Review

The concept of sustainable manufacturing and its definitions: A content-analysis based literature review

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A B S T R A C T

The concept of sustainable manufacturing (SM) is becoming increasingly mature due to the focus on many of its research topics for a long time. This research has undoubtedly extended the body of knowledge, yet the numerous definitions of SM in prior art still indicate a lack of consensus on the true meaning of the concept. It is thus to be expected that these discrepancies will constrain further development and use of the SM concept in industrial practice.

The goal of this paper is to analyze the different definitions of SM and identify the current understanding of what researchers mean by the concept. We use an inductive content analysis of definitions published from 1990 to 2016 in a variety of academic journals. A total of 189 articles including a manifest definition of SM and 89 original definitions were identified. Our analysis revealed that the most commonly used definition is the one proposed by U.S. Department of Commerce in 2008; 63% of the analyzed articles cite or slightly rephrase this definition, while 86% of the identified definitions are used in less than three articles. Although the majority of researchers seems to agree upon eleven sub-categories of SM, a wide range of issues (67 sub-categories) associated with SM indicates inconsistency in the general understanding of the concept. It is proposed that the findings in this study can serve as a foundation for the development of a common language for SM in both research field and industrial practice.

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1. Introduction

After several decades of research in SM, there is still no common definition among scholars. Moreover, many authors argue that there is no common and unified understanding of what SM is (Dornfeld, 2009), (Haapala et al., 2013), (Wang et al., 2016), (Millar and Russell, 2011), (Despeisse, 2013), (Nakano, 2009), who all highlight the problem of numerous definitions (Jawahir and Bradley, 2016). state that "there are no generally accepted or universal definitions for sustainable manufacturing … there are many insufficient attempts". The definitions evolve as authors modify definitions or interpretations of SM. This situation makes it difficult for industry to take the concept from theory to implementation.

One of the reasons behind the large number of definitions is the many different interpretations of the 'sustainability' concept: e.g., seeing sustainability as an environmental initiative; as a goal or a process; as an integration of different aspects; or as a compromise between pillars, etc. Researchers claim that the large number of terms and definitions in the SM research field is a barrier to sharing knowledge, particularly between academia and industry. This calls for a more common terminology and vocabulary to enable effective communication in the field of SM (Despeisse et al., 2012). Differences between the terms used to define SM can lead to misinterpretations of its true meaning and thus how to implement the concept in the industry. This prevents organizations from forming a clear picture of SM, which is needed to implement associated practices. This is supported by the empirical study conducted by (Ihlen and Roper, 2014), who concluded that corporations make no attempt to explicitly define the sustainability concept, thus pursuing sustainability with unclear strategies. While some organizations make efforts to implement SM practices, the lack of a standard terminology constrain dissemination of best practices among manufacturers (Despeisse et al., 2012) (Garretson et al., 2016). argue that a common terminology is essential for development and implementation of best (SM) practices in the industry.

The objective of this work is to identify and analyze the definitions of SM in prior art, as well as to identify the current understanding of what researchers mean by the concept using an inductive content analysis. In other words, the study aims to determine any variability in the understanding of SM as a concept and its content.

The remainder of this paper is structured as follows. Section 2 presents the methodology used in this study. Content analysis as a method to analyze definitions is introduced and its three main phases, preparation, organization and reporting are described. Section 3 discusses the findings from the content analysis. Finally, concluding remarks are drawn in Section 4.

2. Research methodology

Content analysis has previously been used in social science to analyze definitions; e.g., "social participation" (Levasseur et al., 2010), "green supply chain management" and "sustainable supply chain management" (Ahi and Searcy, 2013), and "corporate social responsibility" (Dahlsrud, 2008). Content analysis is currently an established method that also may be used to gain insight into the SM field. Inductive content analysis has been used previously to advance the understanding of the sustainable agriculture concept by (Velten et al., 2015), who conducted a structured literature review of papers that engaged critically with the definitions of sustainable agriculture and applied content analysis to identify categories associated with sustainable agriculture concept.

2.1. Content analysis as a research method

Content analysis is a type of qualitative study, which is defined as "a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes and patterns" (Hsieh and Shannon, 2005). Further, it is a systematic reading for making replicable and valid interferences from texts or other symbolic matter (Krippendorff, 2012). The purpose of using content analysis as a research method is to provide new insights and increase the understanding of a specific phenomenon, and to gain a broader and more condensed description of the phenomenon, as well as to describe and quantify a phenomenon.

Content analysis as a method includes both quantitative and qualitative research strategies. Quantitative analysis gives the result in the form of frequency, typically answering the question 'how many'. Qualitative analysis presents data in the form of categories, enabling interpretation of the text (Bengtsson, 2016).

Two approaches to content analysis can be distinguished: inductive (conventional) and deductive analysis (Moretti et al., 2011). The choice of the approach is determined by the main purpose of the study. Deductive content analysis is recommended when the purpose of the study is to test a theory. Inductive content analysis is used when there are no previous studies that deal with the phenomenon or when the former knowledge is fragmented. The advantage of inductive content analysis is that information is