

Exploratory Study on Sustainable Operations Management Indicators

Kirubel Bruck Kassa*, Mawos Ensermu**, Busha Temesgen***

**Doctoral Student, Department of Logistics & Supply Chain Management, College of Business & Economics, School of Commerce, Addis Ababa University, Ethiopia. Email: bruckkirubel@gmail.com*

***Associate Professor, Department of Logistics & Supply Chain Management, College of Business & Economics, School of Commerce, Addis Ababa University, Ethiopia. Email: ensermujalata@gmail.com*

****Assistant Professor, Department of Logistics & Supply Chain Management, College of Business & Economics, School of Commerce, Addis Ababa University, Ethiopia. Email: bushatm2003@gmail.com*

ABSTRACT

Sustainable Operations Management (SOM) practices must include coordinating, integrating, and directing activities both inside and outside organisational boundaries in order to achieve the desired economic, social and environmental goals. The aim of this article is to use exploratory factor analysis (EFA) to determine whether or not there is a consistent set of factors underlying each of Ethiopia's largest manufacturing firms' SOM dimensions. We primarily defined SOM practices through a literature review. We looked for the most popular subjects in this field and took care to cover operations in all phases that occur in the product life cycle, from conception to the procurement of raw materials to the management of production processes and supply chains. The measurement items indicators for SOM practices were then summarised based on earlier validated studies and in accordance with the literature review. A total of 223 operations managers from large manufacturing companies in Ethiopia participated in a paper survey. In this paper, a literature review and an EFA were used to illustrate the fundamental SOM practices and their corresponding measurement items, respectively.

Keywords: Sustainable Operations Management, Exploratory Factor Analysis

INTRODUCTION

Present manufacturing operations are besieged by increasing pressure that leads them to think beyond the economic benefits of their processes and products; they are forced to consider the environmental and social effects as well (Moldavska & Welo, 2017; Eslami et al., 2018; Malek & Desai, 2020). With this, one can presume that the changes resulting from sustainability considerations are sensed intensely in the area of Operations Management (OM) (Inman, 2010). It has thus become the goal of manufacturing operations managers to promote manufacturing processes and manufactured products that minimise environmental impacts while maintaining social and economic benefits (Hami et al., 2015). This can be vividly seen in United Nations' 2030 Agenda for Sustainable Development. According to the United Nations' 2030 Agenda for Sustainable Development, one among the seventeen essential goals, has direct implication for the industrial sector—ensure sustainable consumption and production patterns (Monteiro et al., 2019). In view

of that, one of the key contributors to the anthropogenic impact on the ecosystem is the manufacturing company's OM decisions; thus Sustainable Operations Management (SOM) practices substantially play a significant role in the part of solutions for challenges faced by the humanity (Swalehe et al., 2020; Sharif et al., 2014). Moreover, the principles and strategies related to SOM contribute to sustainable competitive advantage and organisational performance (De Guimarães et al., 2019). Besides, Kleindorfer et al. (2005) noted that SOM must help companies to become nimble, adaptive and aligned in matching the social, environmental and economic goals in view of increasing cost of materials and energy, growing public pressure on environment, health and safety.

Addressing sustainability in OM requires operations managers to incorporate economic, environmental and social criteria of sustainability simultaneously into the decision-making process (Türkay et al., 2016). The economic pillar of sustainability in OM refers to the firm's intention to undertake its business operations in a way that

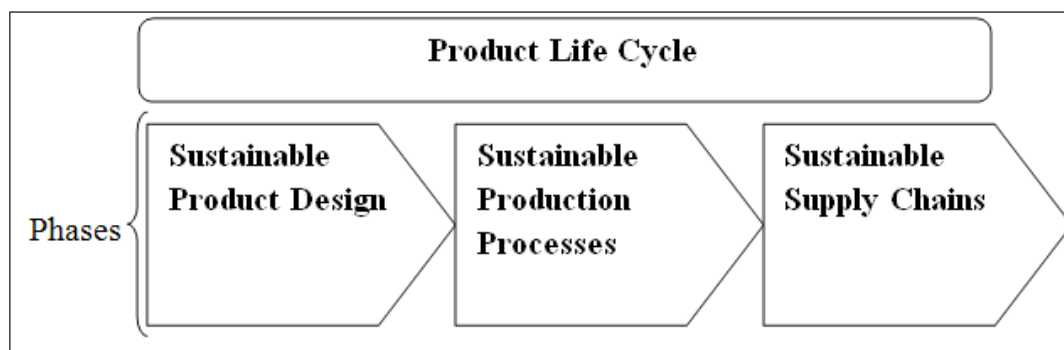
allows it to persist for long period of time, thus focuses on long-term financial performance, competitiveness and cost efficiency (Corbett, 2009; Steurer et al., 2005). On the other hand, the environmental dimension of sustainability in OM entails issues such as reducing input and output impact related to manufacturing and product development; that is reducing or eliminating waste and greenhouse gas emissions, using non-toxic or less-toxic substances, promoting material reuse, remanufacturing or recycling and reducing energy consumption and using renewable energy sources (Machado et al., 2017). Conversely, the social dimension of sustainability in OM consists of facets ranging from workers' health and safety or wellbeing within a production system to the impact of a production system such as noise, heavy traffic and health on local communities (Taylor & Vachon, 2018; Krause et al., 2009). In summary, providing manufacturing operations impact on the planet, profit and people pillars of sustainability, it can be presumed that OM offers new opportunities to considerably contribute to sustainability (Longoni et al., 2014).

To get the desired economic, social and environmental goals, SOM practices must comprise coordinating, integrating and directing the activities inside and outside organisational boundaries (Andersen, 2019). Hence, SOM practices should focus on broad issues such as product design and development, by-product and waste disposal, internal resource efficiencies and supply chains (Sharif et al., 2014). Angell and Klassen (1999) noted that the two most important decision areas of OM that typically determine the types of pollutants emitted, solid and hazardous wastes generated, resources harvested and energy consumed are product design and manufacturing processes. Similarly, Burchart-Korol (2011) revealed

that the concept of sustainable manufacturing operations, perhaps, used for better design and process for a product that reduce waste, eliminates extra material and reduces the use of energy and resources.

On the other hand, Swalehe et al. (2020) stated that the SOM practices integrate the entire facet of operations, that is, not only sustainable product design and sustainable manufacturing process, but also sustainable supply chains to obtain maximum possible benefits. This attitude of managing sustainability in business operations calls upon the concept of life cycle analysis—a technique to measure the environmental impact related to all the phases a product passes through, right from raw material procurement to disposal and recycling of the product (Mann & Kaur, 2019). Similarly, Kleindorfer et al. (2005) noticed that SOM practices and processes developed to meet sustainability demands in OM include green product and process development, lean and green operations and remanufacturing and closed-loops chains. In the same way, Jayal et al. (2010) firmly asserted that achieving sustainability in manufacturing operations requires a holistic view spanning from the product, and the manufacturing processes involved in its fabrication and the supply chain across multiple product life-cycles.

Likewise, in this article, SOM practices are defined through a preliminary literature review, checking for the most discussed topics in this area and taking care to cover operations in all phases that occur in the product life cycle, from the conception of the product project and raw material procurement to the management of production processes and supply chains. Based on this preliminary literature review, a theoretical model, as shown in Fig. 1 is developed.



Source: Author

Fig. 1: Sustainable Operations Management Practices Considered in this Research

Based on the above discussions, the important aspect that needs to be highlighted is that SOM extends the boundaries of the firm and includes not only the implementation of internal sustainable practices (e.g., sustainable product design and sustainable manufacturing processes) that improve the firm's sustainability performance but also the extension of sustainable practices to the supply chain that advances the firm's sustainability performance (Mann & Kaur, 2019).

Moreover, there has been relatively little and inconsistent research on identifying the indicators for SOM practices from a developing nation standpoint and from product design, manufacturing process and supply chain perspectives (e.g., Sarwar et al., 2021; Çankaya & Sezen, 2019; Simões et al., 2017; Agostini et al., 2017; Abdul-Rashid et al., 2017; Lai et al., 2013; Gimenez et al., 2012; Zhu & Sarkis, 2004). This article's overarching goal, then, is to use exploratory factor analysis (EFA) to determine whether or not there is a consistent set of factors underlying each of the SOM's dimensions from the viewpoint of Ethiopia's largest manufacturing firms.

LITERATURE REVIEW

Sustainable Product Design Practice and Indicators

Sustainable product design is aimed at decreasing or eradicating harmful substances, minimising wastes, improving resource recovery, preservation and efficiency, designing for reuse and remanufacturing, as well as adding to the sustainability aspects (Swalehe et al., 2020). Earlier, Zhu and Sarkis (2004) measured sustainable product design, particularly from environmental and economic sustainability perspective, through the design of products for reduced consumption of material/energy; design of products for reuse, recycle, recovery of material, component parts; and design of products to avoid or reduce use of hazardous of products and/or their manufacturing processes. From economic sustainability perspective, a sustainable product design is expected to significantly influence the cost of disassembly, component inspection and repair and remanufacturing and recycling (Gunasekaran et al., 2014). The common impact where a sustainable product design has on the economic and social performances are tied to profitability, wages and employment (Rainock et al., 2018). For example, designing a product that does not have any toxic materials and can be disassembled easily, reduces the recycling costs (Waage, 2007).

