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Change management for sustainability: Evaluating the role of human, operational and technological factors in leading Indian firms in home appliances sector

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A B S T R A C T

In green economy, the concepts like sustainable design, green products, clean technologies, eco-friendly processes have pushed the organizations to opt for change management initiatives, to accomplish sustainable development. Organizational sustainability has been defined using a triple bottom concept that addresses environmental issues, economic aspects, and social concerns. In this sense, it becomes imperative for organizations to evaluate the role of human, operational and technological aspects for setting sustainable business practices in a supply chain context. Sustainable operational practices will deliver the products to the society having zero defects and zero effect to the environment. Therefore, the present study targets to extend the change management initiatives to operations and supply management practices in the leading home appliances companies in India. The study identifies the key factors to sustainable operations management based on human-operational-technological aspects underpinned by literature and expert's agreement. The study proposes to use a fuzzy based Analytic Hierarchy Process and Decision Making Trial and Evaluation Laboratory techniques to prioritize the factors as well as evaluate the cause and effect relationships among factors. This study can facilitate managers to employ change management initiatives in adopting sustainability oriented human-operational-technological management practices and delivering the sustainable development goals of responsible consumption and production and affordable and clean energy in industrial supply chains. Finally, the recommendations to managers and directions for further research have been highlighted.

1. Introduction

Organizational sustainability has been defined using a triple bottom line (TBL) concept addressing environmental issues, economic aspects, and social concerns (Jabbour et al., 2013; Brandenburg et al., 2014; Mangla et al., 2017). TBL has served as the basis for management to transform its activities in operations (Drake and Spinler, 2013; Jabbour and de Sousa Jabbour, 2016) and supply management context (Carter and Rogers, 2008). Currently, the business performance is not only measured by its financial position, but also to attract more business underpin to sustainable production and environmental protection policies (Markley and Davis, 2007; Seuring and Müller, 2008; Gopalakrishnan et al., 2012). There are several studies discussing the TBL of sustainable development in manufacturing organizations (Drake and Spinler, 2013). In today's era of green economy, with the evolution of new concepts like sustainable design, green products, clean technologies, eco-friendly process (Büyüközkan and Berkol, 2011), the literature needs more studies targeting the extension of TBL dimensions of sustainable development in value chain context (Gopalakrishnan et al., 2012; Mangla et al., 2014). To bridge this gap, the present study targets on exploring the various dimensions of sustainable operations management (SOM) practices.

In the literature, little attention is provided to managing the waste generated from electrical and electronic components (WEEE). According to European Commission report in 2018, WEEE wastes (such as computers, TV-sets, fridges cell phones, electrical home appliances etc.) is the fastest growing waste among all the categories and expected to grow more than by 12 million tons by

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2020 in the European Union (EU) (http://ec.europa.eu/environment/waste/weee/index_en.htm). The domestic waste generated from WEEE is huge due to the large population burden in countries like India and China (Sepúlveda et al., 2010; Ongondo et al., 2011). In line with this, countries like India and China is also an attractive destination for importing the used electrical and electronic equipment (EEE) with an estimation of about 50K tons of WEEE imported every year (Manomaivibool, 2009; Ongondo et al., 2011).

With increasing amount of WEEE wastes, improper and unsafe disposal through incineration, and land fillings, consumer motivation to use remanufactured product, etc. have forced the United Nations to adopt the ambitious 2030 agenda for sustainable development in September 2015 (Balde et al., 2017; Vafadarnikjoo et al., 2018). Therefore, it is important to define certain sustainable measures for home appliances' manufacturing industries to deal with WEEE. These measures can be used to evaluate the WEEE's performance and build up higher brand image. There has been an increased recognition on accomplishing sustainability in supply chains among researchers and practitioners (Min and Kim, 2012); however, literature lacks studies evaluating the cause and effect relationships among SOM dimensions and ranking order among the various factors of SOM (Brandenburg et al., 2014; Mangla et al., 2018).

Therefore, to help manufacturing organizations, the present study answers few research questions:

i. What are the key factors to SOM considering human-operational-technological aspects in an industrial context?
ii. How are the listed factors prioritized in implementing SOM practices in an industrial context?
iii. How are the listed factors evaluated for knowing their causal relations?

We conducted a literature survey that lists the key factors to SOM. These factors were discussed with the industry experts. The present study further prioritize the key factors of SOM and analyze the factors for knowing their cause and effect groups to SOM. The problem addressed here is a type of multi-criteria evaluation and thus, a combined approach of fuzzy based Analytic Hierarchy Process (AHP) and Decision Making Trial and Evaluation Laboratory (DEMATEL) was used as an appropriate methodology (Gandhi et al., 2016). To accomplish our objectives, data from five home appliance companies in India have been gathered. The organizations under study are committed to accomplish sustainability in their operations.

There are seven sections in this work, which are presented ahead from readers' perspectives.

2. Literature review

This section highlights the literature on SOM dimensions. In addition, various research gaps have also been shown in this section.

2.1. SOM: an overview

SOM can minimize waste and ensure the proper resource utilization in a manufacturing environment. SOM targets the following areas in manufacturing organizations - supply and production and operations management, research and development, reverse supply chain, human resources, environmental issues, social issues, and economic issues (Ramudhin et al., 2009; Büyüközkan and Berkol, 2011; Tang and Zhou, 2012; Ahi and Searcy, 2013; Belvedere and Grando, 2017; Genovese et al., 2017; Hernandez-Vivanco et al., 2018). Green supply chains target at reducing the adverse ecological impact and can be implemented by considering environmental issues during purchasing, comprehensive purchasing policies, and collaboration with suppliers (Gold et al., 2010). The manufacturing organizations can redesign their products and processes to develop the eco-friendly manufacturing processes and products (Andersen and Skjoett-Larsen, 2009). Sustainable manufacturing also ensure the remanufacturing at the end of life and define techniques to extend the life of the products (Geyer et al., 2007; Linton et al., 2007). Moreover, the integration of green techniques with lean production may facilitate the sustainable supply chains (Farahani and Elahipanah, 2008; Mollenkopf et al., 2010) adoption and help in reducing the wastes such as time, space, process, labor, material, and equipment (Corbett and Klassen, 2006). Corporate social responsibility (CSR) touches the social aspect of sustainable operations (Spence and Bourlakis, 2009; Gold et al., 2010). CSR is extended beyond business ethics and includes dimensions such as manufacturing process, employment opportunities, human rights, workplace diversity, community etc (Carter and Jennings, 2002). There are various studies targeting the role of stakeholders in SOM. Schramm-Klein et al. (2016) defined sustainability considering welfare of employees and middle management. Walker et al. (2008) observed customers' pressure on maintaining sustainability, and Norman and MacDonald's (2004) stressed on benefits of stakeholders while implementing sustainable supply chains. Hence, SOM practices not only focus on the people and green dimension, but also consider the role of stakeholders.

