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Research article

Sustainability performance evaluation: Literature review and future directions

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ABSTRACT

Current global economic activities are increasingly being perceived as unsustainable. Despite the high number of publications, sustainability science remains highly dispersed over diverse approaches and topics. This article aims to provide a structured overview of sustainability performance evaluation related publications and to document the current state of literature, categorize publications, analyze and link trends, as well as highlight gaps and provide research recommendations. 128 articles between 2007 and 2018 are identified. The results suggest that sustainability performance evaluation models shall be more balanced, suitable criteria and their interrelations shall be well defined and subjectivity of qualitative criteria inherent to sustainability indicators shall be considered. To address this subjectivity, group decision-making techniques and other analytical methods that can deal with uncertainty, conflicting indicators, and linguistic evaluations can be used in future works. By presenting research gaps, this review stimulates researchers to establish practically applicable sustainability performance evaluation frameworks to help assess and compare the degree of sustainability, leading to more sustainable business practices. The review is unique in defining corporate sustainability performance evaluation for the first time, exploring the gap between sustainability accounting and sustainability assessment, and coming up with a structured overview of innovative research recommendations about integrating analytical assessment methods into conceptual sustainability frameworks.

1. Introduction

Sustainable development has become a very popular field of research in the last decade. Driven by social changes, environmental deterioration and accompanying public interest, sustainability is becoming a key topic among academics, regulators, and businesses. Scientific research on sustainability can help businesses to adopt those strategies that meet the expectations of their current stakeholders in a broader sense, and at the same time safeguard, sustain and enhance social assets and natural resources for the future (Deloitte and Touche and BCSD, 1992).

Sustainable development shall address the needs of today without compromising future generations' own ability to fulfill their needs while protecting Earth's ecosystems and its life support capabilities (Griggs et al., 2013; WCED, 1987). However, current economic activities are becoming increasingly unsustainable, as economic benefits are reaped locally, while external costs are borne globally. Finding solutions to these problems first requires the assessment of the level of these impacts, i.e. measuring main aspects of sustainability performance and assessing it on the basis of collected data. The multidimensional and intertwined nature of the sustainability context in terms of ecologic resources, societal sensitivities and economic realities turns this need into a challenge. In this paper, the current state of Sustainability Performance Evaluation (SPE) literature is reviewed with a business perspective to capture these needs and come up with research recommendations.

Sustainability is a trending topic in the literature. Thousands of articles are published every year that deal with sustainability in one way or the other. Despite this popularity, the majority of these publications are actually extensively environment-focused, interchanging sustainability with low ecological impacts and ignoring its economic and social dimensions. Moreover, the literature usually pays little attention to what to exactly measure and how to interpret them in order to identify the sustainability performance. Sustainability performance as a new term is also largely ignored. This article defines sustainability performance as the aggregate

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negative or positive bottom line of economic, environmental and social impacts of an entity against a defined baseline. SPE deals with the evaluation of sustainability performance.

Although SPE is widely researched and discussed in the literature under different names, the definition of SPE as a term is lacking. This paper makes the first attempt to do so by exploring the definitions of sustainability performance presented by AccountAbility (2005), performance evaluation by Hu and Gorton (1997), performance measurement by Neely et al. (1995) and environmental performance assessment by Zhang (2010). Based on these definitions, this article defines SPE as the quantification of an organization's total performance based on performance indicators, which can include its policies, decisions, and actions creating economic, social and environmental results.

The concept of sustainability has various perspectives, such as environmental protection, ecosystem services, economic considerations, social acceptance, license to operate and externalities, besides many other aspects (Bartelmus, 2010; Figge and Hahn, 2004; Keijzers, 2002). The recent literature clearly suggests that sustainability science is starting to extend beyond the terms of green and competitiveness towards a more holistic, integrated and methodological understanding of sustainability. Decision makers are aware of the need for systematic sustainability evaluation approaches for assessing complex systems to replace linear, formatted solutions (Lobos and Partidario, 2014). Such tools are inevitably focused on past sustainability performance, underlining the need for updating corporate SPE systems over time (Searcy, 2014), as well as other tools that account for future sustainability risks (Lumsden, 2004).

Under the heading of sustainability management, sustainability performance can be a major concern in sustainability accounting, assessment and reporting processes. The aspect of accounting is closely related with what information to collect for which purpose by defining suitable indicators and measuring them, which requires robust conceptual models, such as indicator sets. The aspect of assessment is about giving a meaning to the collected qualitative and quantitative data by means of analytical integration techniques. Once accounted and assessed, the overall sustainability performance can then be reported as a strategic tool for corporate management and communication. These three main aspects can be approached from the transparency or performance improvement points of view (Maas et al., 2016a).

This study proposes that SPE covers both sustainability accounting and assessment aspects, which can subsequently be used for disclosure (reporting) or decision-making purposes by businesses. Accounting mostly deals with identifying what data (e.g. which key performance indicators - KPIs) to collect for the next steps, requiring conceptual models to be based on. Assessment, on the other hand, is about how to aggregate collected data and turn them into useful messages, which can be effectively accomplished with numerical methods. Once the sustainability performance is captured, they are then reported with standard or custom frameworks. While these three aspects cannot always be separated this distinctively, the extent of their integration largely depends on the specific framework in question, such as XBRL, an emerging international business reporting standard for digital business reporting (Seele, 2016).

A closer look will be taken at these accounting and assessment aspects by analyzing publications about conceptual models and analytical approaches in literature, respectively. To gain a broader perspective, literature reviews will also be discussed. This article thus focuses on the first two boxes of Fig. 1; i.e. the evaluation of sustainability performance.

Despite the high number of sustainability-related articles, the number and scope of literature reviews combining both accounting and assessment aspects are quite limited. They mostly appear to present the state of the art, rather than critically and comparatively analyzing articles and identifying patterns for an integrated SPE. To address this need, this review intends to highlight these gaps and formulate research recommendations. The scope is limited to corporate SPE within organizational boundaries to maintain its thematic focus.

While essential, a perfect SPE is not possible in a world of rapid change, interdependency and uncertainty (Ravetz, 2000). Nevertheless, taking an accurate account of the sustainability performance is not only needed to limit its misuse and undermining, such as greenwashing. SPE can help companies in better understanding their overall impact on their shareholders, their environment, and communities as a whole, and take the necessary measures to mitigate or improve them. Sustainability performance can be approached in various ways. Researchers in environmental sciences, for instance, can be more interested in specific aspects of SPE, such as assessing environmental impacts of industrial processes. Literature in finance and management also discusses sustainability performance mostly in terms of continuity of financial performance, long-term competitiveness and corporate strategy. Operation research literature, on the other hand, focuses on the measurement, ranking, policy guidance and decision-making based on a wide range of sustainability impacts. This paper deals with the latter.

The article will continue with Section 2, which will introduce the methodology of the review. Section 3 will present a list of reviewed publications, along with their categorization and provide a review of the literature for conceptual and analytical papers. In Section 4, the observations derived from Section 2 and 3 will be examined and the findings will be analyzed in a structured way. Section 5 will provide the identified research gaps and recommendations for researchers. Section 5 will discuss the results and conclude this review.

2. Research methodology

The proposed research methodology consists of two consecutive methodological steps. First, it is explained how the papers are identified as the data collection approach, and then how these papers are analyzed.

2.1. Data collection approach

This article follows a structured approach (see Fig. 2) and includes international publications in the English language between 2007 and 2018 that have appeared in the Web of Science and Scopus databases. Conference papers and articles on other databases are excluded.