Sustainable Manufacturing Process and Indicators

The goal of sustainable manufacturing process design is to minimise the negative environmental, economic and social effects of processes (Gupta & Sharma, 1996). According to the three sustainability pillars, Jovane et al. (2008) suggested how manufacturing processes could cope up with environmental, economic and social challenges. From environmental sustainability point of view, Jovane et al. (2008) stated that sustainable manufacturing processes may tackle environmental challenges through the adoption of minimal use of non-renewable natural resources, and managing them in the best possible way while reducing environmental impact. It is also concerned with the reduction of energy and natural resource consumption in operations, production planning and control (Çankaya & Sezen, 2019; Corbett, 2009). The need for environmentally sustainable manufacturing process design requires practices such as reducing energy usage and resource consumption during production, reducing emissions and generation of solid and liquid wastes and using non-conventional sources of energy (Mitra & Datta, 2014). The lessening of environmental challenges, thus, requires the adoption of sustainable manufacturing (Chien & Shih, 2007). The manufacturing processes may also respond to the economic challenges of sustainability through the promotion of wealth and new services that ensure the development and competitiveness of the firm through time; manufacturing processes can also tackle social challenges by upholding improved quality of life and social development (Jovane et al., 2008).

Sustainable Supply Chain Management Practices and Indicators

Through the integration of upstream (input) and downstream (output) partners into the boundary of investigation and management, firms have started redefining the concept of OM using the supply chain perspective (Brandenburg et al., 2014). With the use of literature, this article recognises four sustainable practices such as sustainable warehousing (Abdul-Rashid et al., 2017; Tekin et al., 2015), sustainable packaging (Agostini et al., 2017; Tekin et al., 2015; Ninlawan et al., 2010), reverse logistics (Abdul-Rashid et al., 2017; Ninlawan et al., 2010; Rao & Holt, 2005) and sustainable purchasing (Agostini et al., 2017; Abdul-Rashid et al., 2017; Luthra et al., 2016; Tekin et al., 2015; Ninlawan et al., 2010; Rao & Holt, 2005) to achieve sustainability in supply chain management.

One of the core elements within the supply chain is warehousing (Tan et al., 2009). A sustainable warehouse practice is a set of organisational and technological solutions intended at efficient realisation of the warehouse process, while preserving the maximum social standards, minimising the environmental impact with regard to financial efficiency (Malinowska et al., 2018).

Thus, sustainable warehousing practices and decisions consider economic, environmental and social issues when aiming to achieve higher sustainable performance in supply chain management sustainability (Ishizaka et al., 2020).

Since purchasing plays a major role in the supply chain operations, this function earns more attention from the perspective of SOM (Gunasekaran et al., 2014; Laosirihongthong et al., 2013). Purchasing can contribute to sustainability by addressing issues such as reduction of waste produced, material substitution through environmental sourcing of raw materials, and waste minimisation of hazardous materials (Rao & Holt, 2005). Moreover, sustainable purchasing can be a vital activity to extend the sustainability concept to the suppliers as it selects right suppliers that also implement sustainability concepts in their own processes (Tekin et al., 2015). From environmental point of view, purchasing strategies arguably orbit around two important issues, the evaluation of suppliers' environmental performance and mentoring to aid suppliers improve this performance (Mitra & Datta, 2014; Rao & Holt, 2005). Moreover, Selecting the right supplier and managing the purchasing process by implementing a strategic and collaborative understanding with the suppliers have significant effect in meeting a company's sustainability goals (Çankaya & Sezen, 2019). Sustainable purchasing allows firms to pursue key environmental information from suppliers, which in turn instigates suppliers to be more oriented towards sustainable practices (Baah & Jin, 2019).

From the TBL perspective, Mann and Kaur (2019) explained sustainable purchasing as an activity to procure goods and services from local and small producers. The authors further noted that sustainable procurement from the local and small organisation would have a positive impact on the economic environmental performance of sustainability, as it may result in less transportation and therefore less pollution; at the same time, purchasing from the local suppliers may positively influence the society through the generation of employment for the local workers (Mann & Kaur, 2019). Sustainable purchasing is all about taking social aspects (i.e., issues such as ethical sourcing, human rights and employee conditions)

and environmental aspects (i.e., the environment that the product has over the entire value chain) into consideration alongside economic aspects in making purchasing decisions (Renukappa et al., 2016).

Packaging characteristics such as shape, size and materials have an impact on the management of supply chains as they particularly influence the transport characteristics of the product (Ho et al., 2009; Ninlawan et al., 2010). Due to its waste, a packaging does not only serve to protect the main product, but also expected to be environmental friendly to reduce environmental problems (Auliandri et al., 2018). In this sense, packaging should be sustainable, that is, it should adopt sustainable design and use sustainable materials, while invariably keeping in mind that products must be effective and safe for human health and the environment (Wandosell et al., 2021; Pauer et al., 2019). Sustainable packaging is showing a progressively important part in greening the supply chain (White et al., 2014). According to Gustavo et al. (2018), a sustainable packaging is defined as the one that uses clean production technologies; renewable energy; healthy materials; is physically designed to optimise materials and energy; is beneficial, safe and healthy for both individuals and communities; and is able to be effectively recovered and utilised in biological and/or industrial closed loop cycles. Because sustainable packaging provides product safeguard, waste prevention, operational efficiency and safe use, packaging can make a valuable contribution to the TBL of sustainable performance (Nordin & Selke, 2010). Sustainable packaging practices require the use of minimal and lightweight packaging materials and should not have any unfavorable impact on the environmental, it should also be recyclable and biodegradable (Mitra & Datta, 2014). From economic sustainability point of view, sustainable packaging should reduce materials usage, increase warehouse and trailer space utilisation and reduce the amount of handling require (Ho et al., 2009; Wu & Dunn, 1995).

The other significant practice of sustainable supply chain management (SSCM) is reverse logistics (Islam et al., 2017; Rao & Holt, 2005). Because it combines environmental, economic and social factors, reverse logistics plays an important role in improving the environmental, social and economic performance of supply chain management (Simões et al., 2017; Mutingi, 2014). Reverse logistics practices that have been identified in previous studies include proper disposal of returned products, training of employees on new recovery methods in order to reduce the destruction of returned products without trying to recapture the value associated, recapturing value from returned products and product collection (Simões et

al., 2017). Lai et al. (2013) identified six broad aspects of practicing reverse logistics which embrace waste management, recycling, reuse, reprocessing, materials recovery and design for reverse logistics. According to Dowlatshahi (2010), a reverse logistics system constitutes a sustainable supply chain to systematically manage the

flow of parts and products destined for remanufacturing, recycling or disposal activities.

Based on prior validated studies and in line with the literature review, Table 1 summarises the measurement items (indicators) for SOM practices.

Table 1: Summary of the Measurement Items for SOM Practices

Variable	Measurement Items	Authors Used the Measurement
Sustainable product design	Design of products for reduced consumption of material/energy.	(Zhu & Sarkis, 2004)
	Design of products for reuse, recycle, recovery of material, component parts.	(Sarwar et al., 2021; Zhu & Sarkis, 2004)
	Design of products to avoid or reduce use of hazardous of products and/or their manufacturing process.	(Zhu & Sarkis, 2004)
	Cooperation with customers for eco-design.	(Çankaya & Sezen, 2019; Abdul-Rashid et al., 2017)
	Cooperation with customers for cleaner production.	(Çankaya & Sezen, 2019; Abdul-Rashid et al., 2017)
Sustainable manufacturing process	Monitor and control environmental pollution such as drain emission.	(Sarwar et al., 2021)
	Reduce noise pollution.	(Sarwar et al., 2021)
	Controlling hazardous substances in the manufacturing process and exploitation of the available resources.	(Sarwar et al., 2021)
	Process design focuses on minimising the consumption of energy and natural resources in operations.	(Sarwar et al., 2021; Çankaya & Sezen, 2019)
	Emphasises the proactive and preventative maintenance to increase the operational efficiency of the equipment.	(Sarwar et al., 2021)
	Production planning and control focused on reducing waste and optimising materials exploitation.	(Schmidt et al., 2017; Luthra et al., 2016; Çankaya & Sezen, 2019)
	Substitution of polluting and hazardous materials/parts.	(Çankaya & Sezen, 2019)
	Reduce CO ₂ emissions.	(Simões et al., 2017; Abdul-Rashid et al., 2017; Lai et al., 2013)
Sustainable supply chain management	Providing design specification to suppliers that include environmental requirements for purchased item.	(Çankaya & Sezen, 2019; Zhu et al., 2007)
	Cooperation with suppliers for environmental objectives.	(Çankaya & Sezen, 2019; Zhu et al., 2007)
	Choice of suppliers by environmental criteria.	(Vanalle et al., 2017; Schmidt et al., 2017; Çankaya & Sezen, 2019)
	Suppliers' ISO14000 certification.	(Çankaya & Sezen, 2019; Zhu et al., 2007)
	Environmental audit for suppliers' inner management.	(Zhu et al., 2008)
	Waste management (Incineration—burning to ash Land filling).	(Simões et al., 2017; Lai et al., 2013)
	Recycle (Collection of returned products).	(Simões et al., 2017; Lai et al., 2013)
	Reuse (Separation of reusable products and parts).	(Simões et al., 2017; Lai et al., 2013)
	Reprocess (Refurbish, Remanufacture, and Repair)	(Lai et al., 2013)
	Materials recovery (Disassembly, Inspection of dissembled parts, and Recover reusable parts and reuse them in repairing, refurbishing, or remanufacturing of other products).	(Lai et al., 2013)
	Design for reverse logistics (Use of standardized materials, and Adoption of modular design).	(Lai et al., 2013)
	Ecological materials for primary packaging	(Çankaya & Sezen, 2019)
	Recyclable or reusable packaging/containers in logistics.	(Çankaya & Sezen, 2019)
	Selection of cleaner transportation methods.	(Çankaya & Sezen, 2019)
Effective shipment consolidation and full vehicle loading.	(Çankaya & Sezen, 2019)	

RESEARCH METHODOLOGY

The purpose of this article is to explore the indicators of SOM practices that help firms to achieve better practices of SOM. We have adopted secondary literature survey approach to identify variables and identify research gaps. Based on the constructs and items identified through literature survey, we have developed a structured questionnaire which was pretested before using for final survey. A questionnaire-based survey was chosen as the data collection method because it is the most widely used technique for primary data collection that describes a phenomenon from a large sample (Abdullah et al., 2017), in this case, indicators of SOM practices.