2.2. Proposed factors to SOM considering human-operation-technological aspects

Literature highlighted various dimensions of green management, given as eliminating environmental impacts of business (Andiç et al., 2012; Gandhi et al., 2015; Mangla et al., 2015); raising profits and market share by improving ecological efficiency (Büyüközkan and Çifçi, 2012); environmental performance (Parmigiani et al., 2011); integrating environmental issues in supply chain product design, material selection and sourcing, recovering value of products after their end of life (Gnoni et al., 2011); and decision-making analysis on environmental management choices (Srivastava, 2007). Carter and Jennings (2002) provided six main aspects to define logistics social responsibility, which includes - human rights and working conditions, environment, diversity, ethics, community involvement, and safety. Carter and Jennings (2002) stressed that supply chains should be closed loop, eco-friendly that ensures the maximum utilization of the resources. Guide and van Wassenhove (2009) described the closed loop supply chain into five major phases - activities of reverse logistics, reverse logistics networks, inventory management and remanufacturing, the economic perspective of the product recovery, system design for profitability, and final phase focuses on the marketing and customer reactions on the recovered products. Deakin (2001) advocated that the transport mode should account for the human and ecosystem prosperity while meeting the logistics needs of the society.

Green operations management will help to reduce wastes and costs by improving the quality and environmental performance (Curkovic and Sroufe, 2011). According to Kleindorfer et al. (2005), SOM utilizes the tools of lean manufacturing to ensure the green practices. Linton et al. (2007) stated that product design is a significant phase in deciding its impact on the environment. Total quality environmental management further focuses on the integration of ecological concerns with a quality management system (Curkovic and Sroufe, 2011).

Gopalakrishnan et al. (2012) advocated that sustainable human resource practices such as workplace benefits, skill development programs, compensation policies, health and safety measures, and retirement funds would help to improve employees' commitment towards the sustainable development of the organization. According to Hediger (2000), training, education, income, communication, social contacts, and social security have been the core elements of sustainable business at the micro level and distribution of income and assets have been added to the macro perspective (Fischer-Kowalski et al., 1995).

Hence, various factors affecting sustainable development in the manufacturing organizations were hypothesized to exist. Experts working in the related fields were consulted for finalizing the factors of SOM. In overall, 41 factors (shown in Table 1) affecting the SOM practices in manufacturing organizations, were identified.

2.3. Research gaps

As SOM has been emerged as a global issue for the business organizations, so managers are striving hard to develop more sustainable practices in their organization. According to the United Nations (2004) report, 20–25 million tons of CO_2 have been added to the oceans every day, which are triggering the climate change and global warming. In case of developing economies like India and China, the emission of CO_2 from fossil fuels has increased more than 50% to its levels in 1990 (Olivier et al., 2012). According to IPCC (2007) report, around 45% of the total carbon emission is contributed by the production and transportation of goods.

In literature, researcher suggested that organizations need to consider ecological and social aspects while fulfilling their economic gains; (Wu et al., 2008), however, environmental obligations will also add more costs to the organizations (Margolis et al., 2009; Wu and Pagell, 2011). Hence, it is important to focus on the economic parameters while implementing the SOM practices in different industries such as households' appliances industry. The Indian Government is drafting the WEEE legislation (Sepúlveda et al., 2010), however, due to poor regulations, some organizations are importing the WEEE and abstracting the reusable parts form the equipment in an unprofessional manner, which is creating high health risks and damage to the environment (Sepúlveda et al., 2010; Ongondo et al., 2011). To overcome these challenges, the manufacturing organizations must seek to adopt SOM practices in

Table 1
Factors to SOM.

Factors	References
Green logistics	Zhu et al. (2007); Sbihi and Eglese (2007); Ramudhin et al. (2009); Ahi and Searcy (2013); Genovese et al. (2017).
Green procurement	Markley and Davis (2007); Testa et al. (2016).
Logistics social responsibility	Carter and Jennings (2002); Linton et al. (2007).
Sustainable warehousing	Carter and Jennings (2002); Ahi and Searcy (2013); Rajeev et al. (2017).
Vehicle routing and scheduling	Linton et al. (2007); Ramudhin et al. (2009).
Logistics and supply chain integration	Farahani and Elahipanah (2008); Govindan and Soleimani (2017).
Green manufacturing	Kleindorfer et al. (2005); Ramudhin et al. (2009); Gupta and Palsule-Desai (2011); Hernandez-Vivanco et al. (2018).
Green/sustainable packaging	James et al. (2005); Ciliberti et al. (2008).
Inventory operations	Markley and Davis (2007); Ramudhin et al. (2009).
Productivity	Keating et al. (2008); Büyüközkan and Berkol (2011).
Reduce production risks	James et al. (2005); Mangla et al. (2015).
Green product development	Kleindorfer et al. (2005); Linton et al. (2007); Markley and Davis (2007); Ramudhin et al. (2009); Jabbour et al. (2015).
Green process development	Kleindorfer et al. (2005); De Brito et al. (2008).
Product life extension	Linton and Jayaraman (2005); Geyer et al. (2007); Linton et al. (2007).
Technology commercialization	Markley and Davis (2007); Büyüközkan and Berkol (2011); Hernandez-Vivanco et al. (2018).
Green manufacturing facilities	Markley and Davis (2007); Ramudhin et al. (2009).
Remanufacturing	Kleindorfer et al. (2005); Linton et al. (2007); Ramudhin et al. (2009); Gupta and Palsule-Desai (2011); Govindan and Soleimani (2017).
Circular economy	Kleindorfer et al. (2005); Gupta and Palsule-Desai (2011); Govindan and Cheng (2015); Belvedere and Grando (2017).
Waste management	Markley and Davis (2007); Linton et al. (2007); Sbihi and Eglese (2007); Ramudhin et al. (2009); Büyüközkan and Berkol (2011); Tang and Zhou (2012).
Recycling	De Brito et al. (2008); Gold et al. (2010); Zailani et al. (2012).
Reverse logistics	Linton et al. (2007); Ramudhin et al. (2009); Mangla et al. (2016a,b); Govindan and Soleimani (2017).
Sustainable HRM practices	Hart and Milstein (2003); De Brito et al. (2008); Gopalakrishnan et al. (2012).
Skilled human resources	De Brito et al. (2008); Büyüközkan and Berkol (2011); Jabbour et al. (2015); Jabbour and de Sousa Jabbour (2016).
Work hygiene and health facilities	Spence and Bourlakis (2009); Gold et al. (2010).
Consumption of natural resources	Ukidwe and Bakshi (2005); Markley and Davis (2007); Munda (2009); Mutti et al. (2012); Tang and Zhou (2012).
Pollution emission	Markley and Davis (2007); Ramudhin et al. (2009); Büyüközkan and Berkol (2011); Gupta and Palsule-Desai (2011); Gopalakrishnan et al. (2012).
Clean/sustainable transport modes	Deakin (2001); De Brito et al. (2008).
Global warming	Gupta and Palsule-Desai (2011); Gopalakrishnan et al. (2012).
Wages and Income distribution	Hediger (2000); Metzner (2000); Spangenberg (2004); Mutti et al. (2012).
Employment	Mutti et al. (2012); Gopalakrishnan et al. (2012).
Community wellbeing and safety	Seuring (2013); Hodges (2009); Gopalakrishnan et al. (2012).
Population growth	Seuring (2013).
Cultural impacts	Gopalakrishnan et al. (2012).
Social uncertainties	Mutti et al. (2012).
Operational costs	Margolis et al. (2009); Wu and Pagell (2011); Lovrić et al. (2013); Tukker (2015).
Profitability	Carter and Rogers (2008); Lovrić et al. (2013); Golicic and Smith (2013).
Stakeholders' role (primary and secondary)	Pagell and Wu (2009); Carter and Rogers (2008); Badurdeen et al. (2009); Gopalakrishnan et al. (2012).
GDP contribution	Golicic and Smith (2013).
Labour efficiency	Lovrić et al. (2013).
Market concentration	Carter and Rogers (2008).
Import dependency	Golicic and Smith (2013).