Journals in the fields of engineering, finance, sustainability science and management are searched in their titles, keywords, and abstracts with the following terms: sustainability performance assessment, sustainability performance evaluation, and sustainability performance measurement. While these keyword combinations initially returned a high number of results, many papers are disregarded as their scope is mostly to only environmental, or social aspects, lacking a holistic view. Similarly, many do not specifically discuss sustainability accounting and assessment. In addition to academic references, non-academic publications are explored with the thematic expertise of the authors and recent literature review articles to also include those publications that are employed by the industry. The analysis ultimately reached a total of 128 publications. These articles are then clustered in terms of their publication year, subject and main objective (i.e. literature reviews, conceptual frameworks for accounting purposes, or analytical techniques for

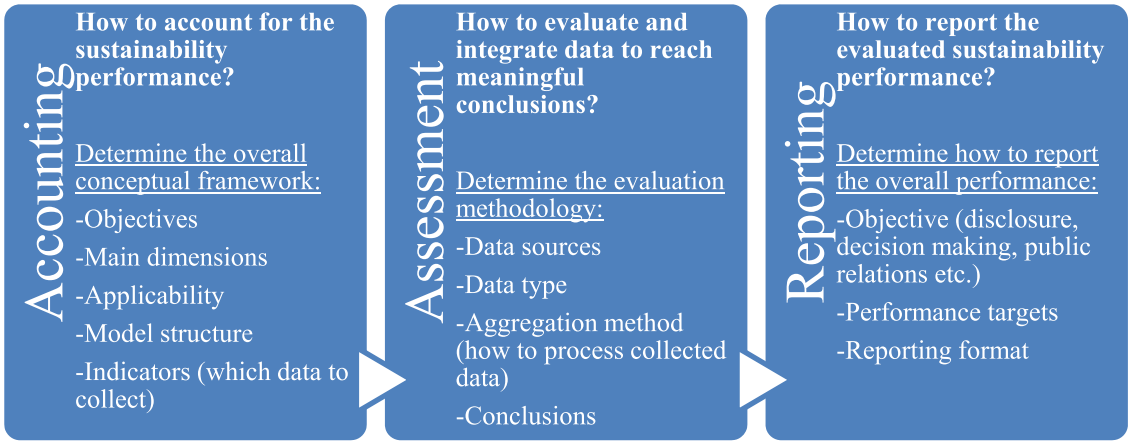

Fig. 1. Main aspects of sustainability performance for businesses.

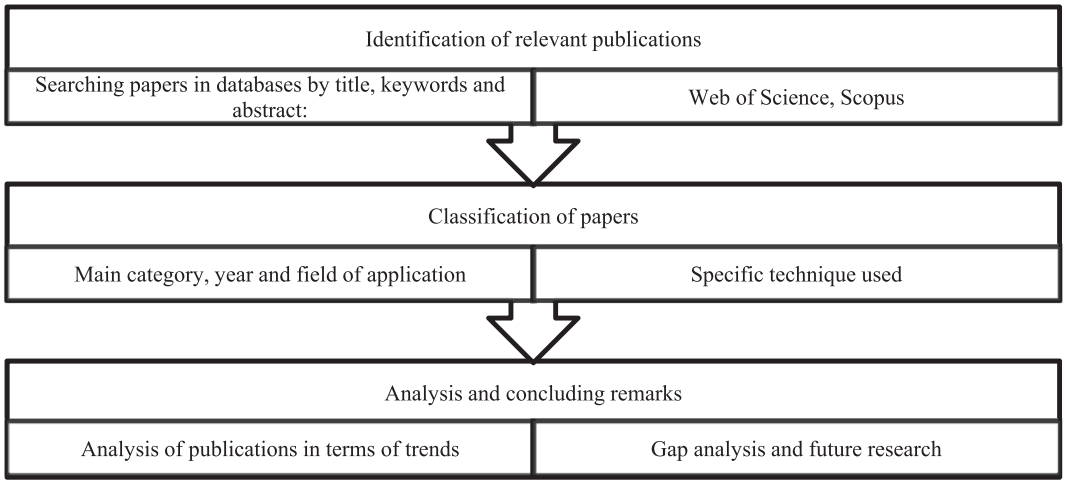

Fig. 2. Research methodology of the literature review.

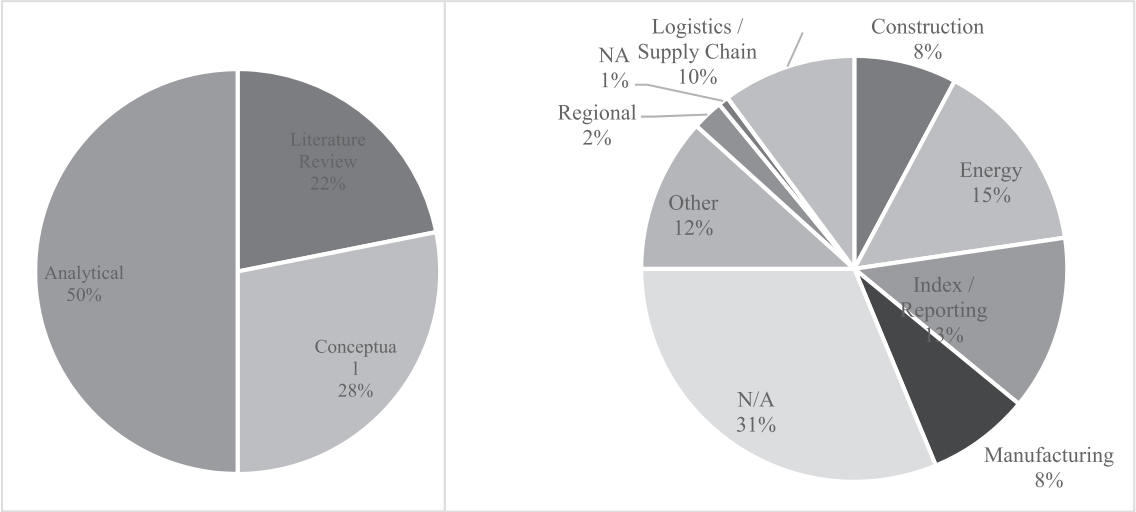

Fig. 3. Distribution of reviewed papers by type (left), and field of application (right).

quantitative assessment purposes). Fig. 3 shows the distribution of the papers reviewed by their type and field of application.

The categories of publication by subject or industry are shown in Fig. 3, which indicates that no one single subject dominates the literature. The majority of papers discussed different fields, such as construction, energy, sustainability index, sustainability reporting, logistics, supply chains, procurement, and manufacturing. Around one-third of reviewed publications are theoretical, without any preferred industry or case application. Fig. 3 also suggests that approx. Half of the reviewed papers are dealing with numerical techniques to assess the overall corporate sustainability performance.

Both sustainability accounting articles that propose conceptual frameworks, and methodological sustainability assessment articles that incorporate analytical data processing techniques, are reviewed. Proposed conceptual frameworks can be a novel composite sustainability index or an industry-specific sustainability indicator set, for instance, to better understand, categorize and account for sustainability impacts. Analytical methodologies include quantitative methods, such as descriptive statistics, multi-criteria decision making (MCDM), composite indices, data envelopment analysis, optimization or similar methodologies to assess the sustainability performance (Zhou and Ang, 2008). Therefore, papers are categorized as 'conceptual' or 'analytical' papers, in addition to the literature review category. Fig. 4 shows the numerical distribution of reviewed publications over the last 11 years. This graph indicates the dominance of analytical papers.

2.2. Data analysis approach

After the identified articles are categorized according to their type, approach, technique, and subject, they are further analyzed one by one to find common patterns in terms of their objectives, methodology, solutions they offer and results they obtain.

