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Editorial

# Eco-efficiency based green supply chain management: Current status and opportunities

## 1. Introduction and background

The main theme of this special issue was derived from the first international workshop on "Eco-efficient based green supply chain management (EE-GSCM)" held at the Department of Business and Economics, University of Southern Denmark, Odense, Denmark. The theme of this workshop was eco-efficient based green supply chain management, eco-efficient based reverse and closed-loop supply chain management and carbon footprints in supply chains. Industries are striving hard to improve their sustainable development through many strategies such as environmental management systems, green and lean manufacturing, eco-effectiveness and efficiency to maintain their place in today's competitive environment.

Among these strategies, eco-efficiency, a tool of sustainable development, gained considerable attention among researchers and practitioners due to its high momentous benefits over a firm's operational performance. While many definitions exist to explain the concept of eco-efficiency, the most cited definition was provided by the World Business Council for Sustainable Development (WBCSD) in 1992 as "eco-efficiency is achieved by the delivery of competitively-priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the earth's estimated carrying capacity" Schmidheiny (1992). In short, eco-efficiency combines both economic and environmental demands. Eco-efficiency is used to identify a set of solutions that do not increase the level of environmental damage unless costs also increase (Neto, Walther, Bloemhof, Van Nunen, & Spengler, 2009). The simplicity of eco-efficiency led it to spread worldwide and to enjoy widespread acceptance by enterprises who used this concept to support their decisions, production strategies, and investments striving for sustainable development (Wursthorn, Poganietz., & Schebek, 2011). Due to its widespread acceptance, eco-efficiency became a popular mechanism by which to examine policy strategies and their possible outcomes (English, Castellucci, & Mynors, 2006; Wursthorn et al., 2011). Eco-efficiency (EE) has been applied successfully by researchers in many fields such as manufacturing, paramedical, management, operations, and others to improve sustainability. More recently, eco-efficiency has been used in the field of supply chain management. While supply chains have been extended through lean and green initiatives, there is still a need to integrate eco-efficiency in supply chains in order to balance and to focus on both economic and environmental aspects. Supply chains are motivated by global trends and seek to achieve sustainable profitability by offering environmentally sound products and practices (Solvang, 2008). While eco-efficiency is still subject to debate in regard to supply chains, it stands as a viable research pursuit. We explore here some of the existing literature on eco-efficiency relevant to our special issue. We categorized the literature into three sections: general (which consists of literature review, empirical surveys, etc.), tools used and fields of application (Table 1), and supply chain management (Table 2).

Honkasalo, Rodhe, and Dalhammar (2005) made an empirical analysis to explore the IPPC directive in terms of driving EE using a case study based on British, Finnish, and Swedish dairy industries. Burritt and Saka (2006) studied the linkage of environmental management accounting and EE measurement using environmental management accounting (EMA) and EE indicators for a Japanese case study. Erkko, Melanen, and Mickwitz (2005) investigated the concept of EE using an empirical study conducted in a Finnish industry. Côté, Booth, and Louis (2006) identified that there is a need to propose new EE indicators for micro and small businesses through an empirical study and literature survey in Canada. Berkel (2007a, 2007b) reviewed the EE related concepts in primary metal production industry with five prevention practices and five resource productivity themes. Dahlström and Ekins (2007) presented the value chain analysis (VCA) to interpolate the economic and environmental dimensions of the aluminum industry in the UK. Prasad and Pagan (2007) identified the current status of EE by investigating a project named 'Queensland food eco-efficiency.' Fernández-Viñé, Gómez-Navarro, and Capuz-Rizo (2010) executed their study in three stages: review with benchmarking, surveys, and interviews. Halkos and Tzeremes (2013) addressed the economic growth and environmental efficiency of UK regions and they plotted the relationship between the regions and their environmental inefficiencies through a Conditional Directional distance function.

Based on the above analysis, it is clear that many works exist in the focus areas of supply chains and other manufacturing and industry concerns. Despite the proliferation of research, no study addresses issues such as an eco-efficiency-based green supply chain, reverse supply chain, closed loop supply chain, and carbon footprint-based supply chain. The special issue (SI) had over 95 submissions, and after a rigorous review and revision process, 13 articles were selected for publication. These articles address the topics previously mentioned and seek to bridge gaps in the literature on eco-efficiency in supply chains. Here, we provide a short review of each paper selected for this special issue, highlighting its major contribution, the tool used, and the industry represented.

