relationships between SC design and PM approach. In this direction, it is important to develop some guidance which measurement approach is suitable for a specific SC configuration.

The success of the measurement system in the SC is dependent on the ability of information systems of each SC member, to capture data related to sustainability dimensions for every SC activity. These data are used to calculate sustainability metrics. How these data and metrics should be shared among SC members per se and SC stakeholders are not present in the reviewed literature. Despite this, surprisingly, information systems are seldom mentioned in reviewed papers. Thus, these important issues should be investigated in detail by future research. Consequently, the proposed framework and outcome of the proposed research would facilitate inter-organizational sustainability metrics selection and collaboration between SC members and external stakeholders. Furthermore, standardization in data collection is seen as a facilitator for data exchange along the supply chain (Beske-Janssen et al., 2015).

6. Conclusions

The review of the literature indicates that research on measuring sustainability performance of SCs is scattered, fragmented, incomplete and relatively new research area. The results indicate that various PM have been proposed, but their implementation in real life cases is sparsely provided. So far, the majority of proposed measurement approaches are focused on measuring sustainability performance between suppliers and manufacturers. Furthermore, the PM approaches based on MCDM methods and fuzzy set theory are thriving, and the number of papers that incorporate all three aspects of sustainability is approximately equal with the number of studies that incorporate environmental and economic aspects of sustainability.

To expand sustainability PM across entire SC, and to help focus attention of practitioners and scholars on key issues of PM, this study proposes a novel conceptual framework and provides a concise guideline for measuring sustainability performance of SCs. The proposed framework systematically integrates SC members, sustainability metrics, and stakeholders as well as explicitly depicts their relationships. It can be used as a design structure at the early development stages of the sustainability PM system in SCs. Additionally, we believe that this study is important and a good starting point for managers and researchers to familiarize with existing measurement approaches used to assess sustainability performance of SCs.

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