Accounting (i.e. conceptual) and assessment (i.e. analytical) methods for sustainability performance are quite dispersed in literature. Reading through SPE literature can create more questions than answers. During this exercise, new 'why's and 'how's have arisen from the observed similarities and diverse approaches used in various publications. These questions guided the review in multiple rounds. Considering the qualitative nature of sustainability science, and that costs and benefits vary across short- and long-term, testing of patterns' validity is not straightforward and involves a certain level of subjectivity. To limit possible bias, a number of hypotheses, some of which are presented in Section 4, are developed by the two authors with industrial and scientific SPE experience in repetitive review rounds to compare and discuss. Research gaps are transparently communicated in the next sections. The usefulness of the findings and observed patterns can be further investigated with follow-up research in the future. This paper is therefore unique for not only in its approach for both its article selection and analysis method but also in attempting to 'connect the dots' by linking conceptual sustainability accounting perspective with data analysis techniques used for sustainability assessment purposes for the first time in sustainability literature.

3. Review of the literature

Businesses can opt-in standard or customized conceptual frameworks for disclosure and decision-making purposes when evaluating their sustainability performance. Many sustainability reporting models and initiatives do not necessitate any assessment, where the user-friendly presentation of accounted data can be sufficient in many cases. This article proposes that SPE needs both steps of accounting and assessment so that different aspects of sustainability can be related to each other and evaluated with a holistic view in a systems-thinking approach, because of numerous correlations, feedback mechanisms and interactions between sustainability perspectives (Williams et al., 2017).

The level of sustainability performance can be captured with the help of general or industry-adjusted performance criteria and associated indicators that are associated with clearly defined goals. Development and use of conceptual and analytical models date back to the late 1990s. In the mid-2000s, composite sustainability indices became attractive. Performance indicators can be merged into aggregated indices, which are principally weighted averages calculated according to a predefined method (Goldberg, 2002; Nardo et al., 2005). Such aggregate indices are basic examples for assessment how conceptual indicator sets can be scored and combined into meaningful results with simple or more complex numerical methods. They can greatly differ in focus, coverage, methodology, and objective. Some examples include, inter alia, the

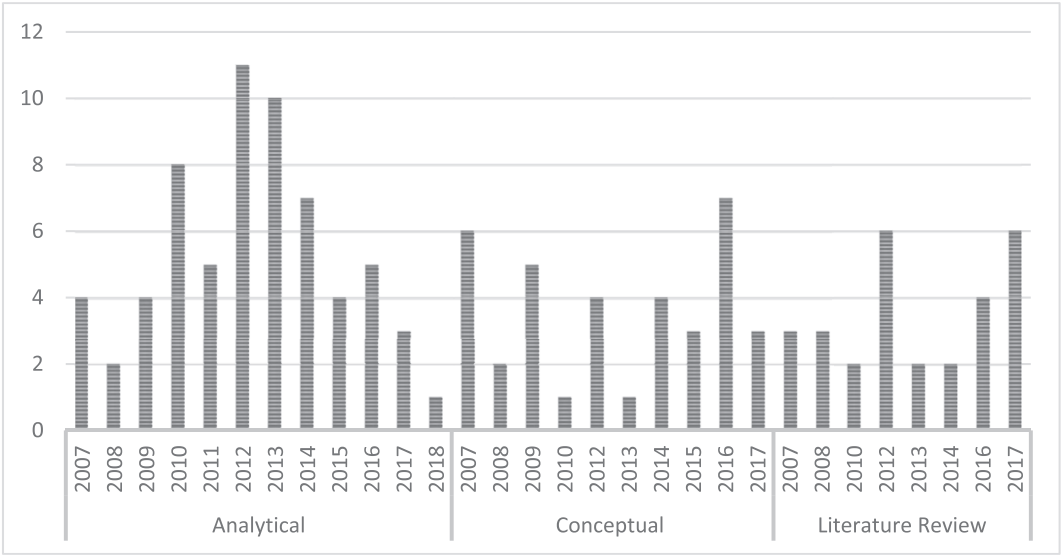

Fig. 4. Yearly distribution of reviewed publications.

Sustainable National Income, Wellbeing Index, Index of Sustainable Economic Welfare, General Progress Indicator, Ecological Footprint, Adjusted Net Savings Genuine Savings, Environmental Sustainability Index and Human Development Index. Although composite indices are known for their ease of generation and use, trade-offs and compromises are often poorly considered, leading to distortions in intended outcomes (Morrison-Saunders and Pope, 2013), as significant information can get lost during the aggregation process (Gasparatos et al., 2008).

A widely used example of SPE frameworks is the Global Reporting Initiative (GRI), which pioneers SPE adoption in the industry by developing a flexible and simple accounting and reporting framework. It is a mainstream model for disclosing corporate sustainability efforts and is an example of a generic conceptual model that can be adapted to specific needs. GRI is built upon a series of hierarchically designed indicators for efficiently reporting their impacts on the environment and the society in a practical way. Despite its shortcomings (McElroy et al., 2008), today GRI has reached its 4th version. Its continuous development and adaptation hint the changing needs of the industry. Another globally recognized SPE framework is the Carbon Disclosure Project (CDP, 2014), which is a disclosure platform that guides firms in adopting sustainable water use practices, tackling climate change, managing deforestation risks and mitigating their supply chain related environmental risks. For these purposes, specific sets of impact categories and indicators are defined. Also, DJSI is a well-known example of SPE frameworks which actively monitors more than 600 publicly traded companies worldwide ("DJSI", 2014). Infrastructure projects and facilities can also be accounted, assessed and reported on their sustainability performance. CER Gold Standard is a project-based SPE framework (GS Foundation, 2012). It is an award-winning certification scheme for greenhouse gas reducing investments to ensure that projects combating global warming also contribute to sustainability agenda. A comparative analysis of popular models currently used by businesses is listed in Table 1. This comparative analysis of the widely used voluntary frameworks shows that available mainstream options have both their strengths and weaknesses.

Many of the popular frameworks acknowledged by the business community share similar weaknesses, such as a lack of standards, third-party auditing, monitoring, and enforcement, all of which limit the value of SPE frameworks. Next, an overview of SPE literature will be provided with a breakdown of literature reviews, conceptual frameworks, and analytical methodologies.

3.1. Review papers

The snapshot of related literature given below provides an overview of the development of conceptual frameworks and SPE indices in the last 10 years. There is only a limited number of literature reviews that analyze the state of the art of SPE publications. Available literature reviews either focus on the methodological choices of analytical SPE methodologies or compare different conceptual SPE frameworks. This scientific gap is addressed by exploring the link between conceptual and analytical publications. The chronological list of literature review articles is given in Table 2.

The chronological order shows a pattern of increased publications of literature reviews in the last 5 years. Among literature reviews, a paper by Ness et al. (2007) presented existing SPE tools in three categories; i.e. composite indices, integrated assessment, and product-related tools. Another paper by Kajikawa et al. (2007) provided an overview of the academic landscape of sustainability science with a topological clustering method. Gasparatos et al. (2008) examined various SPE models, such as composite indices, indicators, biophysical models and monetary tools. Brown et al. (2009) examined the GRI on the basis of interviews and documentary analysis and concluded that it has been a successful institutionalization project. In another literature analysis, Singh et al. (2012) delved into proposed sustainability indices, i.e. how data are scaled, normalized, weighted and aggregated. One of the reasons why sustainability indices kept attracting continued interest and criticism can be attributed to their strengths and weaknesses. In two other literature reviews, Čuček et al. (2012) summarized basic definitions, such as composite sustainability indicators, carbon footprint and ecological footprints and Buter and Raan (2012) analyzed highly cited papers and concluded that the related fields and clusters in literature are becoming more diverse and that social dimensions still remain less visible. In another review, Bond et al. (2012) postulated that SPE may be at the beginning of a phase of expansion not seen since environmental impact assessment was adopted worldwide. More lately, Goyal et al. (2013)

Table 1
Comparison of mostly used SPE tools in the industry.

