MEASURING SUSTAINABILITY IN SUPPLY CHAIN: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT: Sustainability has received substantial attention both in academia and practitioners' world in recent years. Due to growing concerns of environmental and social impacts, governments' regulations, customers, employees, shareholders, community activists and non-governmental organizations have put pressure to encourage companies and their supply chains to adopt sustainability practices. The adoption of sustainability practices in the supply chain is mostly addressed by three interrelated dimensions of sustainability – economic, environmental, and social which are described as tripe bottom line. Multi-dimensional indicators based on triple bottom line approach have been used in measuring sustainability of supply chains. The purpose of this paper is to review the literatures on sustainability performance measurement of supply chains. A systematic literature review was conducted to identify peer-reviewed articles in sustainability measurement of supply chains; and 70 papers are selected for the analysis. Previous research focus on linear supply chains than closed-loop supply chains. 68 papers addressed linear supply chains. Analytical hierarchy process (AHP), data envelop analysis (DEA), and mathematical modeling are the most widely used research methodology. And, 36 papers applied case study in various sectors mostly in food industries and automotive industries.

Keywords**:** Sustainability, Supply chain, Triple bottom line, Performance measurement, Indicators

INTRODUCTION

The issue of sustainability and its use in the context of supply chain have gained considerable attention (Saeed & Kersten, 2017). Sustainability in supply chains is viewed as an essential strategy to deliver long-term profitability (Zhou & Xu, 2018). This paper aimed at reviewing review the literatures on sustainability measurement of supply chain and analyzing previous research practices from various perpectives. Supply chains are vital to global economy and provide many business opportunities (Reefke & Trocchi, 2013). Supply chains are driving forces behind business competitive advantages (Qorri, Mujkić, & Kraslawski, 2018) . However, they can also lead to unintended social and environmental impacts (Reefke & Trocchi, 2013). To alleviate the impacts, sustainability performance management of the supply chains is vital (Qorri et al., 2018; Reefke & Trocchi, 2013). Companies are encouraged to revise their major processes of supply chain management by adopting sustainability practices since environmental and social impacts affect their image and competitiveness (Shahryari Nia, Olfat, Esmaeili, Rostamzadeh, & Antuchevičienė, 2016). With the increasing pressure from various stakeholders for more transparency of sustainability practices, there is a trend in research and practice towards developing tools for sustainability measurement of supply chains (Fritz, Schöggl, & Baumgartner, 2017; Ngan, Promentille, Yatim, Lam, & Er, 2018). Supply chain sustainability cannot be appropriately managed if its performance is not measured effectively (Pourjavad & Shahin, 2018). Measuring sustainability performance of a company and its supply chain has become essential for setting goals and determining future courses of actions (Saeed & Kersten, 2017).

Sustainability measurement of supply chains consists of managing triple bottom line (TBL) that takes into consideration economic, environmental and social aspects (Azevedo, Carvalho, Ferreira, & Matias, 2017; Kumar & Garg, 2017). Triple bottom line (TBL) approach is a central concept that helps organizations to operationalize sustainability while diverse interpretations of sustainability exist (Izadikhah, Saen, & Roostaee, 2018). Triple bottom line (TBL) is the most widely used framework for implementing sustainability practices in the company and supply chain. Long-term sustainability of an organization pivots on economic, environmental and social performances (Shibin et al., 2017). Sustainability measurement of supply chains is complicated since various criteria are considered for the measurement (Pourjavad & Shahin, 2018). Extensive review of the literature revealed that measuring and improving the sustainability performance of supply chain is complex (Shibin et al., 2017). Application of sustainability performance measurement tools to a whole supply chain is complex and challenging (Fritz et al., 2017). The complexity of sustainability performance management of supply chain is due to the presence of a large number of factors and interactions among the supply chain elements. It becomes difficult to deal with such a complex condition in which the sustainability structure of supply chain is not clearly defined. Thus, converting the unclear structure of supply chain into a visible and well-defined structure is required (Santiteerakul, Sekhari, Bouras, & Sopadang, 2015). A defined scope on key elements of supply chain has to be determined (Fritz et al., 2017).

