Contents lists available at ScienceDirect

Sustainable Production and Consumption

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

Energy-related performance measures employed in sustainable supply chains: A bibliometric analysis

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ABSTRACT

The purpose of this paper is to identify and analyze the metrics that have been used to address energy-related issues in green supply chain management (GSCM) and sustainable supply chain management (SSCM). The metrics were identified based on a structured content analysis of 115 peer-reviewed articles published in the Scopus database. A total of 113 unique energy-related metrics were identified. Only three metrics were used more than 10 times: "energy use" (24 times), "energy consumption" (21), and "energy efficiency" (11). The majority of the metrics were used only once (73 metrics) or twice (29). The results highlight a lack of agreement on how energy-related issues should be measured in GSCM and SSCM. To better understand the use of energy-related metrics in GSCM and SSCM highlighted in the literature, the metrics were analyzed using 13 key characteristics of SSCM. Approximately, two-thirds (65%) of the metrics focused exclusively on the environmental focus of SSCM. Thirty-nine (35%) metrics simultaneously addressed two or more key characteristics of SSCM. This paper presents an original contribution through one of the first in-depth analyses of metrics used to measure energy-related issues in the GSCM and SSCM areas. The analysis provides the basis for several recommendations on measuring energy-related issues, including sets of original standardized metrics, in supply chains going forward.

Keywords: Energy; Sustainable supply chain management (SSCM); Green supply chain management (GSCM); Metrics; Indicators; Performance measures

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Received 21 October 2015; Received in revised form 2 February 2016; Accepted 6 February 2016; Published online 16 February 2016.

http://dx.doi.org/10.1016/j.spc.2016.02.001

1. Introduction

Research focused on the integration of sustainability into supply chain management (SCM) is in its emergent stages (Ashby et al., 2012; Ahi and Searcy, 2013). As highlighted by Handfield and Bechtel (2004), the SCM concept extends over multiple interdisciplinary fields, including operations research, business, economics, organizational science, and industrial psychology. Given its broad scope, SCM also covers a wide range of technologies, such as those related to energy generation, that affect its study within these fields (Boone et al., 2007).

Energy has been identified as a vital requirement in every sector (e.g., manufacturing, transportation, retail, etc.), and the growing demand for energy has become a major issue in the last few decades (Tsoutsos et al., 2005; Kotcioglu, 2011; Roldán et al., 2014). Energy has thus become a core issue in SCM. Renewable energy issues, in particular, have been prominently considered in recent publications (Halldorsson et al., 2009; Bagliani et al., 2010; Cucchiella and D'Adamo, 2013; Montoya et al., 2016). Given the widespread economic, environmental, and social impacts of energy, it has become closely associated with the concept of sustainability.

Over the last decade, awareness has been growing on the need to consider sustainability issues in the context of SCM (Carter and Rogers, 2008; Seuring and Muller, 2008). Economic, environmental, and social impacts are commonly referred to as the "triple bottom line" (TBL) of sustainability (Elkington, 1998) and have contributed to a further broadening of the SCM concept. Increasingly, SCM is viewed as constituting a leading edge of business sustainability in practice as it provides a reasonable prospect and opportunity for organizations to assimilate the TBL performance objectives (as a minimum) into decision making processes across the entire value chain of a product or service (Meixell and Luoma, 2015).

Given its key role in both sustainability and SCM, energy-related issues provide an important leverage point for their joint implementation. Better consideration of energy issues in supply chains could potentially provide a clearer path to improved local, regional, and global sustainability (Cucchiella and D'Adamo, 2013; Halldorsson and Svanberg, 2013). These points underline the need for a greater emphasis in both academic and practitioner-oriented work on studying the role of energy-related issues in the management of sustainable of supply chains.

This paper addresses the core research question of "*How should energy-related issues be measured in sustainable supply chains?*" The question is addressed through a multi-stage process. First, an in-depth study of energy-related issues in green and sustainable supply chains is presented. A database of existing energy-related metrics published in the literature is thoroughly analyzed. The database was developed based on a systematic research literature review of 115 relevant articles from the Scopus database. Second, original sets of standardized metrics for measuring energy-related issues in sustainable supply chains are presented. The development of the standardized metrics was informed by the analysis of the database of existing metrics. These standardized metrics will provide a strong basis for future work by both academics and practitioners.

The remainder of the paper is organized as follows. Section 2 presents a review of background material most relevant to the analyses conducted. The research methodology is provided subsequently in Section 3. Detailed analyses of the results, along with accompanying discussions, are provided in Section 4. Research recommendations are presented in Section 5. The conclusion, including research implications, contributions, and suggested future research directions, is provided in Section 6.

2. Background

2.1. *Sustainable supply chains*

Efforts to incorporate sustainability issues into SCM have been carried out under a variety of umbrellas. Two of the most prominent terms used to stress such integration are green supply chain management (GSCM) and sustainable supply chain management (SSCM) (Ashby et al., 2012; Ahi and Searcy, 2013). While the GSCM concept primarily focuses on how SCM can be viewed in the context of the environment (Gurtu et al., 2015; Mangla et al., 2015), the SSCM concept extends its scope to cover economic, social, and potentially other viable issues (e.g., resilience, efficiency) alongside environmental considerations (Shi et al., 2012; Ahi and Searcy, 2013). SSCM therefore expands the basic concept of SCM by widening performance to contemplate the key characteristics of sustainability. Given the broad definitions of both SCM (e.g., Stock and Boyer, 2009) and sustainability (e.g., Dahlsrud, 2008), it is unsurprising that a number of different factors have been used to characterize SSCM. This is reflected in the many different definitions of SSCM in the literature. As a set of representative examples, ten key definitions of SSCM are presented in Table 1.

As shown in Table 1, different definitions of SSCM emphasize different characteristics of both sustainability and SCM. In recognition of this point, Ahi and Searcy (2013) conducted a structured review of 12 definitions of SSCM and 22 definitions of GSCM. The analysis revealed that there were 13 key characteristics of SSCM (Ahi and Searcy, 2013, p. 337–338):

1. Economic focus, which includes "language related to the economic dimension of sustainability", such as economic, profit, etc.
2. Environmental focus, which includes "language related to the environmental dimension of sustainability", such as environment, ecological, etc.