SPE Model	Strengths	Weaknesses
ISO Standards (14000, 26000 etc.)	• Widely known and used by businesses. • Global acceptance across industries. • Definition of basics and overarching principles. • Continuous update and development.	• Partial coverage (no standard for integrated assessment). • Lack of tangible evaluation framework (e.g. criteria etc.) • Limited disclosure. • Lack of ability to enforce.
Carbon Disclosure Project (CDP, 2014)	• Used by largest corporations worldwide. • Credible and standardized sustainability information for corporate investors. • Concrete evaluation tool, ease of use (questionnaire).	• Focus on environmental performance (e.g. carbon footprint, water, and energy consumption). • Targets biggest firms (e.g. FT Global 500) for public disclosure. • Highly descriptive reporting.
Global Reporting Initiative (Global Reporting Initiative, 2013)	• Global recognition and wide usage across countries and industries. • Provision of evaluation and reporting template. • Ease of use, accumulated experience and continuous development (version 4).	• Flexible selection of criteria, leading to over- or under-reporting. • Open to subjective, biased and oral evaluations. • Primary focus on reporting. • Lack of auditing.
Stock Exchange Sustainability Indices; ("DJSI", 2014)	• Public disclosure of sustainability performance as an additional investment parameter for individual and corporate investors. • Incentive for companies to be listed for increased investor interest. • Standard methodology applicable for all firms.	• Oversimplified sustainability evaluation methodologies. • Limited information disclosure by companies. • Limited focus (mostly environmental management and regulatory compliance). • Lack of standards.

Table 2
Literature reviews.

Author	Types of Reviewed Papers	Subject/Case Study
Arodudu et al. (2017)	Conceptual	Biofuels
Diaz-Balteiro et al. (2017)	Analytical	N/A
Myllyviita et al. (2017)	Conceptual	N/A
Onat et al. (2017)	Conceptual	LCA
Sikdar et al. (2017)	Conceptual	N/A
Williams et al. (2017)	Conceptual	N/A
Hansen and Schaltegger (2016)	Conceptual	N/A
Kylili et al. (2016)	Conceptual	Construction
Maas et al. (2016b)	Conceptual	Sustainability reporting
Morioka and de Carvalho (2016)	Conceptual	
Gunasekaran et al. (2014)	Conceptual	Supply Chain
Cinelli et al. (2014)	Analytical	N/A
Goyal et al. (2013)	Conceptual	N/A
Herva and Roca (2013)	Analytical	N/A
Čuček et al. (2012)	Conceptual	Index
Bond et al. (2012)	Conceptual	N/A
Dahl (2012)	Conceptual	Index
Moldan et al. (2012)	Conceptual	N/A
Searcy (2012)	Conceptual	N/A
Singh et al. (2012)	Conceptual	Index
Morhardt (2010)	Conceptual	Sustainability Reporting
Phillis et al. (2010)	Conceptual	Index
Ding (2008)	Conceptual	Construction
Gasparatos et al. (2008)	Conceptual	Index
Mayer (2008)	Conceptual	Index
Bebbington et al. (2007)	Conceptual	Sustainability Accounting
Böhringer and Jochem (2007)	Analytical	Index
Fowler and Hope (2007)	Conceptual	Finance

presented a structured review of available literature that links environmental and social performance with corporate economic performance. The same year, Gatti and Seele (2013) examined the terminology used in the sustainability reports and described the trends in the use of terms and concepts. In another review paper, Morioka and de Carvalho (2016) discussed the main contributions and discrepancies in corporate sustainability performance publications. They identified 9 conceptual frameworks, including DJSI and GRI, and then created a list of sub-dimensions for facilitating further research and application. Maas et al. (2016b) also discussed recent publications and stated that performance assessment, management accounting, management control, and reporting are used in an isolated manner. Then, they proposed an integrated framework for sustainability assessment, accounting, control, and reporting. In that sense, this paper highlights the disconnection between accounting and assessment perspectives. In a very recent article, Williams et al. (2017) reviewed sustainability management literature and found that related work is rapidly increasing since 2011. They then presented many research themes and offered a cross-scale integrated framework. Diaz-Balteiro et al. (2017) discussed MCDM-based SPE frameworks and highlighted the proliferation of works aggregating sustainability criteria by using this type of tool. In contrast to this paper, they reviewed 271 articles utilizing MCDM only with the main aim to differentiate different analytical techniques. Another recent article by Onat et al. (2017) reviewed SPE literature from a life cycle analysis (LCA) point of view, suggesting that social and economic considerations are largely ignored in the literature, which can be best alleviated with a systems-thinking approach that brings tools, methods, and disciplines together. Arodudu et al. (2017) explored alternative tools, methodologies, and frameworks to LCA that can be deployed for bridging methodological gaps in SPE of biofuels. In another review paper, Myllyviita et al. (2017) examined different methods, such as MCDM, LCA, sustainability indicators and indices for the Finnish industry. While these reviews discuss specific fields of study, they also highlight the need for multi-disciplinary works, where conceptual SPE models are supported by and combined with methods from other fields of study to facilitate the evaluation and comparison of sustainability performance across industries and businesses.

3.2. Conceptual SPE frameworks in literature

Conceptual SPE frameworks have shown significant progress in the last decade, not only due to the introduction of new criteria and indicators but also how they are adapted to industries and applied in specific cases of supply chains, company operations, countries, and industries, to name a few. Conceptual frameworks are useful in determining what reflects the sustainability performance, which indicators to use and what to expect from their measurement. Such frameworks aim to identify which data to collect for what purpose. Some of these conceptual frameworks can also be used for reporting, especially in the case of qualitative indicators which are difficult to analytically combine. Conceptual frameworks can be categorized as driving force-state-response, theme-based, capital, accounting and composite indices, to name a few (United Nations, 2007). The chronological list of conceptual papers included in this analysis is provided in Table 3.

While displaying a relatively balanced distribution over years, conceptual frameworks significantly vary in terms of their methodological approach towards SPE. When recent literature is analyzed, numerous indicator-based thematic frameworks can be identified. An early work by Perrini and Tencati (2006) developed an SPE system targeting small and medium-sized enterprises. In another paper dealing with SPE in the construction industry, Berardi (2012) emphasized the importance of energy performance in building sustainability schemes (e.g. BREEAM, LEED). Tokos et al. (2012) proposed GRI-compatible indicators for the brewing industry sustainability measurement, while Zhou et al. (2012) explored various combinations of composite index techniques to find out the most suitable SPE index for the construction industry. Hutchins and Sutherland (2008) introduced a new index for

Table 3
SPE literature implementing a conceptual approach.

Author	Concept	Subject/Case Study
de Almeida Guimarães and Leal Junior (2017)	Framework	Transportation
Pope et al. (2017)	Framework	N/A
Singh and Vinodh (2017)	Framework	N/A
Ferreira and Silva (2016)	Balanced Scorecard	Supply Chain
Garcia et al. (2016)	Framework	Energy
Miller et al. (2016)	Composite Index	Transportation
Nunes et al. (2016)	Framework	N/A
Poveda and Elbarkouky (2016)	Framework	N/A
Rodrigues et al. (2016)	Framework	Product development
Schöggl et al. (2016)	Composite Index	Supply Chain
Boiral and Henri (2015)	Discussion	N/A
Kim et al. (2015)	Framework	N/A
Kühnen and Hahn (2015)	Framework	N/A
Carbon Disclosure Project (2014)	Framework	N/A
Ingwersen et al. (2014)	Framework	N/A
Measuring Intangibles (2014)	Framework	N/A
Searcy (2014)	Framework	N/A
Global Reporting Initiative (2013)	Framework	N/A
Berardi (2012)	Framework	Construction Sustainability Rating
GS Foundation (2012)	Framework	N/A
Schneider and Meins (2012)	Framework	N/A
Tokos et al. (2012)	Framework	Brewing
Chee Tahir and Darton (2010)	Framework	Palm Oil
Brown et al. (2009)	N/A	Sustainability Reporting; Case study
Gjølberg (2009)	Composite Index	N/A
Hubbard (2009)	Composite Index	N/A
Pan and Kao (2009)	Composite Index	N/A
Waheed et al. (2009)	Framework	N/A
Barnett et al. (2008)	N/A	
Hutchins and Sutherland (2008)	Framework	N/A
Adams and McNicholas (2007)	Action Research	Sustainability Reporting; Case study
Ness et al. (2007)	Framework	N/A
Shen et al. (2007)	Framework	Construction
Singh et al. (2007)	Composite Index	Steel
Wang and Lin (2007)	Framework	N/A
Wilson et al. (2007)	Framework	N/A