We conducted a paper survey, which assisted in obtaining the required responses from the sample respondents. The suggested sample size, according to Nunnally and Bernstein (1994), is the rule of 10. According to the rule of 10, we need 10 observations for each observable variable. In the current study, there are three dimensions of SOM practices; the sustainable product design (SD) dimension has six observable variables, while the sustainable manufacturing processes (SMP) and sustainable supply chain (SSC) dimensions have eight and fifteen variables, respectively. This suggests that a minimum of 290 samples are required to run the EFA ($290 = 29$ number of observed variables \times 5 number of samples per observed variable). Although this study supposed to collect data from 290 respondents, we only got 223 complete responses in return. Thus, the response rate is 76.9%. In order to ensure sufficient study validity and confidence in the data's representativeness, the desired response rate must be attained (Mellahi & Harris, 2016). As a result, we researched the field to determine whether our response rate is within the acceptable bounds. In the OM survey, According Frohlich (2002), the typical managerial response rate is around 32%. However, Goyder (1985) generally recommended that the acceptable range for the response rate could be between 30 and 70%. Regarding these claims, the survey's response rate is acceptable because it is higher than the required minimum. The study therefore doesn't need to conduct a non-response bias analysis because the response rate is above the minimum threshold or because there are no other signs that bias may be an issue (United States Office of Management and Budget, 2006).

Once the dataset of 223 operations and supply chain managers of Ethiopian large manufacturing firms had been formed, we coded each variable in the Excel file,

that is, Sustainable product design - SD, sustainable manufacturing processes SMP and sustainable supply chain - SSC. EFA was conducted to examine how the selected measures are extracted.

Measurement Scale Development

Following the discussion in the prior sections, this study will exclusively examine three constructs of SOM practices (sustainable product design, sustainable manufacturing processes and sustainable supply chains), and the impact of these practices on performance is examined through three aspects—economic performance, environmental performance and social performance. As prior researches have already developed a useful set of validated measurement scales, it is not the need of this study to develop new measurement scales from scratch. Therefore, in this study, the measures of SOM practices and sustainable performance dimensions are developed on the basis of previous questionnaires and research literature.

The initial measurement scale in general for SOM practices and in particular for sustainable supply chain management practices together with environmental and economic performances, was developed by Zhu and Sarkis (2004). Zhu et al. (2008) verified the developed measures. Subsequently, the adopted measurement scales have been used by various authors and published across top-tier operations and supply chain management journals.

The SOM construct was characterized by three dimensions, that is, sustainable product design, sustainable manufacturing process, and sustainable supply chain management, quantified by SOM's reflective scales. Sustainable product design will be measured utilising six validated measurement scales adapted from Sarwar et al. (2021), Çankaya and Sezen (2019), Abdul-Rashid, et al. (2017), Zhu et al. (2008) and Zhu and Sarkis (2004); whereas sustainable manufacturing process uses eight validated measurement items, adapted from Çankaya and Sezen (2019), Simões et al. (2017), Abdul-Rashid et al. (2017) and Lai et al. (2013). Meanwhile, sustainable supply chain management will be quantified using fifteen validated measurement items adapted from Çankaya and Sezen (2019), Simões et al. (2017), Lai et al. (2013) and Zhu et al. (2008, 2007). Ethiopian senior manufacturing operations managers were requested to indicate their preference according to a 5-point Likert scale, ranging from 1 (not at all) to 5 (great extent).

Sustainable Design (SD)

Please indicate the extent to which you perceive that your company is implementing each of the following (Five-point scale: 1 = Not at all; 2 = To a small extent; 3 = To a moderate extent; 4 = To a relatively great extent; 5 = To a great extent).

Table 2: Sustainable Design

SD1	Design of products for reduced consumption of materials.
SD2	Design of products for reduced consumption of energy.
SD3	Design of products for reuse, recycle, recovery of material, component parts and by-products.
SD4	Design of products to avoid or reduce use of hazardous materials in their manufacturing process.
SD5	Cooperation with customers for eco-design.
SD6	Cooperation with customers for cleaner production.

Sustainable Manufacturing Processes (SMP)

Please indicate the extent to which you perceive that your company is implementing each of the following (Five-point scale: 1 = Not at all; 2 = To a small extent; 3 = To a moderate extent; 4 = To a relatively great extent; 5 = To a great extent).

Table 3: Sustainable Manufacturing Process

SMP1	Monitor and control environmental pollution such as drain emission.
SMP2	Reduce noise pollution.
SMP3	Controlling hazardous substances in the manufacturing process and exploitation of the available resources.
SMP4	Process design focuses on minimising the consumption of energy and natural resources in operations.
SMP5	Emphasises the proactive and preventative maintenance to increase the operational efficiency of the equipment.
SMP6	Production planning and control focused on reducing waste and optimising materials exploitation.
SMP7	Substitution of polluting and hazardous materials/parts.
SMP8	Reduce CO ₂ emissions.

Sustainable Supply Chain (SSC) Management

Please indicate the extent to which you perceive that your company is implementing each of the following (Five-

point scale: 1 = Not at all; 2 = To a small extent; 3 = To a moderate extent; 4 = To a relatively great extent; 5 = To a great extent).

Table 4: Sustainable Supply Chain Management

SSC1	Providing design specification to suppliers that includes environmental requirements for purchased item.
SSC2	Cooperation with suppliers for environmental objectives.
SSC3	Selection of suppliers by environmental criteria.
SSC4	Suppliers' ISO14000 certification.
SSC5	Environmental audit for suppliers' inner management.
SSC6	Waste management (Incineration—burning to ash Land filling).
SSC7	Recycle (Collection of returned products).
SSC8	Reuse (Separation of reusable products and parts).
SSC9	Reprocess (Refurbish, Remanufacture, and Repair).
SSC10	Materials recovery (Disassembly, Inspection of dissembled parts, and Recover reusable parts and reuse them in repairing, refurbishing, or remanufacturing of other products).
SSC11	Design for reverse logistics (Use of standardized materials, and Adoption of modular design).
SSC12	Ecological materials for primary packaging.
SSC13	Recyclable or reusable packaging/containers in logistics.
SSC14	Selection of cleaner transportation methods.
SSC15	Effective shipment consolidation and full vehicle loading.

Statistical Analysis

The IBM, Statistical Package for Social Sciences (SPSS) version 23 program, using the statistical principle of multivariate analyses was used to process the survey data results based on Likert scale evaluations that allowed for statistical and graphical representation (Klementova et al., 2015). The internal consistency and reliability of the survey were tested using the Cronbach's α reliability test as in Ogunbiyi et al. (2014). According to Gliem and Gliem (2003), an α value of less than 0.6 is considered to be poor, one in the range of 0.7 is considered to be acceptable and any above 0.8 is reckoned to be good. Face and content validity of the measurement instruments were also checked. Next, EFA was carried out, clustering groupings-related variables into dimensions for SOM practices at Ethiopian 223 large manufacturing firms. Exploratory Factor Analysis (EFA) is one of a family of multivariate statistical methods that attempts to identify the smallest number of hypothetical constructs (also

known as factors, dimensions, latent variables, synthetic variables, or internal attributes) that can parsimoniously explain the covariation observed among a set of measured variables (also called observed variables, manifest variables, effect indicators, reflective indicators, or surface attributes) (Watkins, 2018). That is, to identify the common factors that explain the order and structure among measured variables.

According to the recommendation of Urban and Naidoo (2012), when testing the various variables, Kaiser-Meyer-Olkin (KMO) and Bartlett tests should be applied to variables for the purposes of grouping extraction. The Bartlett test is sensitive to even small deviations from randomness, so its results should be backed up with a measure of how well the sample was chosen. The KMO (KMO; Kaiser, 1974) measure of sampling adequacy (MSA) is the ratio of correlations and partial correlations. This shows how much correlations are a function of the variance shared by all variables rather than the variance shared by specific pairs of variables. KMO values range from 0 to 1, and they can be calculated for both the whole correlation matrix and for each of the measured variables. It is preferable to have overall KMO values higher than 0.70 (Kaiser, 1974; Hoelzle & Meyer, 2013).

RESULTS AND DISCUSSIONS

According to Field (2009), prior to conducting any statistical analysis, two main issues concerning the appropriateness of the collected data are central and must be checked using suitable techniques. These two issues are missing data and normal distribution of data. The risk of missing data was alleviated in this research through employing field survey, which allows research teams to collect data through in-person interviews, thus preventing survey submission if any question remained unanswered. The appropriateness of the collected data in terms of its normal distribution is presented in the next section.

Statistical Distribution of the Data

The following step examined the appropriateness of the collected data to check whether the data is normally distributed. To do this, we first transferred the 223 data sets from Excel into an SPSS file, using the IBM SPSS statistical package version 23.00. Summary values for the research constructs were then computed by averaging the measurement items in the variables for all samples, for example, $(SD1+SD2+SD3+SD4+SD5+SD6)/6$ for SD.

The averaged variables were then selected in SPSS for descriptive statistics analysis to summarise the distribution of the data. In addition, the functions of skewness and the kurtosis test were enabled in the descriptive statistics analysis, because the skewness and kurtosis coefficients are used as valid statistical indicators for the appropriateness of data in terms of its normal distribution (Field, 2009). Table 5 presents the descriptive statistics specified in the SPSS output.