the household appliances sector (Ongondo et al., 2011). The area of SOM practices in a household appliance is comparatively less explored (Manomaivibool, 2009; Ongondo et al., 2011; Brandenburg et al., 2014), which provides justification to conduct this work.

3. Research methods

The present research uses a combined hybrid (fuzzy AHP-DEMATEL) approach (Sun, 2010; Chou et al., 2012; Pandey and Kumar, 2017). AHP is a structured tool used for analyzing the complex decisions through hierarchical structure (Ananda and Herath, 2009; Thakur and Ramesh, 2017). However, decision-making involves subjective judgments, qualitative evaluations, perception, and imprecision, (Chou et al., 2012). Hence, to deal with this problem of vague information, several researchers have combined AHP with fuzzy set theory, (Pandey and Kumar, 2017; Mangla et al., 2017). Fuzzy-DEMATEL is helpful in identifying the interrelationships among various factors of investigation under uncertain conditions and information (Lin, 2013; Mangla et al., 2016b). In the present study, fuzzy-DEMATEL helps in categorizing the various factors of SOM in the cause and effect groups.

Amui et al. (2017) suggested that for future sustainable transition researchers should mix various methodologies in various sectors in developing countries.

Furthermore, the fuzzy-AHP and fuzzy-DEMATEL have been combined for the following reasons (Sun, 2010; Chou et al., 2012; Pandey and Kumar, 2017; Mangla et al., 2015): firstly, the prioritization of the factors will help the managers to understand rank of each factor in implementing SOM practices. Secondly, fuzzy-DEMATEL will provide the additional information about the cause-effect relationships among factors, which will help the managers to target the cause variables more in comparison to effect variables in improving long-term performance of the organizations. Thirdly, fuzzy set theory will help in understanding factors deeply by capturing the responses on fuzzy triangular number scale. Finally, the combined fuzzy-AHP and fuzzy-DEMATEL approach will provide comprehensive information that help in setting up the standards operating procedures (SOPs) for business organizations to adopt SOM. Table 2 highlights the applications of the proposed hybrid approach, in various fields.

3.1. Fuzzy set theory

Zadeh (1965) introduced the fuzzy concepts to assist decision making in managerial perspectives. Decision making in business organizations depends on several criteria such as qualitative perceptions provided by human beings, shortage of data, uncertainty in judgements etc. In this sense, business manager's needs to transform linguistic judgements of humans into definite forms for making effective decisions with limited information (Zimmerman, 1996). In uncertain situations, the experts need to use the linguistic variables to make the pair-wise comparisons (Lin, 2013). Further, the results computed can be misleading, if fuzziness during recording uncertain situations is not handled properly (Vafadarnikjoo et al., 2018). Thus, we have used triangular fuzzy numbers (TFNs) to decode the linguistic variables. A fuzzy set is characterized by the membership function, with factors value between zero and one. TFN represented by (l, m, u) has been assigned to various factors.

3.2. Fuzzy AHP

Prof. T. L. Saaty developed AHP, a decision-making technique in the 1971 (Saaty, 1980). AHP is relatively easier and flexible to use (Ananda and Herath, 2009). AHP prioritizes the various factors/alternatives using pair-wise comparison matrices (Tseng et al., 2009; Gandhi et al., 2016; Thakur and Ramesh, 2017). Recent trends in research have shown that using hybrid approach by combining AHP with other models have proliferated, so that synergy can be maximized (Mangla et al., 2016a; Luthra et al., 2017). Fuzzy-AHP is the advanced version of AHP, where the uncertain information collected from various experts is processed to prioritize the factors (Mangla et al., 2015, 2017). The present study includes the following steps of Fuzzy-AHP:

Step 1: Statement of the problem – to prioritize the factors to SOM.
Step 2: Identify all the dimensions and factors affecting the sustainable manufacturing practices.
Step 3: Develop the pair-wise comparison matrices. Here, the pair-wise comparison matrices among all the dimensions and factors have been developed using expert's opinions. The preferences of each factor over other have been recorded using Table 3.

The pair-wise comparison matrix is constructed, as shown in Eqn. (1) below:

$$\tilde{A}^k = \begin{matrix} \tilde{x}^k_{11} & \tilde{x}^k_{12} & \ldots\ldots & \tilde{x}^k_{1n} \\ \tilde{x}^k_{21} & \tilde{x}^k_{22} & \ldots\ldots & \tilde{x}^k_{2n} \\ \ldots & \ldots & \ldots\ldots & \ldots \\ \tilde{x}^k_{n1} & \tilde{x}^k_{n2} & \ldots\ldots & \tilde{x}^k_{nn} \end{matrix} \quad (1)$$

Where, $\tilde{A}^k$ represents the pair-wise comparison matrix concluded from kth brain-storming session. $\tilde{x}^k_{ij}$ represents the preference of ith

Table 3
Fuzzy linguistic scale for prioritizing each factor.

Linguistic variables	TFN	Inverse TFN
Equally preferred $(\tilde{1}/\tilde{1}^{-1})$	(1, 1, 1)	(1, 1, 1)
Weakly preferred $(\tilde{2}/\tilde{2}^{-1})$	(1, 3, 5)	(1/5, 1/3, 1)
Strongly preferred $(\tilde{3}/\tilde{3}^{-1})$	(3, 5, 7)	(1/7, 1/5, 1/3)
Very strongly preferred $(\tilde{4}/\tilde{4}^{-1})$	(5, 7, 9)	(1/9, 1/7, 1/5)
Extremely more preferred $(\tilde{5}/\tilde{5}^{-1})$	(7, 9, 11)	(1/11, 1/9, 1/7)

Source: Kabra and Ramesh (2015).