integrating social sustainability measures into SPE and demonstrated their use in a supply chain decision-making case. Organizational needs are addressed by Hubbard (2009), who proposed the Organizational Sustainability Performance Index. Publications discussing inter-generational equity (Pan and Kao, 2009) and SPE applications in higher educational institutions (Waheed et al., 2009) provided notable methodological contributions to SPE literature. Kim et al. (2015) addressed the weaknesses of LCA-based frameworks for SPE and presented an innovative decision guidance framework to improve sustainability in manufacturing processes. More lately, Poveda and Elbarkouky (2016) introduced a conceptual framework for a hybrid process-criterion benchmarking methodology as a new sustainable rating system for energy industries. Ferreira and Silva (2016) developed a 5-step balanced scorecard model for SPE of supply chains, based on GRI and ISO 14031 indicators. Rodrigues et al. (2016) extracted 787 SPE indicators from literature and systematically categorized them to come up with their set of KPIs for product development. Overall, these papers suggest that evaluation of sustainability performance can be subjective and measured differently, depending on specific needs.

Regarding theoretic sustainability index methods, Böhringer and Jochem (2007) suggested that composite index techniques are highly arbitrary and misleading. They argued that the creation of consistent and meaningful indices requires scientific principles which are often disregarded. Similarly, Barnett et al. (2008) investigated conceptual and methodological challenges associated with composite indices. A paper by Fowler and Hope (2007) scrutinized the methodologies employed in compiling stock exchange sustainability indices and their impact on companies and their investors. Mayer (2008) discussed the scale of available data, weighting and aggregation techniques, the transformation of indicator data, scope and boundaries for such indices. Miller et al. (2016) introduced another SPE composite index for public transportation, while Pope et al. (2017) came up with a descriptive conceptual framework to capture sustainability performance.

A different path followed by researchers explore conceptual aspects of SPE. A study by Adams and McNicholas (2007) discussed the hurdles of corporate sustainability reporting and focused on the relationship between accountability and sustainability performance, while Wang and Lin (2007) presented a more generic sustainability index system that consists of seven index sets. Chee Tahir and Darton (2010) described a conceptual SPE methodology that facilitates comparison and benchmarking. Searcy (2011) highlighted the dynamic evolution of sustainability aspects and presented a framework for updating SPE frameworks over time. The goal-setting aspect of SPE was discussed by Moldan et al. (2012), who suggested that business sustainability shall be linked to reference values and targets. Another innovative perspective was proposed by Schneider and Meins (2012), who came up with the notion of sustainability governance in their work as a dimension of corporate SPE. Kajikawa et al. (2011) analyzed SPE frameworks developed for buildings and discussed the limitations of SPE, such as the use of a mixture of quantitative and qualitative measures, ambiguity of weighing, lack of financial evaluation, and lack of involvement of diverse disciplines and stakeholders. Challenges in SPE are also highlighted by Boiral and Henri (2015). They emphasized the difficulties with the qualitative nature of sustainability,

variety, and non-compliance of existing SPE frameworks, the arbitrary choice of indicators, vague and incomplete information, the problem of fragmented data and limited transparency in reporting. To tackle such conceptual issues, Ingwersen et al. (2014) proposed the combined use of LCA and ecological footprint, besides others for broader capturing sustainability impacts. Kühnen and Hahn (2015) also highlighted the limitations of the current state of SPE research. They argued that there is no unilateral understanding of indicators for measuring businesses social impact. Searcy (2012) formulated a set of key research questions for guiding conceptual SPE research. Again, Searcy (2014) proposed a conceptual SPE framework consisting of 7 main and 35 sub-requirements for companies, showing the rising scientific interest in SPE for businesses. In another paper, Singh and Vinodh (2017) developed another conceptual framework by integrating five enablers with 25 criteria and 75 attributes. These papers underline that SPE is more than only applying a static index model over and over in a defined boundary.

These conceptual frameworks indicate that corporate SPE approaches attempting to account for sustainability performance are considerably fragmented with a wide range of conceptual model structures. It is a challenging task to cover each and every aspect of sustainability performance with one single solution (Wilson et al., 2007). Noting the abundant number of literature discussing the concept of sustainability, publications have so far often disregarded the social dimensions (Székely and Knirsch, 2005) and the causal links and overlapping dependencies among them, implying a lack of balanced SPE approaches. The analysis of conceptual frameworks reveals that many of the proposed taxonomies are often over-subjectively determined with limited underlying selection methods. The diverse and fragmented terminology across publications adds to these complexities. Adapting a conceptual framework to a specific business remains another challenge. This analysis hints that conceptual models are necessary building blocks for corporate SPE for accounting purposes, but they often show weaknesses on their own to capture the total sustainability performance in an objective, consistent manner for business purposes because of their assessment limitations. To deal with some of these complexities, analytical tools have been developed by researchers, as reviewed in the next section.

3.3. Analytical models

Many researchers proposed distinct analytical SPE methods with integrated numerical techniques. These approaches can be stand-alone models with their own conceptual frameworks, or can also extend an existing conceptual framework with quantitative assessment methods. The main goal of analytical SPE in this paper's focus is to give meaning to collected qualitative or quantitative sustainability performance data for decision-making, comparison or other purposes. Considering that different numerical techniques may work best with different conceptual frameworks, this review of relations between accounting and assessment approaches can help create superior SPE models. Analytical papers reviewed in this paper are chronologically listed in Table 4.

The snapshot of related literature given next provides an overview of the development of analytical techniques or the applications of existing models between 2007 and 2018. One pattern is that related literature is distributed over years in a quiet balanced manner, showing a sustained interest from researchers. Different techniques are available in the literature, and their choice also affects the complexity and strength of the analytical models. Hendriksen et al. (2016) presented an approach to quantify the socioeconomic and environmental value that companies create and reduce for society in a format that can easily be understood and used by business leaders to affect key business decisions based on quantitative data.

One of the most frequently used techniques is Analytical Hierarchy Process (AHP), an MCDM technique. As an example, Ugwu and Haupt (2007) came up with an AHP-based sustainability index for the South African construction industry, while Singh et al. (2007) proposed a similar index for the steel industry. For the energy industry, Karger and Hennings (2009) implemented an AHP hierarchy consisting of 31 criteria on 2nd level and 86 criteria on 3rd level to assess four future scenarios for electricity supply in Germany, while Dinh et al. (2009) used the same AHP method for evaluating sustainability of feedstock used for biodiesel manufacturing. Parra-López et al. (2008) extended the AHP method as a decision making support tool and illustrated its usefulness in a sustainable olive farming case study, while Erol et al. (2009) selected appropriate SPE indicators in grocery retailing and used AHP to rank sustainability indicators. Kahraman and Kaya (2010) presented a combined approach integrating combining the fuzzy set theory with AHP for selecting the most suitable energy policy and demonstrated its use in a case study for Turkey. Other articles that dealt with the energy topic using MCDM methods are authored by Doukas et al. (2010) who utilized TOPSIS and linguistic variables for SPE of renewable energy sources and by Frangopoulos and Keramioti (2010) who presented a multi-criteria approach for SPE, which is then applied for the assessment and ranking of energy system alternatives. Succeeding these publications, Hu et al. (2011) proposed a GRI-based SPE model to evaluate corporate sustainability reports with the help of fuzzy AHP for finding the relative weights of decision attributes. Liu et al. (2011) also used the fuzzy AHP method and proposed a composite SPE index consisting of 11 indicators for a renewable energy system. The index is then applied to a case study in Australia. Lately, Büyüközkan and Karabulut (2017) combined AHP with VIKOR to assess and rank the sustainability performance of similarly sized power plants. While case applications abound, it is notable that real case studies for SPE are rather rare in the literature.