Table 5: Descriptive Statistics

Variable	N	Mean	Std. Deviation	Minimum	Maximum	Skewness	Kurtosis
SD	223	3.4611	0.61349	1.83	4.83	-0.090	-0.303
SMP	223	3.7635	0.78312	1.75	5	-0.359	-0.485
SSC	223	3.5767	0.68455	1.8	4.8	-0.445	-0.711

According to Field (2009), the recommended value for skewness and kurtosis coefficients that determine data normality is within the -2.00 to +2.00 range. Drawing on Table 5, the collected data for all of the variables is normally distributed, with the skewness and kurtosis coefficients falling within the recommended range. This confirms that we have a normal data distribution.

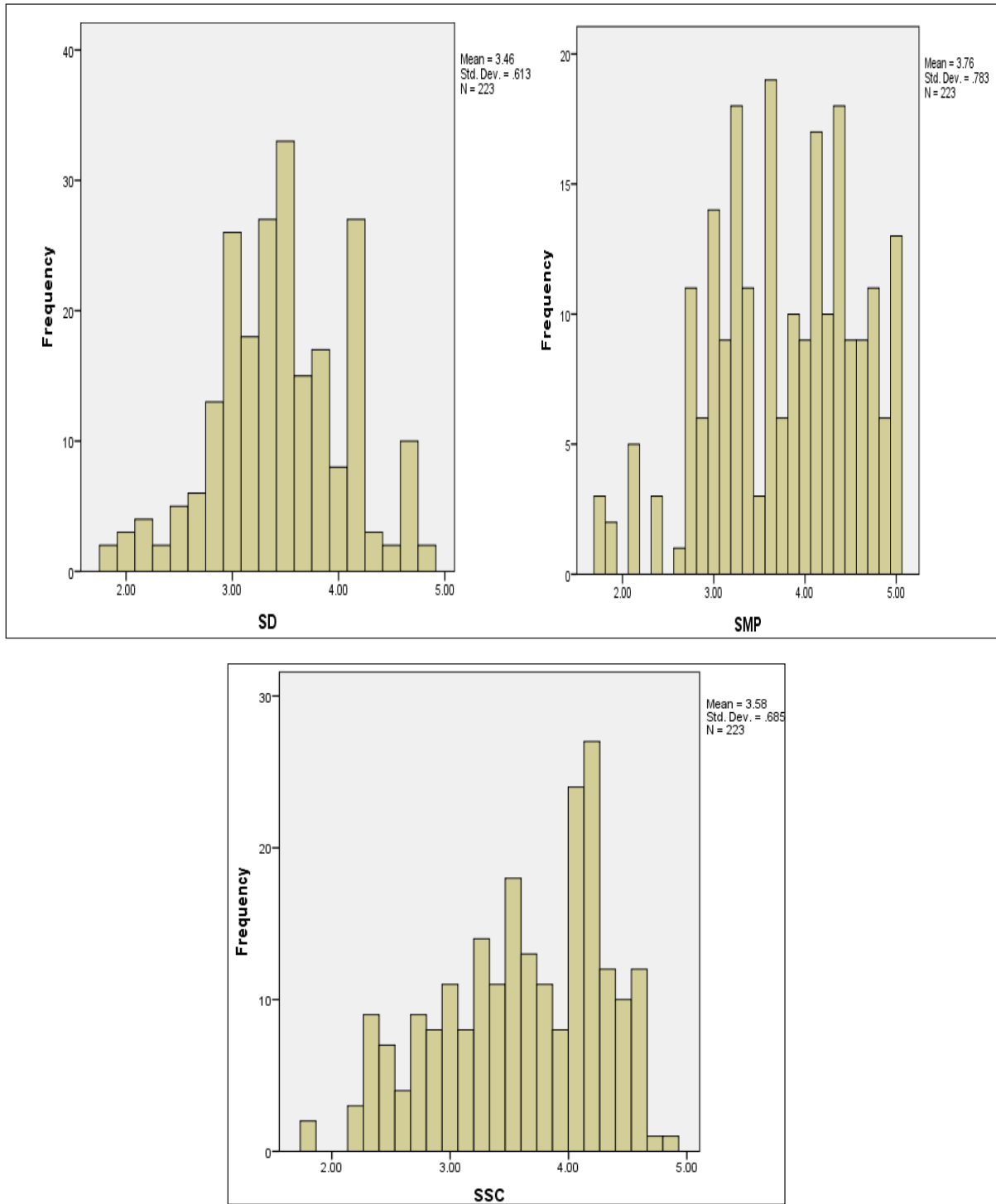


Fig. 2: Histograms of SD, SMP, and SSC Variables for Data Distribution

Data Quality

Having discussed the appropriateness of the collected data in terms of both the risk of missing data and the normal distribution of the data, it is beneficial to address data quality implications before conducting the statistical analyses. Data quality is a crucial issue in both quantitative and qualitative social research, as it is one of the most important indicators for establishing the truthfulness and credibility of results, maintaining the robustness of research findings (Kaplan, 2004). Data quality is commonly determined by the two main complementary concepts of reliability and validity (Saunders et al., 2009).

The first aspect for measuring the quality of data is reliability. Reliability is concerned with the question of whether the results of a study are repeatable; the term is commonly used in relation to the question of whether or not the measures that are devised for concepts in business and management are consistent (Bryman & Bell, 2015). It is also defined as the extent to which a variable or set of variables is consistent in what it is intended to measure, it requires that the numerical results generated by the indicators of a measure should not vary on account of the characteristics of the measurement procedure or measurement scale itself (Hair et al., 2019). Therefore, reliability mainly deals with the quality of research measures in terms of their consistency or repeatability (Esfahbodi, 2016).

Cronbach's alpha, α , is the most common measure of scale reliability (Field, 2009). It ranges from 0 to 1 to measure the reliability of data, with values of 0.60–0.70 deemed the lower limit of acceptability. We used the SPSS software package to empirically analyse the reliability of each of the research measures. To do this, we selected all measurement items for each measure (e.g., SD1, SD2 and SD3) and carried out the reliability analysis individually for each research measure (seven times). The results of the reliability analysis are presented in Table 6.

Table 6: Reliability Statistics

Variable	Cronbach's alpha
SD	0.770
SMP	0.905
SSC	0.907

As can be seen from Table 6, the Cronbach's alpha values for all variables exceed the ideal recommended 0.70 level, indicating high construct reliability.

The other important concept that determines data quality is validity. Validity tests how well an instrument that is

developed measures the particular concept it is intended to measure; in other words, validity is concerned with whether we measure the right concept (Sakran, 2002). It is basically associated with evaluating the precision and relevance of research results, determining the integrity of research findings (Saunders et al., 2009). Thus, validity is deemed to be the most important criterion of research quality, determining the extent to which the research findings can be generalised.

The face validity in this article was assured in line with our comprehensive pilot test where a pre-test of the measures employed was conducted with a number of academics specialising in the OM area. Since qualified academics and professionals involved in operations management verified the correspondence between the indicators and their associated construct (i.e., that the indicators really measure the construct), the face validity of the measurement scales was confirmed.

In terms of content validity, since all the measurement scales were adopted directly from prior research such as Abdul-Rashid et al. (2017), Simões et al. (2017), Lai et al. (2013), Zhu et al. (2008) and Zhu and Sarkis (2004); that had already been validated and used in other published researches including Sarwar et al. (2021) and Çankaya and Sezen, (2019) content validity was assured. In addition, the content validity of the measurement scales was further confirmed by the systematic review of pertinent SOM literature along with the conducted pilot study that involved the judgment of academics and professionals expert in OM. As such, in this research both the face validity and content validity of the adopted measurement scales were confirmed. Furthermore, construct validity is commonly empirically tested through factor analysis and can be attained through confirming convergent validity using EFA, which is assessed in the following section.

DISCUSSION

An EFA was performed using a principal component analysis and varimax rotation. The minimum factor loading criteria was set to 0.50. The communality of the scale, which indicates the amount of variance in each dimension, was also assessed to ensure acceptable levels of explanation.

Sustainable Product Design (SD) Measure

The Sustainable Product Design (SD) measure comprises six measurement items. A vital first step has been undertaken to weigh the overall significance of the

correlation matrix through Bartlett's Test of Sphericity, which provides a measure of the statistical probability that the correlation matrix has significant correlations among some of its components. The results were significant, $X^2 (n=223) = 347.928 (p < 0.001)$, which indicates its suitability for factor analysis. The KMO MSA, which indicates the appropriateness of the data for factor analysis, was 0.767, exceeding the suggested minimum standard of 0.60 required for conducting factor analysis (Field, 2009; Luthra et al., 2014). The analysis also shows that all communalities were over 0.50; except one item that had commonality (SD3 = 0.474) slightly less than 0.50, but it was kept in the data as it did not influence the overall factor structure of the measure; furthermore it was loaded well in its own item. In addition, the eigenvalue for the SD measure was 2.822, higher than the acceptable value of 1. Finally, the factor solution derived from this analysis yielded one factor for the measure. Since one factor was extracted among the SD measuring items, a loadings plot was not produced in the SPSS output.

Nonetheless, in this initial EFA, one item (i.e. "SD1: Design of products for reduced consumption of materials") failed to load on in this dimension significantly, which indicates SD1 has little association with the measure – Sustainable product design; hence, it was removed from further analysis.

The authors repeated the EFA without including this item. The analysis again yielded a one factor solution, suggesting that all the measuring items truly represent the SD measure accounting for one underlying factor (Field, 2009). The KMO MSA turned out to be 0.766, and the Bartlett's test of sphericity proved to be significant. The factor loading for the SD measure was 0.55, exceeding the minimum suggested standard level of 0.50 (Hair et al., 2019) and specifying the practical significance of the derived factor. This also indicated that the one factor solution accounted for 55% of variance in the SD measure, providing sufficient evidence of convergent validity.