Table 2
Applications of hybrid AHP/fuzzy-AHP and DEMATEL/fuzzy-DEMATEL.

Sl. No.	Area	Reference
1.	Examined the human resource for science and technology	Chou et al. (2012)
2.	Examined ERP adoption in the organization.	Rouhani et al. (2013)
3.	Evaluating the performance indicators of human resource management.	Abdullah and Zulkifli (2015)
4.	Evaluated the green management adoption	Gandhi et al. (2016)
5.	Evaluated the reverse logistics adoption	Mangla et al. (2016a)
6.	Evaluated the incomplete pair-wise comparison done in AHP.	Zhou et al. (2018)

factor over jth factor given by kth team/panel. For all pair-wise comparison matrices resulted from five different brain-storming sessions, the average has been calculated as shown below:

$$\tilde{x}_{ij} = \frac{\sum_{k=1}^{k} \tilde{x}_{ij}^{k}}{k} \quad (2)$$

k = number of brain-storming sessions.

Step 4: The geometric mean of fuzzy values of all the pair-wise comparison matrices has been calculated by using following equation (Buckley, 1985):

$$\widetilde{GM}_i = \left[\prod_{j=1}^{n} \widetilde{x_{ij}} \right]^{1/n}, \; i = 1,\, 2,\, \ldots,\, n \quad (3)$$

Step 5: Now, to calculate the fuzzy weights of each factor, the following steps are taken:

i) Compute the vector summation of each $\widetilde{GM}_i$ for all the factors.
ii) Find the inverse vector of summation of $\widetilde{GM}_i$ and arrange the triangular fuzzy number in-terms of increasing order.
iii) To find out the fuzzy weight of ith criterion, multiply each $\widetilde{GM}_i$ with the reverse vector.

$$\widetilde{w_i} = \widetilde{GM}_i * \left(\widetilde{GM}_1 + \widetilde{GM}_2 + \ldots\ldots + \widetilde{GM}_i \right)^{-1} \quad (4)$$

$$= (lw_i,\, mw_i,\, uw_i)$$

Step 6: The $\widetilde{w_i}$ is a TFN and need to be converted into single crisp values. Here, the center of area method given by Chou and Chang (2008), has been used for defuzzification.

$$\boldsymbol{C_i} = \frac{(lw_i,\, mw_i,\, uw_i)}{3} \quad (5)$$

Step 7: In the end, all-crisp values need to be normalized by applying the following equation:

$$N_i = \frac{\boldsymbol{C_i}}{\sum_{i=1}^{n} \boldsymbol{C_i}} \quad (6)$$

3.3. Fuzzy-DEMATEL

DEMATEL method can solve problems based on the visualization method (Wu and Tsai, 2012; Lin, 2013; Mangla et al., 2018). DEMATEL technique uses structural modeling method to depict the effect of one factor on the other and also the directions of relationships among the various factors involved in the study. Further, we applied fuzzy DEMATEL (Mangla et al., 2016b) for handling uncertain situation using following steps:

Step 1: Calculate the average crisp values for all the pair-wise comparisons

The responses about the relationships among various factors are recorded from the industry experts' panel. Experts have given their preferences for various factors using the five-point linguistic scale as shown in Table 4. Then these linguistic variables are decoded into

Table 4
Fuzzy linguistic scale for recording influence of one factor on other.

Linguistic variables	Triangular fuzzy number
No influence ($\tilde{1}$)	(0, 0.1, 0.3)
Very low influence ($\tilde{2}$)	(0.1, 0.3, 0.5)
Low influence ($\tilde{3}$)	(0.3, 0.5, 0.7)
High influence ($\tilde{4}$)	(0.5, 0.7, 0.9)
Very high influence ($\tilde{5}$)	(0.7, 0.9, 1.0)

Source: Wu and Lee (2007).

TFNs, which have been further converted into crisp values for mathematical calculations.

To get the aggregated results from TFNs, the defuzzification steps (shown in Appendix A (a1-a9)) are used to compute the crisp value from the defined fuzzy set (Lin, 2013).

Step 2: Compute average relationship matrix (A)

Here, average direct relationship matrix is developed by calculating the average of all the ratings assigned by various experts. Hence, to calculate the average matrix of all the responses, the following equation is used:

$$A = [a_{ij}] = 1/n \sum_{k=1}^{n} a_{ij}^{k} \quad (7)$$

Step 3: Normalize the direct relationship matrix

Here, the direct relationship matrix is normalized by using following equation:

$$F = m \times A \quad (8)$$

Where,

$$m = 1 \Big/ \max_{1 \le i \le n} \sum_{j=1}^{n} a_{ij} \quad (9)$$

Step 4: Total relationship matrix

Total direct relation matrix is computed using the following equation:

$$T = F(I - F)^{-1} \quad (10)$$

where I represents the identity matrix.

Let 'RS' and 'CS' represent the row sum and column sum in the matrix 'T' respectively. The $(RS)_i$ value reflects the total direct and indirect effects given by the ith factor on the other factors in the final developed digraph. Similarly, $(CS)_j$ value indicates the total direct and indirect effect received by the jth factor from all other factors in the model. For all i = j, the total of row and column sum ($RS_i + CS_j$) reflects the total effect contributed and received by ith factor in the whole model developed. Hence, higher the value of ($RS_i + CS_j$), more important that factor is in the model. (RS_i-CS_j) value illustrates the net effect contributed by the ith factor in the system. If (RS_i-CS_j) gives positive value, then it indicates that ith factor is a net cause variable in the developed model and if value is negative then ith factor is the net receiver variable (Lee et al., 2011).

Step 5: Develop the digraph: Finally, the digraph is developed by setting up the threshold value. Digraph considers the values greater than the threshold value. The digraph is developed by drawing the dataset of (RS + CS, RS-CS) on the two-dimensional plane.

4. Proposed framework

Fig. 1 illustartes the research framework proposed for the present study. The study has been carried out in three stages as highlighted below:

Phase 1: Identification and validation of factors (human-operational-technological aspects) to SOM

The factors to SOM practices in HAIs were identified through literature review, field surveys and experts' opinion. The identified factors of SOM practices were empirically validated through questionnaire survey in the HAIs.

Phase 2: Prioritisation of factors

After validation of factors of SOM, the fuzzy-AHP approach has been applied to prioritize the factors. The responses related to preferences over various factors have been collected through the brain-storming sessions held with the industry experts.

Phase 3: Categorisation of factors into cause and effect

After the prioritization, these factors were analyzed to find the cause and effect groups. The opinion from the industry experts were taken as input for this.