The use of indicators is crucial for easy and comparable sustainability performance measurement (Bai & Sarkis, 2014). Sustainability indicators are increasingly recognized as a powerful tool providing information on sustainability performance in areas of economy, environment and society (Ngan et al., 2018). The difficulty to measure sustainability along the whole supply chain is the main criticism of measuring sustainability in the supply chains (Santiteerakul et al., 2015). The formulation and application of sustainability indicators depend on the purpose for which they will be applied (on the context of the business). The current approaches to measure, evaluate and improve sustainability have shortcomings in addressing industrial needs in a comprehensive and suitable manner (Demartini, Pinna, Aliakbarian, Tonelli, & Terzi, 2018). In this paper, using systematic literature review approach, 70 papers are identified and selected for analysis. The results showed that most of the papers (68 papers) considered linear supply chains. Analytical hierarchy process (AHP), data envelop analysis (DEA), and mathematical modeling are most widely applied research methodologies used for data analysis. About half of the papers applied case study in various sectors such as food industry, automotive industry, cement manufacturing, and plastic manfacturing.

RESEARCH METHOD

A systematic research literature review was conducted to identify peer-reviewed articles that focused on sustainability performance measurement in supply chains. The papers were identified based on systematic search of Scopus database. Scopus was selected since it provides extensive coverage of peer-reviewed journal articles in sustainability, supply chain, business and management, and engineering (Ahi & Searcy, 2015; Hassini, Surti, & Searcy, 2012; Qorri et al., 2018). The selected keywords were used in the title, abstract and keyword search field using the following Boolean operators: (TITLE-ABS-KEY ("sustainable supply chain*" OR "sustainable supply chain management" OR "supply chain* sustainability")) AND (TITLE-ABS-KEY ("indicator*" OR "metric*" OR "measure*")). The search considered peer-reviewed articles published in English language from "All Years" to "2019". All fields as well as all subject areas available in the Scopus database were taken for the search.