SD1 in the survey questionnaire is concerned Please indicate the extent to which you perceive that your company is implementing with the question "Please indicate the extent to which you perceive that your company is implementing the design of products for reduced consumption of materials" Based on the statistical procedures of the EFA test, SD 1 was excluded to ensure that the rigor of the results was not put at risk. The reason for this may be down to the fact that SD1 covers relatively more technical issues compared to the other SD measuring items, which makes it less consistent with the other items within the SD variable. It is important to note that this was recommended by the literature (Zhu et al.,

2008), although it appears that SD1 was not a good fit with the sustainable product design measure, and thus it was abandoned.

Sustainable Manufacturing Processes (SMP) Measure

There are eight measurement items in the Sustainable Manufacturing Processes (SMP) measure. The correlation matrix passed Bartlett's Test of Sphericity with an overall significance of $X^2 (n=223) = 956.058 (p < 0.001)$, indicating its suitability for factor analysis. The factor analysis KMO MSA was 0.911, exceeding the recommended minimum standard of 0.60 (Luthra et al., 2014). The SMP measure had one factor solution with an eigenvalue of 4.862, which was greater than the suggested minimum standard of 1. A loadings plot, like the SD measure, was not produced in the SPSS output because the desired one factor was extracted from the SMP measuring items.

The factor loading of the SMP measure produced in the SPSS output was 0.61, which was higher than the recommended level of 0.50 (Hair et al., 2019), indicating that the derived factor was practical. As a result, the SMP measure explained 61% of the total variance, providing sufficient evidence for convergent validity. As a result, the SMP measure's convergent validity was established.

Sustainable Supply Chain (SSC) Measure

There are fifteen different measurement items that make up the Sustainable Supply Chain (SSC) scale. Through Bartlett's Test of Sphericity, the overall significance of the correlation matrix was found to be $X^2 (n=223) = 1786.510 (p < 0.001)$, which indicates that it is suitable for factor analysis. With a KMO value of 0.846, the sampling adequacy for principal component analysis was confirmed. This value is higher than the recommended minimum standard of 0.60, which is necessary for carrying out factor analysis (Field, 2009). In addition, the eigenvalue of the SSC measure that was specified in the SPSS output was 6.654, which is an acceptable value that is greater than the minimum value of 1. In contrast to the preceding measures, SD and SMP, factor analysis delivered three factor solutions for the SSC measure. This result suggests that none of the measuring items adequately represent the SSC measure in its entirety. As a result, a factor analysis rotation and a loadings plot were produced in the SPSS output (refer to Fig. 3 for further explanation), both of which assisted us in locating the measuring item that did not conform to the pattern established by the other items.

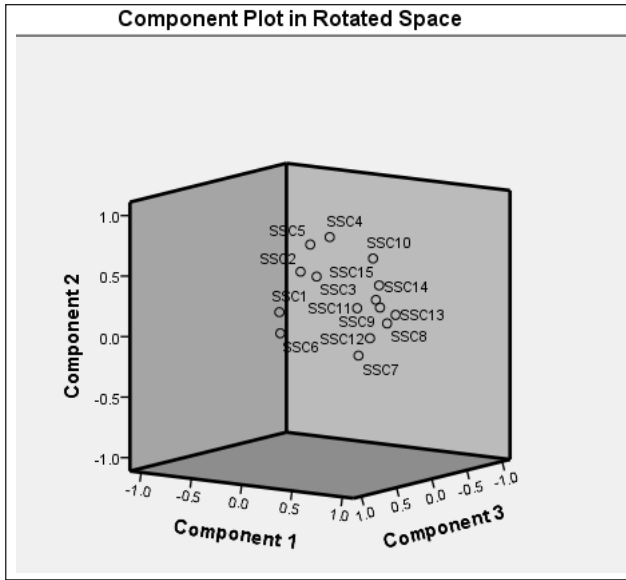


Fig. 3: SSC Factor Analysis: Rotation and Loadings Plot

Fig. 3 demonstrates that the two items of SSC6 and SSC1 were relatively separated from the other items, preventing them from converging into a single factor. We excluded SSC6 from the SSC measure because, relative to SSC1, it was more likely that SSC6 prevented the other items from converging as a single factor. The factor analysis was then conducted without SSC6, yielding three factor solutions and another loading plot (see Fig. 4). As previously discussed, we must continue to modify the research measure until a single underlying factor is identified.

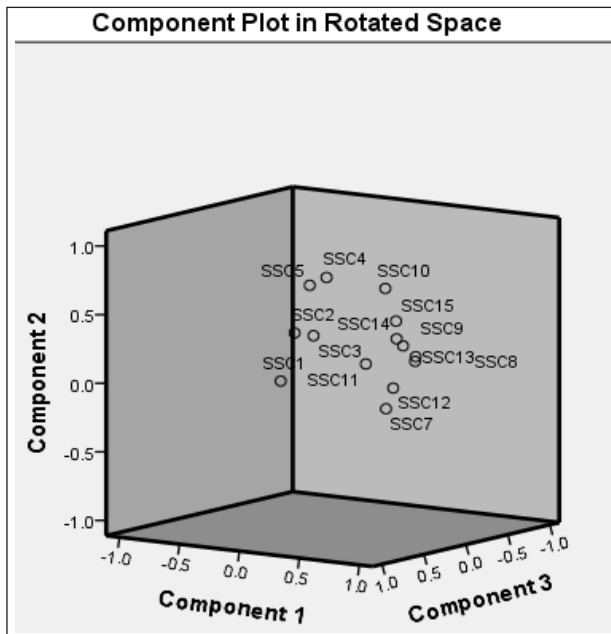


Fig. 4: SSC Factor Analysis: Rotation and Loadings Plot (with SSC6 Excluded)

According to the factor analysis rotation and loadings plot produced in SPSS output (Fig. 4), SSC1 was then excluded, as it was distant from the remaining items of the SSC measure. The factor analysis was then performed again for the SSC measure without SSC6 and SSC1, this time resulting in a two factor solution. Therefore, factor analysis rotation and a loadings plot were produced in the SPSS output (see Fig. 5), through which we decided to cast out SSC5 as it is relatively far away from the other items.

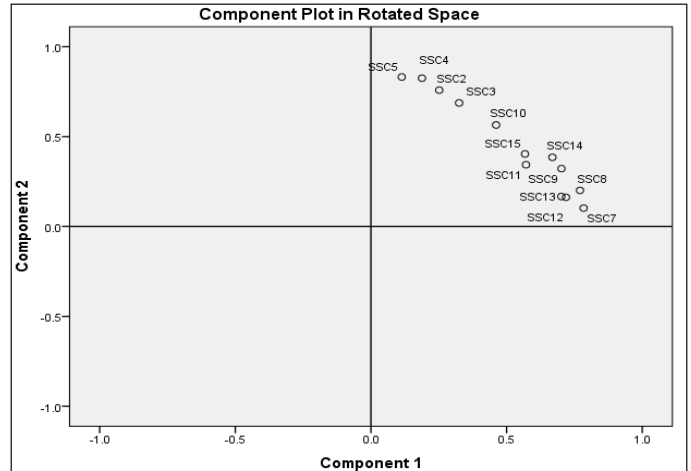


Fig. 5: SSC Factor Analysis: Rotation and Loadings Plot (with SSC6 and SSC1 Excluded)

After performing the factor analysis for the SSC measure a fourth time, this time excluding SSC6, SSC1 and SSC5, the same result of a two-factor solution was obtained. As a result, factor analysis rotation and a loadings plot were produced in the SPSS output (see Fig. 6). Using these tools, we came to the conclusion that SSC2 should be excluded from the analysis because it is detached from the other items to a significant degree.

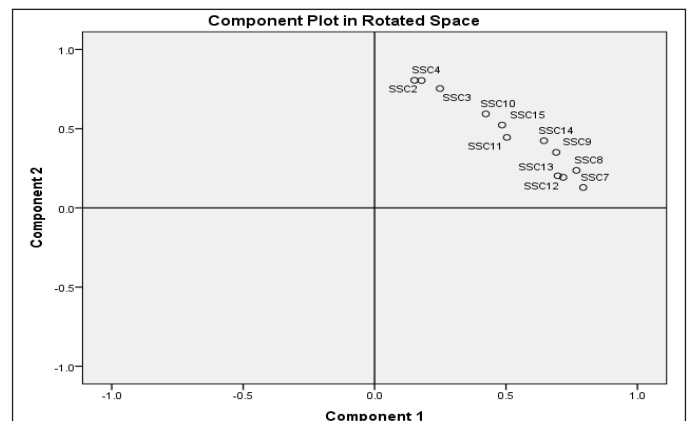


Fig. 6: SSC Factor Analysis: Rotation and Loadings Plot (with SSC6, SSC1 and SSC5 Excluded)

After performing the factor analysis for the SSC measure a fifth time, but this time excluding SSC6, SSC1, SSC5 and SSC2, the same result of a two-factor solution was obtained. As a result, a loadings plot and an additional factor analysis rotation were generated in the SPSS output (see Fig. 7).