5. Case study

Initially, we approached 12 manufacturing units, but due to seasonal demand of the products and other operational issues, only five manufacturing units were participated (see Table 5) in this work. The other reason for participation in this study by the five organizations is - all five units are involved in the environmental sustainability practices. All these manufacturing units may vary in their product range, but for our study we have considered the operations and supply chain practices of those appliances' industries, which are having the product age between 8 and 12 years (like: juicer, mixture and grinders (JMG), air condition (AC), iron, fans, cooler, dishwashers, washing machines, microwave ovens, freezers etc.). All these manufacturing units may have different products mix, but they are somewhat similar in their operational and supply chain practices.

The data collection process for this work lasted for approximately five months (March 2018 to July 2018), including the brainstorming sessions. Brainstorming sessions were held with the experts of different areas to get the preferences of one factor over other factors. The qualitative data were recorded form each brain-storming session and further used for the analysis. Data collection has been done in two stages: firstly, all the identified variables of SOM have been verified through experts' inputs in various brain-storming sessions and secondly, the selected variables have been further analyzed with respect to HAIs. Data were collected from the manufacturing plants, which have been producing the home appliances with products' average age between 8 and 12 years. As per the proposed framework, the three phases' results have been shown in the following sub-sections.

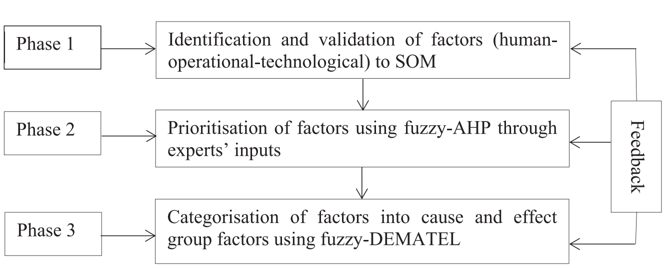


Fig. 1. Proposed research framework.

5.1. Phase 1: identification and validation of factors (human-operational-technological aspects) to SOM

First stage questionnaire has been developed by including 41 factors of SOM practices in manufacturing industries irrespective of the nature of the product, they are producing. Then these items have been verified by conducting the survey through various home appliances manufacturing organizations in India. The inputs from the experts from the manufacturing industries and other pilot surveys ensured the reliability and face validity of the questionnaire (Ye and Wang, 2013). The five-point Likert's scale (ranging from strongly disagree (1) to strongly agree (5)) has been developed to record the preferences of the respondents over these 41 items. The detailed sample taken from each firm and effective questionnaires received (response rate) have been shown in Table 5. Notably, 250 questionnaires were sent to five home appliances industries and we received 197 filled questionnaires back, out of which 44 were incomplete. Hence, finally, 153 questionnaires were analyzed (with a response rate of 61.2%), which is acceptable as per Hair et al. (2009).

The descriptive statistics of the survey has been highlighted in Table 6. The results clearly show that not all factors of SOM practices are significant for the home appliance manufacturing organization. Out of total 41 factors identified, only 28 factors are having the mean score ranging from 3.92 to 4.61 with a standard deviation (SD) of ranging from 0.675 to 0.839. Thereafter, the selected 28 factors have been categorized into eight dimensions of SOM practices with the consent of industry experts. Hence, finally, 28 factors of SOM in HAIs have been further analyzed for implementation purpose.

5.2. Phase 2: prioritisation of factors to SOM

Next, the selected factors were analyzed for their ranking. To collect the experts' opinion, five brainstorming sessions were held with experts of five different manufacturing firms. The members present in each session and their experience details have been highlighted in Table 5. Each brainstorming session was started with the structured questionnaire and the responses from the five brainstorming sessions have been collected. The preferences for eight main dimensions of SOM have been compiled from brain-storming sessions. The pairwise comparison matrices for eight dimensions have been highlighted in Table 7.

The above linguistic pair-wise comparison matrix has been converted into TFNs using Table 3 and further, the average matrix from all the five brain-storming sessions have been computed by applying Eqn. (2). Thereafter, the geometric mean for all the pair-wise comparisons has been calculated by using Eqn. (3). After calculating the aggregated matrix, now, the vector sum of the geometric mean for each factor is computed as defined in Step 5 in the methodology section. Thereafter, Eqn. (4) has been applied to calculating the fuzzy weight of each dimension of SOM. These fuzzy weights have been further converted into crisp values using Eqn.

Table 5
Details of five manufacturing firms and experts participated in brainstorming sessions.

Manufacturing unit	Location	Products considered	Sample for empirical investigation		Members in the brain-storming sessions			
			Sample	Response rate	Experience (10–15 years)	Experience (15–20 years)	Experience (20–25 years)	Total members
A	Baddi, Himachal Pradesh, India	JMG, Irons, Fans, AC	50	37 (74%)	07	03	01	11
B	Baddi, Himachal Pradesh, India	JMG, Fans, Coolers	50	23 (46%)	08	03	02	13
C	Chandigarh, India	AC, Coolers, Fans, Dishwashers	50	41 (82%)	10	01	00	11
D	NCR, Delhi, India	Freezers, AC, Coolers, Fans	50	19 (38%)	06	05	03	14
E	NCR, Delhi, India	Microwave oven, JMGs, Irons	50	33 (66%)	07	02	03	12

Table 6
Descriptive statistics for SOM dimensions.

Dimensions	SOM sub-factors	Mean	SD	Further analysis
Supply chain and logistics management (SCLM)	Green logistics (SCLM1)	3.95	0.79	Included
	Green procurement (SCLM2)	3.96	0.81	Included
	Logistics social responsibility (SCLM3)	3.92	0.68	Included
	Sustainable warehousing (SCLM4)	4.21	0.67	Included
	Vehicle routing and scheduling (SCLM5)	2.99	0.83	Deleted
	Logistics and supply chain integration (SCLM6)	2.09	0.73	Deleted
Production management (PM)	Green manufacturing (PM1)	3.98	0.77	Included
	Green/sustainable packaging (PM2)	4.60	0.81	Included
	Inventory operations (PM3)	4.01	0.83	Included
	Productivity (PM4)	4.13	0.69	Included
	Reduce production risks (PM5)	1.50	0.67	Deleted
Innovation and technological aspects (ITA)	Green product development (ITA1)	4.57	0.80	Included
	Green process development (ITA2)	4.51′	0.72	Included
	Product life extension (ITA3)	4.25	0.79	Included
	Technology commercialization (ITA4)	4.13	0.68	Included
	Green manufacturing facilities (ITA5)	3.01	0.75	Deleted
Resource recovery management (RRM)	Remanufacturing (RRM1)	4.54	0.69	Included
	Circular economy ((RRM2)	4.22	0.80	Included
	Waste management (RRM3)	3.99	0.72	Included
	Recycling (RRM4)	4.58	0.69	Included
	Reverse logistics (RRM5)	2.04	0.67	Deleted
Human resources (HR)	Sustainable HRM practices (HR1)	4.01	0.68	Included
	Skilled human resources (HR2)	3.92	0.81	Included
	Work hygiene and health facilities (HR3)	3.95	0.77	Included
Environmental aspects (EA)	Consumption of natural resources (EA1)	4.61	0.71	Included
	Pollution emission (EA2)	4.52	0.79	Included
	Clean/sustainable transport modes (EA3)	4.24	0.76	Included
	Global warming (EA4)	2.96	0.81	Deleted
Social aspects (SA)	Wages and Income distribution (SA1)	4.48	0.83	Included
	Employment (SA2)	4.02	0.69	Included
	Community wellbeing and safety (SA3)	3.98	0.69	Included
	Population growth (SA4)	1.23	0.61	Deleted
	Cultural impacts (SA5)	2.45	0.74	Deleted
	Social uncertainties (SA6)	1.98	0.84	Deleted
Economic issues (EI)	Operational costs (EI1)	4.55	0.71	Included
	Profitability (EI2)	4.61	0.77	Included
	Stakeholders' role (primary and secondary) (EI3)	3.99	0.77	Included
	GDP contribution (EI4)	2.21	0.78	Deleted
	Labour efficiency (EI5)	2.98	0.69	Deleted
	Market concentration (EI6)	2.28	0.73	Deleted
	Import dependency (EI7)	2.45	0.75	Deleted