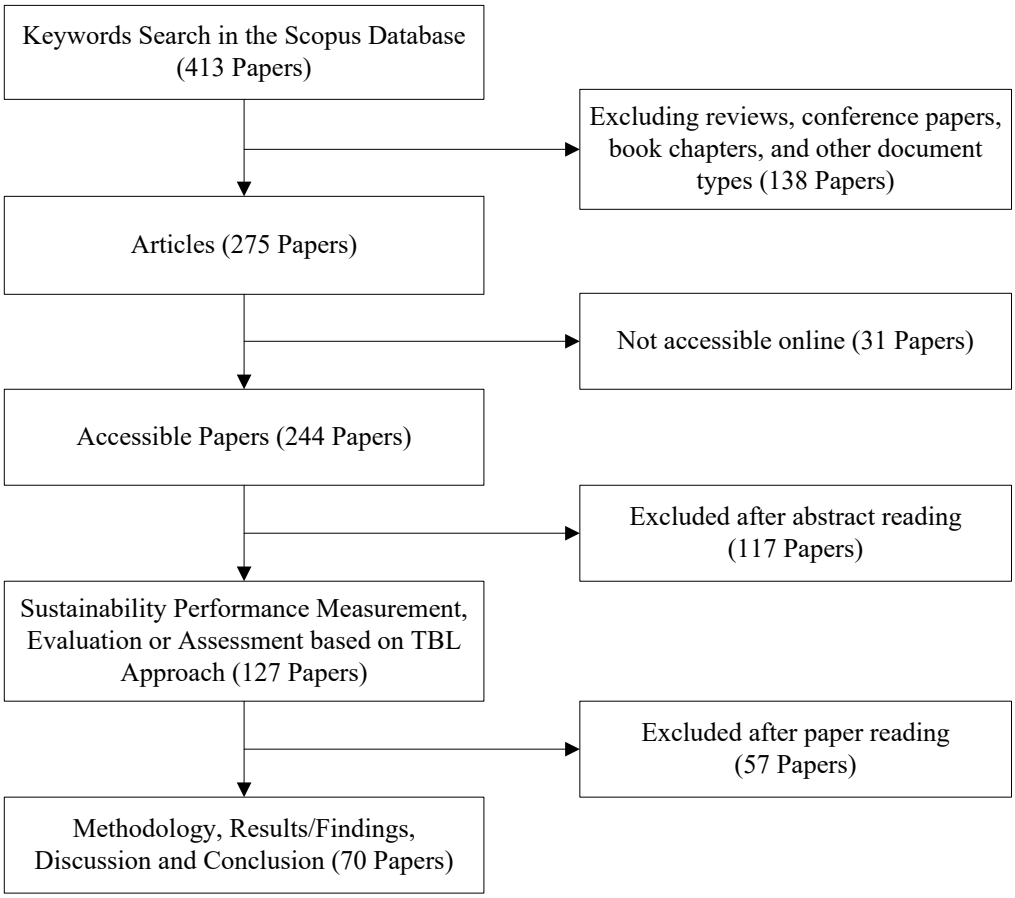

Fig. 1. Approach of the systematic literature review.

As seen in Fig. 1, a total of 413 papers were initially found using the keywords search in the Scopus database. By excluding reviews, conference papers, book chapters, and other document types, 275 papers were identified. It was not possible to access 31 papers through online search. Hence, the total number of articles accessed became 244. Taking into consideration issues of sustainability performance measurement, evaluation or assessment based

on TBL approach in the abstract reading, 127 papers were excluded. Through paper reading, (methodology/research approach, results/findings, discussion and conclusion), 57 articles were excluded. Finally, 70 papers were identified and selected for the analysis.

FINDINGS AND DISCUSSION

Fig. 2 (a) shows the distribution of selected papers by the type of journal. It is revealed that six journals (i.e. Journal of Cleaner Production, Sustainability (Switzerland), Computers and Operations Research, Benchmarking, International Journal of Productivity and Performance Management, Sustainable Development, Supply Chain Management: An International Journal) contribute more than 50% of the selected papers. Journal of Cleaner Production is the leading contributor of the papers. Fig. 2 (b) illustrates the distribution of the selected articles by publication year. It is seen that there is an increasing trend revealing an increasing research interest in sustainability measurement of supply chains.