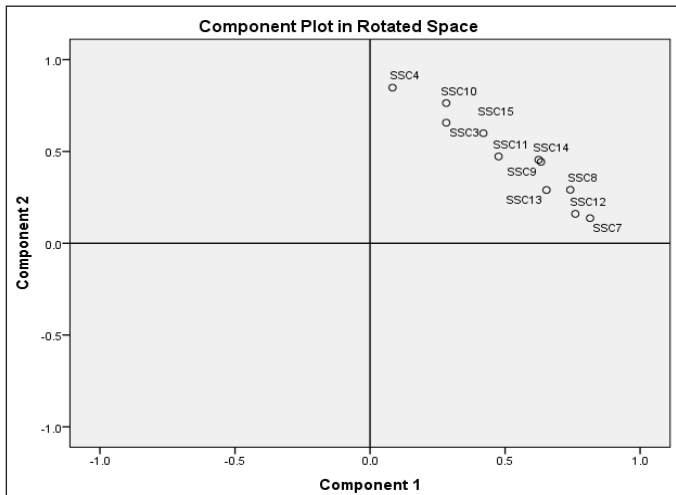


Fig. 7: SSC Factor Analysis: Rotation and Loadings Plot (with SSC6, SSC1, SSC5 and SSC2 Excluded)

Fig. 7 demonstrates that the item SSC4 was relatively separated from the other items, preventing them from converging into a single factor. We excluded SSC4 from the SSC measure due to its greater separation from other items, implying that SSC4 was more likely preventing the other items from converging as a single factor. The factor analysis was then repeated for the SSC measure without SSC6, SSC1, SSC5, SSC2 and SSC4. This time, a one-factor solution was obtained, indicating that all measuring items accurately represent the SSC measure and account for a single underlying factor. According to Bartlett's Test of Sphericity, the overall significance of the correlation matrix was $X^2(n=223) = 1020,456$ ($p < 0.001$), indicating its suitability for factor analysis. The KMO MSA was 0.877, exceeding the recommended minimum of 0.60 for conducting factor analysis (Luthra et al., 2014). The SSC measure had one factor solution with an eigenvalue of 5.097, which was greater than the suggested minimum standard of 1. The SSC measure factor loading in the SPSS output was 0.51, slightly higher than the recommended level of 0.50 (Hair et al., 2019), indicating the practical significance of the derived factor. As a result, the SSC measure explained 51% of the total variance, providing sufficient evidence for convergent validity. As a result, after removing SSC6, SSC1, SSC5, SSC2 and SSC4, the construct validity of the SSC measure was also verified in terms of convergent validity.

CONCLUSION

The present paper demonstrates the basic SOM practices and indicators in conducting SOM. As far as sustainable product design measurement items are concerned, the EFA strongly suggests that SD1 be removed from the sustainable product design construct because it did not load in the component matrix. SD1 in the survey questionnaire is concerned with "Please indicate the extent to which you perceive that your company is implementing the design of products for reduced consumption of materials". Based on the statistical procedures of the EFA test, SD 1 was excluded to ensure that the rigor of the results was not put at risk. The reason for this may be down to the fact that SD1 covers relatively more technical issues compared to the other SD measuring items, which makes it less consistent with the other items within the SD variable. It is important to note that this was recommended by the literature (Zhu et al., 2008), although it appears that SD1 was not a good fit with the sustainable product design measure, and thus it was abandoned. This follows that metrics like SD2 (Design of products for reduced consumption of energy), SD3 (Design of products for reuse, recycle, recovery of material, component parts and by-products), SD4 (Design of products to avoid or reduce use of hazardous materials in their manufacturing process), SD5 (Cooperation with customers for eco-design) and SD6 (Cooperation with customers for cleaner production) could be applied to evaluate sustainable product design in Ethiopia's largest manufacturing environment.

According to the EFA, all of the collected indicators of the sustainable manufacturing process converged. This suggests that SMP1 (Monitor and control environmental pollution such as drain emission, SMP2 (Reduce noise pollution), SMP3 (Controlling hazardous substances in the manufacturing process and exploitation of the available resources, SMP4 (Process design focuses on minimising the consumption of energy and natural resources in operations, SMP5 (Emphasises the proactive and preventative maintenance to increase the operational efficiency of the equipment), SMP6 (Production planning and control focused on reducing waste and optimising materials exploitation), SMP7 (Substitution of polluting and hazardous materials/parts) and SMP8 (Reduce CO2 emissions) could be used to assess the sustainability of the manufacturing process in Ethiopia's largest manufacturing context.

EFA has also suggested dropping some collected indicators of the sustainable supply chain management dimension of SOM via graphical presentation. SSC1, SSC2, SSC4, SSC5 and SSC6, in the survey question-

naire are concerned with the question “Please indicate the extent to which you perceive that your company is implementing each of the following: Providing design specification to suppliers that includes environmental requirements for purchased item (SSC1); Cooperation with suppliers for environmental objectives (SSC2); Suppliers’ ISO14000 certification (SSC4); Environmental audit for suppliers’ inner management (SSC5); Waste management (Incineration—burning to ash Land filling) (SSC6)”. These five items were excluded from the SSC measure based on the EFA statistical procedures, assuring the rigor of the results. The reasoning for this may be because SSC1, SSC2, SSC4 and SSC5 are deemed to be relatively associated with SSC3 (Selection of suppliers by environmental criteria) with respect to the comprehension of this concept, i.e. SSC1, SSC2, SSC4, SSC5 and SSC3 may be considered as overlapping issues. As for SSC6, it may be assumed that this item is relatively vaguer to respondents compared to other SSC measuring items. Thus, SSC6 may not be fully consistent with other respective items and in turn may not truly represent the SSC measure. As previously mentioned, it is common in quantitative research to have anomalies within certain measuring items, as the real data collected from the survey may not always fit the measures (Kaplan, 2004).

As a result, SSC3 (Selection of suppliers by environmental criteria), SSC7 (Recycle or Collection of returned products), SSC8 (Reuse or Separation of reusable products and parts), SSC9 (Reprocess), SSC10 (Materials recovery), SSC11 (Design for reverse logistics), SSC12 (Ecological materials for primary packaging) and (Recyclable or reusable packaging in logistics, SSC14 (Selection of cleaner transportation methods) and SSC15 (Effective shipment consolidation and full vehicle loading) can be considered as indicators to measure sustainable supply chain management practices from the perspective of Ethiopia’s largest manufacturers.

LIMITATIONS OF THE STUDY AND FUTURE RESEARCH DIRECTIONS

Confirmatory factor analysis (CFA) can be used by future researchers to evaluate the measurement model. This study is limited to EFA to evaluate construct validity individually for each construct without taking the entire model into account, whereas future studies may use CFA to assess construct validity within the context of the entire measurement model (Esfahbodi, 2016). Future researchers may, therefore, start with conceptualising a model through CFA and end with evaluating the data-model fit and considering potential model modification; in other words,

models or theories may be refuted, but results may also suggest potential changes (Mueller & Hancock, 2001). Additionally, this study is restricted to validating SOM practices using EFA; however, it is advised that future researchers use structural equation modeling (SEM) to examine the impact of the aforementioned SOM practices on the sustainable performance of a manufacturing firm. This study concentrated on the frequently discussed aspects of operations management that relate to sustainability, but it is advised that future studies assess the sustainability indicators of other aspects of OM, such as facility location, facility layout, work measurement, aggregate planning and inventory management. Using operations research techniques like the analytical hierarchy process and other goal programming techniques, the SOM factors examined in this study can also be further prioritized and documented.

CONTRIBUTION TO THEORY AND PRACTICE

This study aims to advance on the knowledge SOM, particularly in terms the indicators of SOM in manufacturing firms. The academic and practical significance of this study are respectively presented.

Second, the researcher aims to contribute to the current literature by considering the Ethiopian large manufacturing contexts with respect to the adoption of SOM practices for managers, it will be interesting to know which sustainable practices of OM are widely applied in Ethiopia. Ethiopian manufacturing operations, especially the largest ones, are under increasing pressure to not only provide high-quality, innovative products at competitive prices, but also to build operations and supply chains that are sustainable in the long run. This is due to growing global competition and a growing emphasis on environmental concerns (Gupta & Palsule-Desai, 2011). Ethiopia is therefore anticipated to experience significant growth in the future in terms of emission and waste reduction, climate change mitigation and energy conservation. By carefully identifying the indicators of SOM practices that have been used by the largest manufacturing firms in Ethiopia, this study provides managers and decision-makers with information on the current situation. Managers and decision-makers would use the knowledge gained from this study to make decisions regarding sustainable manufacturing operations. Additionally, the results of this study add to the literature on operations and supply chain management by identifying the specific indicators for fundamental SOM practices, which will be used as a starting point by the future researchers to conduct additional research in the area.

Finally, developed countries have been the main focus of SOM research. However, this study takes into account SOM practices from the standpoint of a developing nation, which broadens our comprehension of SOM practices and measurement criteria in different contexts.