With passing time, analytical techniques used for SPE became more advanced. The literature review by Herva and Roca (2013) also suggest a similar trend. Awasthi et al. (2010) proposed a hybrid fuzzy TOPSIS method for assessing city logistics initiatives for sustainability. The same hybrid technique is used by Escrig-Olmedo et al. (2015), who applied their model to the apparel industry. Yao et al. (2011) simulated an SPE model for constructing and operating stages of infrastructure projects using a system dynamics principle, while Erol et al. (2011) came up with a multi-criteria SPE model for supply chains, using a multi-criteria framework based on fuzzy entropy and fuzzy multi-attribute utility. They then tested their framework with industry data collected from a Turkish grocery retailer. Fuzzy TOPSIS is combined with stochastic AHP by Zhao and Li (2016) to assess smart power grid planning in China with the help of 4 criteria and 12 sub-criteria. Dai and Blackhurst (2012) proposed an SPE methodology using four-phase AHP–QFD for supplier selection and provided an illustrative large retail company example. Recently, Maltz et al. (2016) proposed another innovative analytical model based on statistical process control charts to assess variations in sustainability performance and applied it to benchmark energy companies in the US. Vinodh and Girubha (2012a, 2012b) used ELECTRE II and PROMETHEE, other MCDM techniques, to improve sustainability performance in the manufacturing industry. Recent fuzzy logic examples for SPE include Govindan et al. (2013), Costa and Menichini (2013) and Alves de Albuquerque et al. (2013) who combined MCDM and Petri nets. On the other hand, well-known industry focused articles continued, such as Akadiri et al. (2013) and Pons and de la Fuente (2013) for the construction industry, Nikolaou et al. (2013) for

Table 4
SPE literature implementing an analytical approach.

Author	Basic Approach	Technique(s)	Subject/Case Study
Boggia et al. (2018)	MCDM	TOPSIS	Regional
Acquaye et al. (2017)	Input-output analysis	MRIO	Energy; Chemical processes
Büyüközkan and Karabulut (2017)	MCDM	AHP, VIKOR	Energy
Khishtandar et al. (2017)	MCDM	Hesitant fuzzy	Energy
Kolak and Feyzioglu (2016)	MCDM	TOPSIS, Choquet integral	Transportation
Maltz et al. (2016)	Descriptive Statistics	Statistical charts	Energy
Medel-González et al. (2016)	MCDM	ANP; BSC	Energy
Onat et al. (2016)	MCDM	TOPSIS; Intuitionistic fuzzy	Transportation
Wibowo and Grandhi (2016)	MCDM	Intuitionistic hesitant fuzzy Choquet integral	Energy
Zhao and Li (2016)	MCDM	fuzzy TOPSIS, stochastic AHP	Energy
Escrig-Olmedo et al. (2015)	MCDM	Fuzzy TOPSIS	Manufacturing
Rajak and Vinodh (2015)	MCDM	Fuzzy	Automotive
Tan et al. (2015)	Descriptive Statistics	Correlation and regression	Construction
Barata et al. (2014)	MCDM	ELECTRE	Energy
Boggia et al. (2014)	MCDM	DRSA	Regional
Chardine-Baumann and Botta-Genoulaz (2014)	Composite Index	Arithmetic Weighting	N/A
Liu (2014)	MCDM, Composite Index	Fuzzy AHP, Arithmetic Weighting	Energy
van der Voet et al. (2014)	Framework, MCDM	N/A	N/A
Ziolkowska (2014)	MCDM	PROMETHEE	Biofuels
Zolfani and Saparauskas (2014)	MCDM	SWARA	N/A
Akadiri et al. (2013)	MCDM	FAHP	Construction
Babcicky (2013)	Descriptive Statistics	PSR, Regression	Index; Case Study
Büyüközkan and Çifçi (2013)	MCDM	QFD, GDM	Supply Chain
Costa and Menichini (2013)	MCDM	Fuzzy, 2-tuple	Sustainability Reporting
Govindan et al. (2013)	MCDM	Fuzzy TOPSIS	Supply Chain
Hsu et al. (2013)	MCDM	ANP	Sustainability Reporting; Case study
Nikolaou et al. (2013)	Composite Index	Arithmetic Weighting	Logistics
Pons and de la Fuente (2013)	MCDM	Value Function	Construction
Ren et al. (2013)	MCDM	DEMATEL	Supply Chain
Vinodh et al. (2013)	MCDM	VIKOR	Manufacturing
Bilbao-Terol et al. (2012)	MCDM	Fuzzy Goal Programming	Finance
Dai and Blackhurst (2012)	MCDM	AHP, QFD	Purchasing
García-Melón et al. (2012)	MCDM	ANP, Delphi	Tourism
Ghadimi et al. (2012)	MCDM	Fuzzy AHP, Weighted Fuzzy Assessment	Automotive
Lee and Farzipoor Saen (2012)	DEA		Electronics
Li et al. (2012)	Composite Index	PCA	N/A
Traverso et al. (2012)		LCA	Photovoltaics
Vinodh and Girubha (2012a)	MCDM	ELECTRE II	Manufacturing
Vinodh and Girubha (2012b)	MCDM	PROMETHEE	Manufacturing
Wolfslehner et al. (2012)	MCDM	PROMETHEE	Forestry; Case Study
Zhou et al. (2012)	Composite Index	Various Normalization, Weighting and Aggregation Methods	Construction
Büyüközkan and Berkol (2011)	MCDM	ANP, QFD, ZOGP	Supply Chain
Büyüközkan and Çifçi (2011)	MCDM	Fuzzy ANP	Supply Chain
Erol et al. (2011)	MCDM	Fuzzy Entropy, Fuzzy MAUT	Retail Supply Chain
Hu et al. (2011)	MCDM	Fuzzy AHP	Sustainability Reporting
Yao et al. (2011)	Scenario Analysis	N/A	Construction
Artiach et al. (2010)	Descriptive Statistics	Univariate and multivariate tests, sensitivity analysis	Stock market
Awasthi et al. (2010)	MCDM	Affinity Diagram, AHP, Fuzzy TOPSIS	Logistics
Boggia and Cortina (2010)	MCDM	SWING	Regional
Castellani and Sala (2010)	Composite Index	Arithmetic Weighting	Tourism
Doukas et al. (2010)	MCDM	TOPSIS	Energy
Frangopoulos and Keramioti (2010)	MCDM	Arithmetic Weighting	Energy
Kahraman and Kaya (2010)	MCDM	Fuzzy AHP	Energy
Weber et al. (2010)	Descriptive Statistics	Regression, discriminant and covariate analysis	Banking
Dinh et al. (2009)	MCDM	AHP	Biofuels
Erol et al. (2009)	MCDM	AHP, Arithmetic Weighting	Retailing
Karger and Hennings (2009)	MCDM	Expanded AHP, Geometric Mean	Energy
Shmelev and Rodríguez-Labajos (2009)	MCDM	NAIADE	Index
Parra-López et al. (2008)	MCDM	AHP	Agriculture
Van de Kerk and Manuel (2008)	Composite Index	Arithmetic Weighting	N/A
Begić and Afgan (2007)	MCDM	ASPID	Energy
Ugwu and Haupt (2007)	Framework, MCDM	Arithmetic Weighting, Additive Utility Model, AHP	Construction
Yakovleva (2007)	Numerical Analysis	N/A	Food; Case Study
Ziegler et al. (2007)	Descriptive Statistics	Multifactor model	Stock market