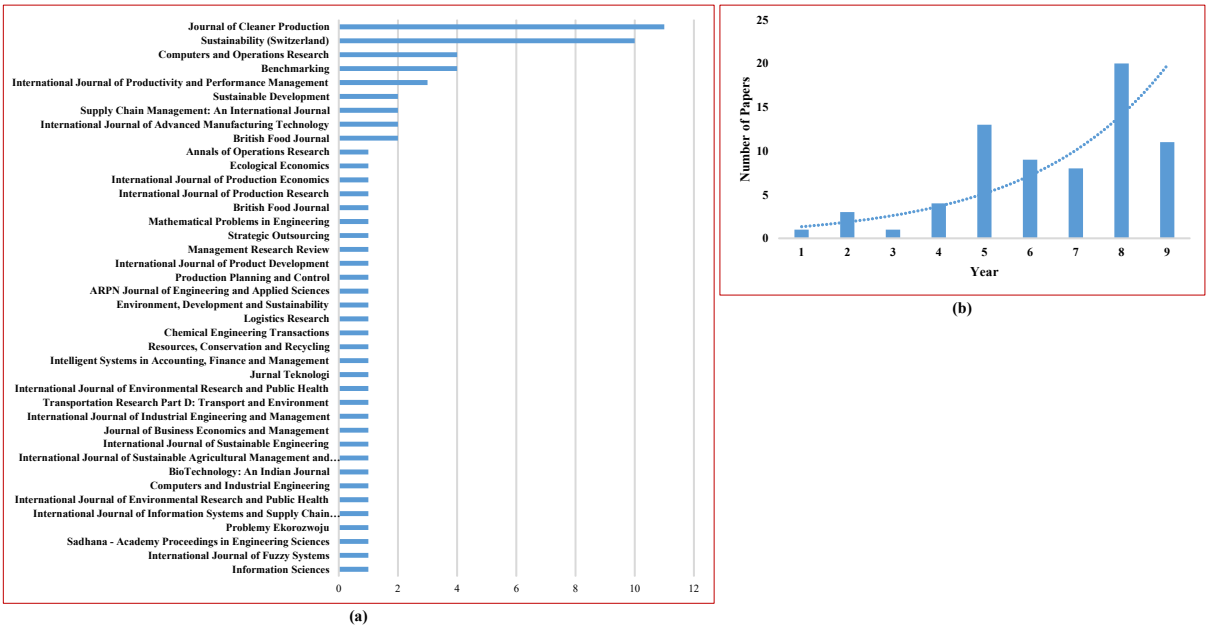

Fig. 2. Distribution of papers by journal type (a) and year (b).

As seen in Table 1, most of the papers considered linear supply chain than closed-loop supply chains; and this reveals that the lack of research on sustainability measurement in closed-loop supply chains.

Table 1
Distribution of papers by supply chain echelon

Supply Chain Echelon	Number of Papers
Single-Echelon	14
Multi-Echelon Supply Chain	54
Closed-Loop Supply Chain	2

Table 2 shows research methodologies which are used by three or more papers.

Table 2
List of research methodologies applied

Research Methodology	Number of Papers
Case Study	36
Analytical Hierarchy Process (AHP)	13
Data Envelopment Analysis (DEA)	12
Mathematical Modeling	6
Literature Review	6
Content Analysis	4
Delphi Method	4
Decision-Making Trial and Evaluation Laboratory (DEMATEL)	4
Conceptual Analysis	4
Analytic Network Process (ANP)	3
Quality Function Deployment (QFD)	3
Technique for Order Performance by Similarity to Ideal Solution (TOPSIS)	3

Multi-criteria decision analysis (MCDA) techniques including AHP, DEMATEL, and TOPSIS were widely applied to analyze sustainability performance measurement. AHP was used to determine weight of indicators by incorporating experts' opinion. DEMATEL was applied to identify the influential indicators from a recommended list. TOPSIS was employed to rank and select the best alternatives such as best suppliers based on sustainability criteria. Data envelopment analysis (DEA) was also widely used to evaluate sustainability performance of supply chain by defining decision making units. Fuzzy logic is applied to MCDA techniques to represent vagueness of experts' opinion. Several papers applied case study in various sectors to show the applicability and validity of sustainability performance measurement frameworks. Food industry and automotive industry are the most considered sectors compared to other sectors such as cement manufacturing, plastic manufacturing, oil and gas company, chemical industry, and apaprel manufacturing.

CONCLUSIONS

This paper presents the analysis of previous research published in the literature on sustainability measurement of supply chains. Systematic literature review was conducted to find research papers in this area. The results showed that most research practices considered linear supply chains. Research on sustainability measurement in closed-loop supply chain is lacking. Multi-criteria decision analysis techniques are the most widely applied research methodology in this area. More case studies are applied in food industry and automotive industry. The paper provides a number of theoretical implications. It provides insights on the type of research methodologies widely applied in this research area the focus of previous research. It also provides research agenda in closed-loop supply chains as previous research on sustainability measurement of closed-loop supply chains are limited. As practical implication of the paper, it is stated that companies and their supply chains need to view sustainability as essential strategy to increase their growth and global competitiveness. It is recognized that there are some limitations to this paper. First, although Scopus covers a wide range of peer-reviewed articles in sustainability, supply chain, business and management, and engineering, it does not include all reputable peer-reviewed journals. Hence, additional databases beyond Scopus may have resulted in the identification of additional papers. Second, it would be better if content and thematic analysis of the sustainability indicators is conducted to quantify and analyze their presence, meanings and classifications.

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