REFERENCES

- Abdul-Rashid, S. H., Sakundarini, N., Raja Ghazilla, R. A., & Thurasamy, R. (2017). The impact of sustainable manufacturing practices on sustainability performance. *International Journal of Operations and Production Management*, 37(2), 182-204. doi:https://doi.org/10.1108/IJOPM-04-2015-0223
- Abdullah, I., Wan Mahmood, W. H., Md Fauadi, H. F., Ab Rahman, M. N., & Mohamed, S. B. (2017). Sustainable manufacturing practices in Malaysian palm oil mills: Priority and current performance. *Journal of Manufacturing Technology Management*, 28(3), 278-298. doi:http://dx.doi.org/10.1108/JMTM-09-2016-0128
- Agostini, M. D., Tondolo, V. A. G., Camargo, M. E., Dullius, A. I. dos S., Tondolo, R. da R. P., & Russo, S. L. (2017). Relationship between sustainable operations practices and performance: A meta-analysis. *International Journal of Productivity and Performance Management*, 66(8), 1020-1042. doi:https://doi.org/10.1108/IJPPM-11-2015-0168
- Andersen, P. H. (2019). Sustainable operations management (SOM) Strategy and management: An introduction to part I. In L. de Boer, & P. H. Andersen (Eds.), *Operations Management and Sustainability*. Cham: Palgrave Macmillan. doi:https://doi.org/10.1007/978-3-319-93212-5_2
- Angell, L. C., & Klassen, R. D. (1999). Integrating environmental issues into the mainstream: An agenda for research in operations management. *Journal of Operations Management*, 17(5), 575-598. doi:https://doi.org/10.1016/S0272-6963(99)00006-6
- Auliandri, T. A., Armanu, Rohman, F., & Rofiq, A. (2018). Does green packaging matter as a business strategy? Exploring young consumers' consumption in an emerging market. *Problems and Perspectives in Management*, 16(2). doi:https://doi.org/10.21511/ppm.16(2).2018.34
- Baah, C., & Jin, Z. (2019). Sustainable supply chain management and organisational performance: The intermediary role of competitive advantage. *Journal of Management and Sustainability*, 9(1), 119-131. doi:https://doi.org/10.5539/jms.v9n1p119
- Bryman, A. & Bell, E. (2003). *Business research methods*. Oxford, Oxford University Press.
- Burchart-Korol, D. (2011). Significance of environmental life cycle assessment (LCA) method in the iron and steel industry. *Metallurgija*, 50(3), 205-208.
- Çankaya, S. Y., & Sezen, B. (2019). Effects of green supply chain management practices on sustainability performance. *Journal of Manufacturing Technology Management*, 30(1), 98-121. doi:https://doi.org/10.1108/JMTM-03-2018-0099
- Chien, M. K., & Shih, L. H. (2007). An empirical study of the implementation of green supply chain management practices in the electrical and electronic industry and their relation to organisational performances. *International Journal of Environmental Science and Technology*, 4(3), 383-394.
- Corbett, L. M. (2009). Sustainable operations management: A typological approach. *Journal of Industrial Engineering and Management*, 2(1), 10-30. doi:https://doi.org/10.3926/jiem.2009.v2n1.p10-30
- De Guimarães, J. C. F., Dorion, E. C. H., & Severo, E. A. (2019). Antecedents, mediators and consequences of sustainable operations: A framework for analysis of the manufacturing industry. *Benchmarking: An International Journal*, 27(7), 2189-2212. doi:https://doi.org/10.1108/BIJ-09-2018-0296
- Dowlatshahi, S. (2010). A cost-benefit analysis for the design and implementation of reverse logistics systems: Case studies approach. *International Journal of Production Research*, 48(5), 1361-1380. doi:https://doi.org/10.1080/00207540802552642
- Esfahbodi, A. (2016). *Sustainable supply chain management (SSCM): An empirical analysis of the UK automotive industry* (Doctoral thesis, The University of Birmingham).
- Eslami, Y., Dassisti, M., Lezoche, M., & Panetto, H. (2018). *A survey on sustainability in manufacturing organisations: Dimensions and future insights*, 7543. doi:https://doi.org/10.1080/00207543.2018.1544723
- Field, A. (2009). *Discovering statistics using SPSS* (3rd ed.). Sage Publications Inc.
- Gerbing, D. W., & Hamilton, J. G. (1996): Viability of exploratory factor analysis as a precursor to confirmatory factor analysis, structural equation

- modeling. *A Multidisciplinary Journal*, 3(1), 62-72
doi:http://dx.doi.org/10.1080/10705519609540030
- Gimenez, C., Sierra, V., & Rodon, J. (2012). Sustainable operations: Their impact on the triple bottom line. *International Journal of Production Economics*, 140(1), 149-159. doi:https://doi.org/10.1016/j.ijpe.2012.01.035
- Gliem, J. A., & Gliem, R. R. (2003). Calculating, interpreting, and reporting Cronbach's Alpha reliability coefficient for likert-type scales. *2003 Midwest Research to Practice Conference in Adult, Continuing, and Community Education*, 82-88.
- Goyder, J. (1985). Nonresponse effects on relationships between variables. *Public Opinion Quarterly*, 40, 360-369.
- Gunasekaran, A., Irani, Z., & Papadopoulos, T. (2014). Modelling and analysis of sustainable operations management: Certain investigations for research and applications. *Journal of the Operational Research Society*, 65(6), 806-823. doi:https://doi.org/10.1057/jors.2013.171
- Gupta, M., & Sharma, K. (1996). Environmental operations management: An opportunity for improvement. *Production and Inventory Management Journal*, 37, 40-46.
- Gupta, S., & Palsule-Desai, O. D. (2011). Sustainable supply chain management: Review and research opportunities. *IIMB Management Review*, 23(4), 234-245. doi:10.1016/j.iimb.2011.09.002
- Gustavo, J. U., Pereira, G. M., Bond, A. J., Viegas, C. V., & Borchardt, M. (2018). Drivers, opportunities and barriers for a retailer in the pursuit of more sustainable packaging redesign. *Journal of Cleaner Production*, 187, 18-28. doi:https://doi.org/10.1016/j.jclepro.2018.03.197
- Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. *European Business Review*, 31(1), 2-24. doi:https://doi.org/10.1108/EBR-11-2018-0203
- Hami, N., Muhamad, M. R., & Ebrahim, Z. (2015). The impact of sustainable manufacturing practices and innovation performance on economic sustainability. *Procedia CIRP*, 26, 190-195. doi:https://doi.org/10.1016/j.procir.2014.07.167
- Ho, J. C., Shalishali, M. K., Tseng, T. L., & Ang, D. (2009). Opportunities in green supply chain management. *The Coastal Business Journal*, 8(1), 18-31.
- Hoelzle, J. B., & Meyer, G. J. (2013). Exploratory factor analysis: Basics and beyond. In I. B. Weiner, J. A. Schinka, & W. F. Velicer (Eds.), *Handbook of Psychology: Research Methods in Psychology* (2nd ed., vol. 2, pp. 164-188). Wiley.
- Inman, R. A. (2010). Implications of environmental management for operations management. *Production Planning & Control: The Management of Operations operations*, 13, 37-41. doi:https://doi.org/10.1080/09537280110061575
- Ishizaka, A., Khan, S. A., Kusi-Sarpong, S., & Naim, I. (2020). Sustainable warehouse evaluation with AHPSort traffic light visualisation and post-optimal analysis method. *Journal of the Operational Research Society*, 1-18. doi:https://doi.org/10.1080/01605682.2020.1848361
- Islam, S., Karia, N., Fauzi, F. B. A., & Soliman, M. S. M. (2017). A review on green supply chain aspects and practices. Management and marketing. *Challenges for the Knowledge Society*, 12(1), 12-36. doi:https://doi.org/10.1515/mmcks-2017-0002
- Jayal, A. D., Badurdeen, F., Dillon, O. W., & Jawahir, I. S. (2010). Sustainable manufacturing: Modeling and optimisation challenges at the product, process and system levels. *CIRP Journal of Manufacturing Science and Technology*, 2(3), 144-152. doi:https://doi.org/10.1016/j.cirpj.2010.03.006
- Jovane, F., Yoshikawa, H., Alting, L., Boër, C. R., Westkamper, E., Williams, D., Tseng, M., Seliger, G., & Paci, A. M. (2008). The incoming global technological and industrial revolution towards competitive sustainable manufacturing. *CIRP Annals - Manufacturing Technology*, 57(2), 641-659. doi:https://doi.org/10.1016/j.cirp.2008.09.010
- Kaiser, H. F. (1974). Analysis of factorial simplicity. *Psychometrika*, 39, 31-36.
- Kleindorfer, P. R., Singhal, K., & Wassenhove, L. N. Van. (2005). Sustainable operations management. *Production and Operations Management Society*, 14(4), 482-492.
- Klementova, J., Zavadsky, J., & Zavadska, Z. (2015). The measurement and evaluation of the service quality through customers' satisfaction. *Procedia Economics and Finance*, 26(15), 126-130.
- Krause, D. R., Vachon, S., & Klassen, R. D. (2009). Special topic forum on sustainable supply chain management: Introduction and reflections on the