(5). Finally, the priority weight of each dimension has been normalized and results have been highlighted in Table 8.

Similarly, the pair-wise comparison matrices for various sub-factors grouped into main dimensions of SOM, have been recorded (as highlighted in Appendix B1-B8). Thereafter, the individual weight of each factor, their priority weights and the overall relative weight of each factor have been computed as shown in Table 8.

5.3. Phase 3: classification of factors into cause and effect group

To develop the cause and effect digraph, the experts in the brainstorming sessions were asked to rate the degree of influence of one factor on the other on a scale of 1–5 as shown in Table 4. The linguistic data collected from five different sessions have been converted into TFNs and further normalized by using equations shown in Appendix A (a1-a6). The obtained right and left

Table 7
Pair-wise comparison matrix of dimensions of SOM.

	SCLM	PM	ITA	RRM	HR	EA	SA	EI
SCLM	(1, 1, 1)	$\tilde{2}^{-1}, \tilde{1}^{-1}, \tilde{2}^{-1}, \tilde{3}^{-1}, \tilde{2}^{-1}$	$\tilde{3}^{-1}, \tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{3}^{-1}, \tilde{4}^{-1}$	$\tilde{5}^{-1}, 5^{-1}, \tilde{3}^{-1}, \tilde{5}^{-1}, 4^{-1}$	$\tilde{2}, \tilde{1}, \tilde{2}, \tilde{3}, \tilde{3}$	$\tilde{5}^{-1}, \tilde{4}^{-1}, \tilde{3}^{-1}, \tilde{5}^{-1}, \tilde{5}^{-1}$	$\tilde{3}^{-1}, \tilde{5}^{-1}, \tilde{3}^{-1}, \tilde{4}^{-1}, \tilde{2}^{-1}$	$\tilde{4}^{-1}, \tilde{5}^{-1}, \tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{4}^{-1}$
PM		(1, 1, 1)	$\tilde{2}^{-1}, \tilde{2}^{-1}, \tilde{1}^{-1}, \tilde{4}^{-1}, \tilde{3}^{-1}$	$\tilde{4}^{-1}, \tilde{2}^{-1}, \tilde{5}^{-1}, \tilde{4}^{-1}, \tilde{4}^{-1}$	$\tilde{3}, \tilde{2}, \tilde{4}, \tilde{3}, \tilde{2}$	$\tilde{3}^{-1}, \tilde{4}^{-1}, \tilde{2}^{-1}, \tilde{5}^{-1}, \tilde{3}^{-1}$	$\tilde{3}, \tilde{2}, \tilde{3}, \tilde{3}, \tilde{2}$	$\tilde{4}, \tilde{2}, \tilde{1}, \tilde{3}, \tilde{2}$
ITA			(1, 1, 1)	$\tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{2}^{-1}, \tilde{4}^{-1}, \tilde{2}^{-1}$	$\tilde{2}, \tilde{3}, \tilde{4}, \tilde{3}, \tilde{5}$	$\tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{2}^{-1}, \tilde{4}^{-1}, \tilde{2}^{-1}$	$\tilde{3}, \tilde{4}, \tilde{1}, \tilde{3}, \tilde{2}$	$\tilde{3}, \tilde{4}, \tilde{4}, \tilde{3}, \tilde{2}$
RRM				(1, 1, 1)	$\tilde{3}, \tilde{5}, \tilde{4}, \tilde{3}, \tilde{5}$	$\tilde{2}^{-1}, \tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{4}^{-1}, \tilde{2}^{-1}$	$\tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{2}^{-1}, \tilde{4}^{-1}, \tilde{2}^{-1}$	$\tilde{2}^{-1}, \tilde{2}^{-1}, \tilde{3}^{-1}, \tilde{4}^{-1}, 3^{-1}$
HR					(1, 1, 1)	$\tilde{5}^{-1}, \tilde{4}^{-1}, \tilde{5}^{-1}, \tilde{3}^{-1}, \tilde{4}^{-1}$	$4^{-1}, \tilde{5}^{-1}, 3^{-1}, \tilde{4}^{-1}, 4^{-1}$	$\tilde{5}^{-1}, \tilde{4}^{-1}, \tilde{3}^{-1}, \tilde{5}^{-1}, \tilde{4}^{-1}$
EA						(1, 1, 1)	$\tilde{3}, \tilde{4}, \tilde{5}, \tilde{3}, \tilde{4}$	$\tilde{3}, \tilde{1}, \tilde{4}, \tilde{3}, \tilde{2}$
SA							(1, 1, 1)	$\tilde{2}^{-1}, 3^{-1}, \tilde{2}^{-1}, \tilde{4}^{-1}, \tilde{2}^{-1}$
EI								(1, 1, 1)

Table 8
Weights of eight dimensions and 28 sub-factors of SOM.