The first paper in this SI, *"Quantitative models for sustainable supply chain management: developments and directions"* (Brandenburg,

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**Table 1**
Eco-efficiency based literatures categorized by focus and tools used.

| Tools/methodology used[a] | Author | Problem addressed | Field of application |
|---|---|---|---|
| DEA | Dyckhoff and Allen (2001) | Extended the generalized DEA model for evaluating the eco- efficiency (EE) | General |
| | Sarkis and Cordeiro (2001) | Investigated the relationship between the pollution prevention and end-of-pipe efficiencies using data collected from 482 U.S. firms during 1992 | General |
| | Korhonen and Luptacik (2004) | Tried to measure the technical efficiency and EE as an indicator and combined these indicators to decrease the pollutants in 24 power plants in Europe | Power plant |
| | Yang and Pollitt (2009) | Proposed six DEA models to check the EE of the Chinese coal-fired power plants | Power plant |
| | Picazo-Tadeo, Beltrán-Esteve, and Gómez-Limón (2012) | Computed the wide range of EE indicators and validated with the Spanish olive growing farms | Olive farms |
| | Sarkis and Cordeiro (2012) | Checked whether the innovation in organizational practices improve the eco-efficiency with the case of 437 largest fossil fuels electricity generating plants | Power plant |
| LCA | Kerr and Ryan (2001) | Attempted to prove that the remanufacturing practices are more eco-efficient for a Xerox photocopier remanufacturing case | Re-Manufacturing |
| | Seppälä et al. (2002) | Conducted a research to improve the EE | Finnish metal industry |
| | Park, Tahara, Jeong, and Lee (2006) | Compared four decision making methods under both environmental and economic aspects of end-of-life washing machine | Decision making |
| | Breedveld, Timellini, Casoni, Fregni, and Busani (2007) | Evaluated the environmental impact and EE of the fabric filter | Ceramic tile industry |
| | Bidoki and Wittlinger (2010) | Identified the best EE based PVC coating agent | Decision making |
| | LaRosa et al. (2013) | Explored the EE of the new material (usage of hemp mats instead of glass fiber in composite material) | Decision making |
| EE indicators | Maxime, Marcotte, and Arcand (2006) | Addressed the environmental issues in Canadian food and beverage industry using a new eco-efficiency indicator | Food and beverage Industry |
| | Mickwitz, Melanen, Rosenström, and Seppälä (2006) | Proposed and explained the EE indicators using a Kymenlaakso case study | Kymenlaakso case study |
| | Aoe (2007) | Proposed EE indicator and provide the relationship between the functions of EE and eco design | EEE products |
| | Salmi (2007) | Integrated the complex utilization production model in mining sectors to maintain the waste management to increase the EE | Waste management |
| | Kharel and Charmondusit (2008) | Investigated the eco-efficiency of iron rod industry in Nepal through quantitative analysis | Iron rod industry |
| | Klang, Vikman, and Brattebø (2008) | Measured the sustainability in waste management by combining the EE indicator with environmental indicator | Waste management |
| | Park and Behera (2013) | Proposed the EE indicators to evaluate the eco-efficiency of seven industrial symbiosis networks (ISN) | ISN |
| LP | Park and Tahara (2008) | Identified the key eco design issues with the assistance of producer-based EE and consumer-based EE | Eco design |
| | Simic and Dimitrijevic (2012) | Proposed a model to improve the EE and profitability of the vehicle recycling factories under the EU legislative specifically on production planning | Industry |
| Snapshot graph and EE indicators | Charmondusit and Keartpakpraek (2011) | Evaluated the EE of the petroleum and petrochemical group | Petroleum |
| Re and De linking evaluation | Wang, Liu, Hansson, Zhang, and Wang (2011) | Explored the Shandong Province's pulp and paper industry EE trend from 2001 to 2008 | Pulp and paper industry |
| MFEFP | Cerutti, Beccaro, Bagliani, Donno, and Bounous (2013) | Examined the sustainability and EE of food production in Northern Italy using the footprint analysis | Fruit production |
| EIO-LCA, DEA and LP | Egilmez, Kucukvar, and Tatari (2013) | In order to increase the EE, sustainability was measured among U.S. manufacturing sectors and the results compared from various industries | Manufacturing |
| Delphi method | Fernández-Viñé et al. (2013) | Reviewed the tools which stimulate the EE practices in SME's under the pressure of public administration in Venezuela | SME's in Venezuela |
| RELPM | Simic and Dimitrijevic (2013) | Proposed a methodology to reduce the landfill of end-of-life vehicles under the consideration of risk and economical aspects | End of life vehicles |

[a] DEA – data envelopment analysis; LCA – life cycle analysis; LP – linear programming; MFEFP – multi functional ecological foot print; EIO-LCA – economic input output-life cycle analysis; RELPM – risk explicit linear programming method.