- role of purchasing management. *Journal of Supply Chain Management*, 45(4), 18-25. doi:<https://doi.org/10.1111/j.1745-493X.2009.03173.x>
- Lai, K., Wu, S. J., & Wong, C. W. Y. (2013). Did reverse logistics practices hit the triple bottom line of Chinese manufacturers? *International Journal of Production Economics*, 146(1), 106-117. doi:<https://doi.org/10.1016/j.ijpe.2013.03.005>
- Laosirihongthong, T., Adebajo, D., & Tan, K. C. (2013). Green supply chain management practices and performance. *Industrial Management & Data Systems*, 113(8), 1088-1109. doi:<https://doi.org/10.1108/IMDS-04-2013-0164>
- Longoni, A., Golini, R., & Cagliano, R. (2014). The role of new forms of work organisation in developing sustainability strategies in operations. *International Journal of Production Economics*, 147(PART A), 147-160. doi:<https://doi.org/10.1016/j.ijpe.2013.09.009>
- Luthra, S., Garg, D., & Haleem, A. (2016). The impacts of critical success factors for implementing green supply chain management towards sustainability: An empirical investigation of Indian automobile industry. *Journal of Cleaner Production*, 121. doi:<https://doi.org/10.1016/j.jclepro.2016.01.095>
- Machado, C. G., Pinheiro de Lima, E., Gouvea da Costa, S. E., Angelis, J. J., & Mattioda, R. A. (2017). Framing maturity based on sustainable operations management principles. *International Journal of Production Economics*, 190, 3-21. doi:<https://doi.org/10.1016/j.ijpe.2017.01.020>
- Malek, J., & Desai, T. N. (2020). A systematic literature review to map literature focus of sustainable manufacturing. *Journal of Cleaner Production*, 256. doi:<https://doi.org/10.1016/j.jclepro.2020.120345>
- Malinowska, M., Rzeczycki, A., & Sowa, M. (2018). Roadmap to sustainable warehouse. *SHS Web of Conferences*, 57, 01028. doi:<https://doi.org/10.1051/shsconf/20185701028>
- Mann, B. J. S., & Kaur, H. (2019). Sustainable supply chain activities and financial performance: An Indian experience. *Vision: The Journal of Business Perspective*. doi:<https://doi.org/10.1177/0972262919863189>
- Markham, T., & Frohlich, M. T. (2002). Techniques for improving response rates in OM survey research. *Journal of Operations Management*, 20(1), 53-62. doi:[10.1016/s0272-6963\(02\)00003-7](https://doi.org/10.1016/s0272-6963(02)00003-7)
- Mellahi, K., & Harris, L. C. (2015). Response rates in business and management research: An overview of current practice and suggestions for future direction. *British Journal of Management*, 27(2), 426-437. doi:[10.1111/1467-8551.12154](https://doi.org/10.1111/1467-8551.12154)
- Mitra, S., & Datta, P. P. (2014). Adoption of green supply chain management practices and their impact on performance: An exploratory study of Indian manufacturing firms. *International Journal of Production Research*, 52(7), 2085-2107. doi:<https://doi.org/10.1080/00207543.2013.849014>
- Moldavska, A., & Welo, T. (2017). The concept of sustainable manufacturing and its definitions: A content-analysis based literature review. *Journal of Cleaner Production*, 166, 744-755. doi:<https://doi.org/10.1016/j.jclepro.2017.08.006>
- Monteiro, J., Silva, F. J. G., Ramos, S. F., Campilho, R. D. S. G., & Fonseca, A. M. (2019). Eco-design and sustainability in packaging: A survey. *Procedia Manufacturing*, 38(2019), 1741-1749. doi:<https://doi.org/10.1016/j.promfg.2020.01.097>
- Mutingi, M. (2014). The impact of reverse logistics in green supply chain management: A system dynamics analysis. *International Journal of Industrial and Systems Engineering*, 17(2), 186-201. doi:<https://doi.org/10.1504/IJISE.2014.061993>
- Ninlawan, C., Seksan, P., Tossapol, K., & Pilada, W. (2010). The implementation of green supply chain management practices in electronics industry. *Proceedings of the International MultiConference of Engineers and Computer Scientists, III*.
- Nordin, N., & Selke, S. (2010). Social aspect of sustainable packaging. *Packaging Technology and Science*, 23(6), 317-326. doi:<https://doi.org/10.1002/pts.899>
- Ogunbiyi, O., Oladapo, A., & Goulding, J. (2014). An empirical study of the impact of lean construction techniques on sustainable construction in the UK. *Construction Innovation: Information, Process, Management*, 14(1), 88-107.
- Pauer, E., Wohner, B., Heinrich, V., & Tacker, M. (2019). Assessing the environmental sustainability of food packaging: An extended life cycle assessment including packaging-related food losses and waste and circularity assessment. *Sustainability*, 11. doi:<https://doi.org/10.3390/su11030925>
- Rainock, M., Everett, D., Pack, A., Dahlin, E. C., & Mattson, C. A. (2018). The social impacts of products: A review. *Impact Assessment and Project Appraisal*, 36(3), 230-241. doi:<https://doi.org/10.1080/14615517.2018.1445176>

- Rao, P., & Holt, D. (2005). Do green supply chains lead to competitiveness and economic performance? *International Journal of Operations and Production Management*, 25(9), 898-916.
- Renukappa, S., Egbu, C., Akintoye, A., & Suresh, S. (2016). Sustainable procurement strategies for competitive advantage: An empirical study. *Proceedings of the Institution of Civil Engineers Management, Procurement and Law*, 169(1), 17-25. doi:https://doi.org/doi:10.1680/jmapl.15.00006
- Sarwar, A., Zafar, A., Hamza, M. A., & Qadir, A. (2021). The effect of green supply chain practices on firm sustainability performance: Evidence from Pakistan. *Uncertain Supply Chain Management*, 9(1), 31-38. doi:https://doi.org/10.5267/j.uscm.2020.12.004
- Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research methods for business students*. In R. Silkoset, K. Nielsen, P. H. Andersen, F. Wijbenga, L. Ple, J. Thomas, D. Douglas, A. Byrne, A. Corley, & J. Newall (5th Eds.). Pearson Education Limited.
- Schmidt, C. G., Foerstl, K., & Schaltenbrand, B. (2017). The supply chain position paradox: Green practices and firm performance. *Journal of Supply Chain Management*, 53(1), 3-25.
- Sekaran, U., & Bougie, R. (2016). *Research methods for business: A skill building approach* (7th ed.). West Sussex: Wiley.
- Sharif, A. M., Alshawi, S., Kamal, M. M., Eldabi, T., & Mazhar, A. (2014). Exploring the role of supplier relationship management for sustainable operations: An OR perspective. *Journal of the Operational Research Society*, 65(6), 963-978. doi:https://doi.org/10.1057/jors.2013.145
- Simões, R., Carvalho, C., Félix, R., & Arantes, A. (2017). Survey of reverse logistics practices - The case of Portugal. In *Proceedings of the 6th International Conference on Operations Research and Enterprise Systems, Porto, Portugal, 23–25 February*, 393–400. doi:https://doi.org/10.5220/0006198403930400
- Steurer, R., Langer, M. E., Konrad, A., & Martinuzzi, A. (2005). Corporations, stakeholders and sustainable development I: A theoretical exploration of business-society relations. *Journal of Business Ethics*, 61(3), 263-281. doi:https://doi.org/10.1007/s10551-005-7054-0
- Swalehe, R., Odock, S., & Wainaina, G. (2020). Sustainable operations management practices and competitive advantage of manufacturing firms in Kenya. *European Scientific Journal ESJ*, 16(28), 241-262. doi:https://doi.org/10.19044/esj.2020.v16n28p241
- Tan, K. S., Ahmed, M. D., & Sundaram, D. (2009). Sustainable warehouse management. *Proceedings of the International Workshop on Enterprises & Organisational Modeling and Simulation - EOMAS '09*. doi:https://doi.org/doi:10.1145/1750405.1750415
- Taylor, K. M., & Vachon, S. (2018). Empirical research on sustainable supply chains: IJPR 's contribution and research avenues. *International Journal of Production Research*, 56(1-2), 950-959. doi:https://doi.org/10.1080/00207543.2017.1402139
- Tekin, E. K., Ertürk, A., & Tozan, H. (2015). Corporate social responsibility in supply chains: Applications of contemporary management approaches in supply chains. In *Tech*. doi:https://doi.org/doi:10.5772/59582
- Türkay, M., Saraço, Ö., & Arslan, M. C. (2016). Sustainability in supply chain management: Aggregate planning from sustainability perspective. *PLoS ONE*, 11(1), e0147502. doi:https://doi.org/10.1371/journal.pone.0147502
- United States Office of Management and Budget. (2006). Standards and guidelines for statistical surveys. Retrieved from https://www.whitehouse.gov/sites/default/files/omb/inforeg/statpolicy/standards_stat_surveys.pdf
- Urban, B., & Naidoo, R. (2012). Business sustainability: Empirical evidence on operational skills in SMEs in South Africa. *Journal of Small Business and Enterprise Development*, 19(1), 146-163.
- Vanalle, R. M., Ganga, G. M. D., Godinho Filho, M., & Lucato, W. C. (2017). Green supply chain management: An investigation of pressures, practices, and performance within the Brazilian automotive supply chain. *Journal of Cleaner Production*, 151, 250-259. doi:https://doi.org/10.1016/j.jclepro.2017.03.066
- Waage, S. A. (2007). Re-considering product design: A practical “road-map” for integration of sustainability issues. *Journal of Cleaner Production*, 15(7), 638-649. doi:https://doi.org/10.1016/j.jclepro.2005.11.026
- Wandosell, G., Parra-meroño, M. C., Alcayde, A., & Baños, R. (2021). Green packaging from consumer and business perspectives sustainability green packaging from consumer and business perspectives. *Sustainability*, 13(January). doi:https://doi.org/10.3390/su13031356
- Watkins, M. W. (2018). Exploratory factor analysis: A guide to best practice. *Journal of Black Psychology*, 44, 219-246. doi:https://doi.org/10.1177/0095798418771807
- White, G. R. T., Wang, X., & Li, D. (2014). Inter-organisational green packaging design: A case study of

- influencing factors and constraints in the automotive supply chain. *International Journal of Production Research*, 37-41. doi:<https://doi.org/10.1080/00207543.2014.975854>
- Wu, H.-J., & Dunn, S. C. (1995). Environmentally responsible logistics systems. *International Journal of Physical Distribution & Logistics Management*, 25(2), 20-38. doi:<https://doi.org/10.1108/09600039510083925>
- Zhu, Q., & Sarkis, J. (2004). Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. *Journal of Operations Management*, 22(3), 265-289. doi:<https://doi.org/10.1016/j.jom.2004.01.005>
- Zhu, Q., Sarkis, J., & Lai, K. (2007). Green supply chain management: Pressures, practices and performance within the Chinese automobile industry. *Journal of Cleaner Production*, 15, 15(11/12), 1041-1052. doi:<https://doi.org/10.1016/j.jclepro.2006.05.021>
- Zhu, Q., Sarkis, J., & Lai, K. H. (2008). Confirmation of a measurement model for green supply chain management practices implementation. *International Journal of Production Economics*, 111(2), 261-273. doi:<https://doi.org/10.1016/j.ijpe.2006.11.029>