SOM Dimensions	Normalized priority weights	Ranking order	SOM sub-factors	Normalized priority weights	Overall priority weights	Ranking order
SCLM	0.034	7	SCLM1	0.068	0.002	27
			SCLM2	0.271	0.009	20
			SCLM3	0.076	0.003	26
			SCLM4	0.585	0.020	13
PM	0.101	5	PM1	0.064	0.006	23
			PM2	0.571	0.058	5
			PM3	0.133	0.013	18
			PM4	0.232	0.023	12
ITA	0.164	2	ITA1	0.570	0.093	2
			ITA2	0.283	0.046	8
			ITA3	0.103	0.017	15
			ITA4	0.044	0.007	21
RRM	0.139	3	RRM1	0.308	0.043	9
			RRM2	0.128	0.018	14
			RRM3	0.042	0.006	24
			RRM4	0.522	0.073	3
HR	0.020	8	HR1	0.703	0.014	17
			HR2	0.079	0.002	28
			HR3	0.218	0.004	25
EA	0.352	1	EA1	0.763	0.269	1
			EA2	0.162	0.057	6
			EA3	0.075	0.026	11
SA	0.079	6	SA1	0.707	0.056	7
			SA2	0.091	0.007	22
			SA3	0.207	0.016	16
EI	0.111	4	EI1	0.301	0.033	10
			EI2	0.614	0.068	4
			EI3	0.084	0.009	19

normalized triangular values have been converted into crisp numbers by applying equations shown in Appendix A (a7-a9). Thereafter, Eqn. (7) has been applied to calculate the initial direct relationship matrix (A) (shown in Eqn. (11)) of eight dimensions to SOM.

$$A=\begin{bmatrix} 0 & 0.578 & 0 & 0.766 & 0.358 & 0.766 & 0.376 & 0.766 \\ 0.766 & 0 & 0.358 & 0.376 & 0.376 & 0.578 & 0.376 & 0.766 \\ 0.578 & 0.766 & 0 & 0.766 & 0 & 0.766 & 0.376 & 0.578 \\ 0.578 & 0.766 & 0.766 & 0 & 0 & 0.766 & 0.578 & 0.766 \\ 0.376 & 0.578 & 0.578 & 0.578 & 0 & 0.578 & 0.766 & 0.766 \\ 0.578 & 0.766 & 0.358 & 0.358 & 0 & 0 & 0.578 & 0.578 \\ 0 & 0.376 & 0 & 0.358 & 0.578 & 0.376 & 0 & 0.766 \\ 0.766 & 0.578 & 0.358 & 0.578 & 0.578 & 0.578 & 0.578 & 0 \end{bmatrix} \quad (11)$$

Now, the initial direct relationship has been normalized, which is further converted into Total relation matrix has been calculated using Eqn. (10).

Total relation matrix

$$(T)=\begin{bmatrix} 0.26 & 0.40 & 0.17 & 0.38 & 0.21 & 0.43 & 0.32 & 0.47 \\ 0.40 & 0.30 & 0.23 & 0.32 & 0.22 & 0.40 & 0.32 & 0.47 \\ 0.38 & 0.45 & 0.18 & 0.40 & 0.15 & 0.45 & 0.33 & 0.45 \\ 0.40 & 0.47 & 0.32 & 0.29 & 0.17 & 0.47 & 0.38 & 0.51 \\ 0.37 & 0.44 & 0.30 & 0.39 & 0.17 & 0.44 & 0.42 & 0.51 \\ 0.34 & 0.39 & 0.21 & 0.29 & 0.14 & 0.26 & 0.32 & 0.40 \\ 0.19 & 0.28 & 0.13 & 0.24 & 0.22 & 0.28 & 0.18 & 0.37 \\ 0.42 & 0.43 & 0.25 & 0.38 & 0.26 & 0.43 & 0.38 & 0.37 \end{bmatrix} \quad (12)$$

From the total relationship matrix (T), the total effect given and received by a particular dimension has been calculated. Table 9 highlights the interrelationships among eight dimensions to SOM. Fig. 2 depicts the corresponding cause and effect digraph for the dimensions. The direction of arrow coming out from the particular dimension in the digraph represents the effect contributed to the dimension at the head of the arrow. The arrow coming into the dimension shows the total effect received by that factor from the other factors in the digraph.

Similarly, all the sub-factors categorized under eight dimensions

Table 9
Cause and effect analysis of all dimensions and sub-factors of SOM.

Dimensions	R + C	R–C	Dimensions' Group	Sub-factors	R + C	R–C	Factors' Group
SCLM	5.416	−0.102	Effect	SCLM1	14.52	−1.59	Effect
				SCLM2	15.99	−0.11	Effect
				SCLM3	11.96	2.45	Cause
				SCLM4	15.35	−0.75	Effect
PM	5.805	−0.517	Effect	PM1	12.08	−0.09	Effect
				PM2	9.03	−1.17	Effect
				PM3	10.71	1.64	Cause
				PM4	10.85	−0.39	Effect
ITA	4.565	0.999	Cause	ITA1	6.71	−0.67	Effect
				ITA2	6.80	−0.64	Effect
				ITA3	6.37	−0.33	Effect
				ITA4	6.43	1.65	Cause
RRM	5.708	0.314	Cause	RRM1	28.89	−0.98	Effect
				RRM2	28.96	0.91	Cause
				RRM3	26.73	1.05	Cause
				RRM4	28.89	−0.98	Effect
HR	4.561	1.501	Cause	HR1	11.14	−0.67	Effect
				HR2	9.82	2.00	Cause
				HR3	10.49	−1.33	Effect
EA	5.478	−0.818	Effect	EA1	1.54	0.52	Cause
				EA2	1.43	−1.43	Effect
				EA3	1.62	0.91	Cause
SA	4.513	−0.749	Effect	SA1	14.65	−0.92	Effect
				SA2	13.81	1.98	Cause
				SA3	14.95	−1.06	Effect
EI	6.443	−0.627	Effect	EI1	2.17	2.17	Cause
				EI2	2.20	−0.74	Effect
				EI3	1.83	−0.34	Effect

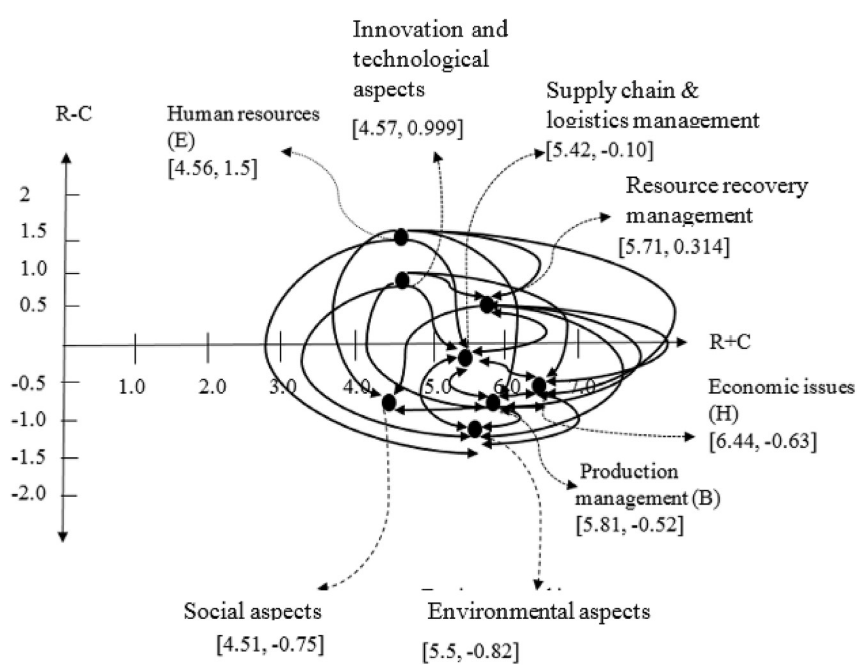


Fig. 2. Cause and effect relationship digraph for main dimensions of SOM.

of SOM with respect to HAIs, have been analyzed to compute their cause and effect relationships. The results have been summarized in Table 9. The cause and effect digraph for all 28 factors grouped into eight dimensions of SOM in HAIs have been shown in Appendix C (C1–C8).