reverse logistics systems, Ren et al. (2013) for hydrogen gas production and Vinodh et al. (2013) for manufacturing. Onat et al. (2016) developed a hybrid life-cycle SPE model for transportation alternatives with the help of TOPSIS and intuitionistic fuzzy methods. A similar topic was explored by Kolak and Feyzioglu (2016) using TOPSIS and Choquet integral techniques together. A comparable sophisticated method, intuitionistic hesitant fuzzy Choquet integral, was utilized by Wibowo and Grandhi (2016) to assess power generation alternatives. Discussion about sustainability indices also continued. Babcicky (2013), for instance, critically discussed the validity and reliability of the Environmental Sustainability Index. Also lately, Tan et al. (2015) empirically explored the relationship between sustainability performance and business competitiveness of international construction contractors. Many of these papers assume that evaluation criteria are completely independent of each other and depend on opinions of a single expert, which contains a fair level of subjectivity. A sustainability index proposed by Pinar et al. (2014) introduced a nonlinear aggregation method by utilizing the Choquet Integral procedure, which can be seen as a novelty in the field of SPE. It also enabled to deal with the interactions among the indicators.

The review suggests a trend towards operation research techniques in SPE literature. While acknowledging the complex nature of the problem, this also implies that quantitative methods can provide alternative solutions to SPE, particularly in its assessment aspect. Gunasekaran et al. (2014) emphasized the importance of operation research techniques for accounting for the trade-offs between the three pillars of sustainability. Khishtandar et al. (2017) developed another hesitant fuzzy-based approach for SPE of energy generation from biofuels. Chardine-Baumann and Botta-Genoulaz (2014) and Liu (2014) came up with composite indices, the latter suggesting that traditional crisp data analysis methods are insufficient for capturing the vague nature of sustainability and human evaluations. Zolfani and Saparauskas (2014) showed that SWARA, another MCDM technique, can be a useful SPE framework for an energy system. In another innovative article, Ziolkowska (2014) presented a multi-objective linear programming approach for sustainable biofuel production under limited resources and uncertainty. A paper authored by van der Voet et al. (2014) addressed both compensation possibilities and importance weights in an integrated hierarchical SPE system. Similar to Kühnen and Hahn (2015), Rajak and Vinodh (2015) suggested that social sustainability evaluation with performance indicators is rather limited in the literature. They presented their own social sustainability performance evaluation approach. This state of the literature demonstrates that SPE models are still in rapid development and their common problems of widely recognized frameworks, robust criteria, and data analysis techniques continue to present challenges. Despite methodological richness, current research mostly lacks effective ways of dealing with qualitative parameters in SPE.

This review of analytical methods in SPE literature indicates that there are many different quantitative approaches to evaluate sustainability performance analytically, which is a main activity area in the operation research literature. The papers discussed above show that sustainability accounting is a very significant area of research, the results of which can be strengthened by treating its different aspects with the help numerical assessment methods.

4. Results

Around half of all corporate SPE publications in the last decade are found to be based on analytical techniques, while approximately a third of articles are proposing conceptual approaches. Literature reviews and case studies are more limited in number and scope but do show an increasing trend. Within analytical publications, approx. 80% of the papers proposed their own set of SPE criteria, where the remaining ones used an existing conceptual framework. This underlines that most of the analytical papers do first come up with their own sustainability hierarchy and attributes, instead of applying an established conceptual model. This can be interpreted with different possible explanations; the needed data for evaluation might be unavailable or criteria might be too subjective for specific applications so that each time new suitable criteria shall be developed, terminology might be perceived differently by researchers, or available conceptual models are not suitable for integration with numerical methods. These causes can be forcing researchers to come up with their own conceptual models first, and then integrate their analytical techniques. This article suggests that an underlying reason of why researchers feel the need to develop their own criteria and their hierarchy is that there are no well-defined, generic criteria frameworks that are easily adaptable to a wide range of applications.

Conceptual models are useful for simply reflecting the collected data without combining them into quantifiable meaningful results. However, this helps little with determining the extent of the economic, environmental and social performance with respect to a selected baseline, or over the competitors. Combined accounting and assessment, hence SPE, tools can support the identification and monitoring of the overall corporate sustainability performance for decision-making purposes (e.g. selection of green supplier, evaluation of sustainable product design, industry benchmarking, ranking of sustainable project alternatives etc.). Operation research tools can be instrumental in analyzing the trading-offs among the sustainability dimensions (Gunasekaran et al., 2014). This review demonstrates that SPE science is moving towards a more quantitative field of research (Mayer, 2008).

Observed literature patterns, findings, and research gaps are discussed next.

4.1. Proposed SPE solutions do not serve all needs

Corporate SPE is associated with economic, environmental and social sensitivities and expectations. SPE frameworks can change across industries, locations and time. Dick et al. (2014) suggest that the choice of conceptual SPE frameworks depends on the specific question and scale being addressed. The use of a single “SPE framework to fit all” is commonly discouraged among sustainability practitioners due to the varying nature of context, methods, and tools, such as life cycle costing, social LCA, cost-benefit analysis, MCDM, etc. (Arodudu et al., 2017). Analytical techniques used can also differ due to their specific strengths and weaknesses. The number of criteria, the scale of the evaluation and other characteristics of SPE practices, can lead to the use of one technique or another. Many different MCDM tools are employed to address SPE in literature. A review by Diaz-Balteiro et al. (2017) mention up to 15 different methods that are employed. These can be combined in varying settings to explore how they match with conceptual sustainability accounting frameworks. Accounting and assessment frameworks, therefore, need to be customizable, compatible and adaptable, for example by using different performance parameters or using the same criteria with different weights. No SPE method is proposed so far that can address all SPE problems once and for all. Criteria-based data collection can be strengthened with different analytical performance assessment tools to bridge this gap and serve different needs.

4.2. A general SPE framework is a need for businesses

Despite methodological challenges, businesses need to set targets for their sustainability performance, evaluate their own

performance accordingly and benchmark with the industry and their competitors periodically. There is no standard methodology for solving sustainability problems (Santos and Brandi, 2015). For standardization, generic corporate SPE frameworks supported with analytical techniques can benefit businesses for monitoring their results in a coherent and consistent way. Hierarchical sustainability taxonomies can be particularly suitable as they are well-known and easily recognized both in literature and industry. SPE is a data-intensive practice, and data-driven methods can be strengthened with digital systems. As more data can be extracted from business IT systems almost real-time, the bottleneck in accounting, assessment and reporting processes shifts from data unavailability towards the lack of standardized methods.

4.3. Sustainability indices have their strengths and weaknesses

Procedures for aggregating indicators have several advantages and disadvantages (Reisi et al., 2014). Composite sustainability indices as they are easy to produce, understand and explain, but they rely on the flawed assumption that a low performance in one of the indicators can be offset by another well-performing indicator, which can possibly overlook important over- and under-performing attributes. Composite indices may lead to information loss during the aggregation step (Gasparatos et al., 2008), in addition to complexities associated with dependencies among criteria and scoring of qualitative indicators. Despite methodological criticism, sustainability indices have their advantages when it comes to conveying a simple message to decision makers, showing the need for integrating accounting and assessment methods.

4.4. Evaluation of sustainability performance is subjective

The unavoidable subjectivity embedded in qualitative aspects of sustainability remains a challenge. Despite arguments that personal values and societal beliefs should be avoided in SPE (Marshall and Toffel, 2005), it is rather difficult to completely prevent it. Sustainability indicators are often evaluated by people, and even industry experts do think differently. The reliability of indicators also relies on how the data is collected from experts (Münnich and Seger, 2014). Literature suggests that the traditional crisp (precise) data analysis methods are not always suitable for SPE. Incorporation of fuzzy logic has increased significantly in recent years, many of them combined with MCDM techniques. Integration of such tools can be helpful in solving problems characterized by imprecision and subjectivity (Herva and Roca, 2013; Liu, 2014).

4.5. The traditional understanding of sustainability is losing ground

Distinct separation of economic, environmental and social elements is no longer explicit, as in UNCSD (United Nations, 2007). In addition to these three pillars, many recent frameworks are expanded with technical, political, technological, recreational, institutional and community perspectives (Diaz-Balteiro et al., 2017). The line between the three pillars of sustainability can be difficult to draw because of mutual dependencies, subjective understanding of criteria meanings and overlapping impacts, considering the difficulty of assigning each indicator to one single pillar. Hybrid use of conceptual and analytical approaches can be beneficial in this respect to better simulate these interactions and avoiding strict criteria boundaries.

These findings suggest that business managers can benefit from a customizable generic SPE model that is supported with, or adaptable to analytical techniques which can sufficiently deal with the subjectivity, feedbacks, and interrelations among selection criteria.

5. Discussion

This discussion aims to present common patterns in SPE research and possible solutions to improve observed challenges. Recommendations are developed with the aim to address these gaps and come up with potential research directions. The topic of SPE is vast and findings in this article will inevitably lead to subjectivity. On the other hand, it holds a unique perspective by ambitiously analyzing the conceptual and analytical literature simultaneously. Recommendations mentioned next are based on hypotheses that are developed in the light of literature trends and perceived needs of businesses, subject to further investigation and validation in the future.

5.1. Lack of more balanced SPE approaches

Despite an increase in publications discussing all the three pillars of sustainability, publications on social performance with more objective and tangible methods are still limited (Morioka and de Carvalho, 2016). Social aspects of sustainability are usually disregarded in literature, often leading to skewed and incomplete evaluations. SPE frameworks that cover different dimensions of sustainability without significantly prioritizing any of them can help standardize and streamline corporate sustainability practices. Future research can address this gap by approaching the concept of sustainability in a more balanced manner, by giving similar importance to the main dimensions of sustainability. Analytical tools, such as MCDM, can be helpful in reducing the bias and imbalance that may stem from the negligence of impacts, arbitrary criteria selection, and subjective weighing.

5.2. Lack of specific practical applications

Sustainability performance is being increasingly used by decision makers as input. In addition to reporting purposes, treating SPE as a decision support tool for businesses can transform the understanding of the literature. Scientific progress can also encourage more real case studies. Considering the high relevance for both accounting and assessing sustainability performance, the rarity of SPE case studies hints such a gap. There is a scientific potential for case studies and action researches, as they are adequate to promote in-depth understanding of SPE processes (Mir and Rahaman, 2011).

5.3. Lack of consideration of criteria's interdependency

As also discussed in Section 3.3, many publications oversimplify SPE problems by assuming that sustainability attributes are independent of each other. However, such correlations are inevitable because of vague criteria definitions, complex causal links, and the difficulty to completely distinguish and separate sustainability impacts. Different indicators might be correlated with each other. If the correlation is high, excluding some of them should also be considered, requiring the use of numerical techniques (Huth et al., 2005). Neglecting these mutual interactions such as dominance and compensation can mislead to biased results. Conceptual SPE frameworks often disregard overlapping relationships between criteria, where certain analytical techniques can effectively help to manage such challenges.

5.4. Lack of multi-criteria measurement of user preferences

The increase in the number of KPIs proposed by SPE frameworks, associated workload, and uncertainties related to data used can be handled with MCDM tools, modeling approaches and

software supports (Arodudu et al., 2017). Many papers arbitrarily assign (often equal) criteria weights, which may lead to judgmental, imprecise and systematically faulty results. This methodological choice may be associated with simplicity, but also with limited expert evaluations. An enhanced model should, therefore, be able to quantify different user preferences. In order to reduce user-related bias, a group of experts (decision makers) can be integrated into such frameworks. For this purpose, group decision-making techniques can be combined with analytical tools to better handle uncertainty, conflicting indicators, and linguistic evaluations. Many papers in other research fields combine MCDM techniques with group decision-making and/or fuzzy methods (Mardani et al., 2015), which can bring additional benefits to the SPE literature.

5.5. Lack of efficient means to address qualitative parameters and fuzzy expressions

SPE can be approached by defining an initial set of indicators by adequately defining a multi-disciplinary list of acceptable qualitative and quantitative criteria. Operation research tools, such as MCDM, are widely applied in SPE literature as they look for compromise solutions among conflicting criteria and indicators (Diaz-Balteiro et al., 2017; Janeiro and Patel, 2015). A fuzzy component can be deployed into frameworks to introduce the imprecision usually inherent in the information available into the model (Zimmermann, 1978). A major bottleneck in SPE is the high level of subjectivity both in terms of selection of indicators, and their evaluation. Qualitative nature of many criteria, particularly for the social, institutional and governance-related aspects of sustainability, makes SPE a heavily subjective practice. Businesses need less-biased setups that can be easily and practically applied. The credibility of SPE can be improved by adopting robust uncertainty and sensitivity assessment tools (Sala et al., 2015). Scientific progress can be achieved with operation research tools, such as fuzzy logic, for better managing such subjectivity.

5.6. Lack of common terminology for basic sustainability criteria

An important role of SPE is to facilitate the definition of objectives to be fulfilled by businesses towards improved sustainability performance. This enables businesses to identify the most critical performance areas, define KPIs and distribute their scarce resources accordingly (Morioka and de Carvalho, 2016). Standardized criteria definitions and KPIs can be highly useful to ensure wide-reaching sustainability management efforts across industries. This review highlights the diverse use of terminology and indicators, where similar criteria are formulated in different wordings (e.g. jobs and employment). Many metrics, indicators, and criteria are often thematically overlapping or almost identical. Streamlining these terms with a structured approach can contribute to the literature by providing a more common and standard basis for researchers to build upon.

6. Conclusions

Sustainability-related publications remain widely dispersed in terms of approach, technique, and terminology, with no particularly dominating framework. This paper suggests that SPE consists of two main components; accounting of sustainability performance with conceptual frameworks, and assessment of sustainability performance by using information collected from conceptual frameworks.

Review of the publications dealing with conceptual accounting and quantification of corporate sustainability performance suggest a clear focus on environmental aspects, which can be associated with the arbitrary prioritization of selected attributes, as well as the difficulty of evaluating qualitative attributes. These challenges can be better overcome with digital technologies, as well as quantitative methods, considering that integrated SPE models for businesses is a promising research area.

Although businesses aim to understand their overall sustainability performance to enhance their operations, most SPE frameworks so far fail to “talk to each other”. This emphasizes the importance of flexible and modular solutions that are also compatible with other sustainability accounting and assessment frameworks, such as using common criteria structures and generating outputs that can be used as input by others. Standardization of terminology and numerical operation research methods, such as group decision-making, the fuzzy set theory, and MCDM techniques, can offer potential value in this respect.

This paper aims to present gaps to guide future research by considering the conceptual and analytical SPE frameworks together with a business focus for the first time in recent literature. It is unique in defining key concepts, exploring the gap between accounting and assessment of sustainability, and proposing a structured overview of innovative research recommendations about integrating analytical assessment methods into conceptual sustainability frameworks. This work emphasizes the need for criteria models, supported by suitable analytical techniques, that are able to calculate the level of sustainability impacts in a balanced and practical manner to stimulate this field of research.

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