6. Discussions

Fuzzy-AHP has resulted 'Environmental aspects (35.2%)' as the highest rated dimension in the HAIs. The present study also concluded that approximately 65% weight has been given to top three dimensions: 'Environmental aspects (35.2%)', 'Innovation and technological aspects (16.4%)' and 'Resource recovery management (13.9%)'. Then economic issues (11.1%), production management (10.1%), social aspects (7.9%), supply chain and logistics management (3.4%), and human resources (2.0%) have followed these dimensions. Additionally, fuzzy DEMATEL analyzed the interrelationships among various dimensions of SOM and their factors. Based on fuzzy DEMATEL analysis, the innovation and technological aspects, resource recovery management, and human resources are classified under cause group dimensions. While, environmental aspect, supply chain and logistics management, production management, and social aspects belong to effect dimensions. The factors within the dimensions are also evaluated for their priority and cause and effect relationships along with a detailed analysis as follows:

- In 'supply chain and logistics management' dimension, 'sustainable warehousing (58.5%)' has been given the highest priority, followed by 'green procurement (27.1%)', then 'logistic social responsibility (7.6%)' and in the last 'green logistics (6.8%)'. Sustainable warehousing should provide safe storage for hazardous material and support the reverse logistics functions to ensure the recycling initiatives (Carter and Jennings, 2002). Howarth and Hadfield (2006) highlighted that the manufacturing organizations should select the eco-friendly raw material, followed by proper production and distribution system and specify the final disposal with the least impact on the environment. Under 'supply chain management' dimension, 'logistics social responsibility' has been identified as the causal factor and the rest three factors are effect factors. Therefore, implementing strategies like: green logistics, green procurement, and sustainable warehousing would take care of the society during transportation.
- In 'production management' dimension, 'green packaging (57.1%)' has been assigned the highest degree, followed by 'productivity (23.2%)' and 'inventory operations (13.3%)'. Respondents have given the lowest importance to 'green manufacturing (6.4%)' for implementing sustainable production management practices in HAIs. James et al. (2005) stressed that sustainable packaging should protect the product through the whole supply chain; should be material and energy efficient; and could be recycled continuously without posing any risks to ecosystems. Zailani et al. (2012) has shown positive effects of sustainability consideration on supply chain performance with respect to the economy and social aspects. Further, within this dimension, 'inventory operations' has been calculated as the causal factor while implementing the SOM practices in the HAIs. While, green manufacturing, sustainable packaging, productivity have been observed as the effect factors.
- In 'innovation and technological aspects' dimension, 'green product development (57.0%)' and 'green process development (28.3%)' have been rated high, and 'product life extension (10.3%)' and 'technology commercialization (4.4%)' have been given low preferences. Green product and green process development can be achieved by using more clean technologies for making the products/services and eliminating the by-products (Kemp, 1994; Mangla et al., 2017). Further, within this dimension, 'technology commercialization' has been stated as the causal factors, which will drive the performance of three other effect factors (green product development, green process development, product life extension) in the group.
- In 'resource recovery management, 'recycling (52.2%)' has been assigned the highest degree for implementing reverse supply chain operations in HAIs. This has been followed by 'remanufacturing (30.8%)', then 'circular economy (12.8%)' and 'waste management (4.2%)'. Gold et al. (2010) and Kannan et al. (2014) highlighted the key drivers of recycling: cooperation and collaboration with green suppliers for reducing packaging, wastes, and by-products. For implementing the remanufacturing process in HAIs, it is important to analyze the remaining life of the various components at the end of the products (Geyer et al., 2007). Developing reverse logistics channels (Mangla et al., 2013, 2016a) could also be an effective area to manage waste in HAIs. Further, within this dimension, 'circular economy' and 'waste management' have been calculated as the causal factor, which will affect the implementation of 'remanufacturing' and 'recycling' in HAIs. If proper segregation of the used products can be assured by proper waste management policies, then it can help in reuse and recycling some of its components.
- In the 'human resources' dimension, 'sustainable HRM practices (70.3%)' has been given the most importance for implementing sustainable human resource practices in HAIs. Work hygiene and health facilities (21.8%) and skilled human resources (7.9%) have followed this. Hart and Milstein (2003) advocated that sustainable HRM development include human development as a prime resource. The investment for the development of human skills is the part of sustainable human resources (Yadav et al., 2018). Further, within this dimension, 'skilled human resources' is identified as the causal factor, while other two factors (sustainable HRM and work hygiene & health facilities) are the effect group factors, whose implementation will depend upon the skills and knowledge of the people working in the organization.
- In the 'environmental aspects' dimension, 'consumption of natural resources (76.3%)' factor has been given the highest degree, followed by 'pollution emission (16.2%)' and 'sustainable transportation mode (7.5%)'. Home appliances' supply chains in the market, are continuously exploiting the natural resources to deliver their products to the customers for making economic profits. Hodges (2009) stressed environmental sustainability should be implemented through: energy efficiency, use and reuse of resources, waste recycling, standard practices, and safety measures. Further, within this dimension, 'consumption of natural resources' and 'sustainable transport mode' are causal factors that produce an effect on 'pollution emission' factor. More usage of clean transport modes and less depletion of natural resources will help in providing pollution free environment to the society.
- In the 'social aspects' dimension, the 'wages and income distribution (70.7%)' has been given the highest degree, followed by 'community well-being and safety (20.7%)' and 'employment (9.1%)'. Fair income distribution, good health, full employment, and employees' rights are the main elements of the sustainable social dimension in every organization. There should be an equal distribution of income and assets; otherwise, it may create huge problems for the social dimension of sustainable operations management (Spangenberg, 2004). Further, within this dimensions, 'employment generation' has been determined as the causal group factor and 'wages and income generation' and 'community wellbeing and safety' have been identified as the effect group factors. More employment opportunities will help in raising the income of the community and people will feel more secure for their financial concerns.
- Under 'economic issues' dimension, the 'profitability (61.4%)' factor has been rated highest, then 'operational costs (30.1%)' followed by 'stakeholders' role (8.4%)' for implementing sustainable economic dimension in HAIs. Supplier management is also crucial in improving sustainability among organizations (Luthra et al., 2017). Sustainable value chains have a positive influence on firms' profitability (Carter and Rogers, 2008; Golicic and Smith, 2013). Sustainable operations management will help in lowering the operational and transportation costs, and hence, firms can enjoy higher market share. Further, within this dimension, 'operational costs' factor has been identified as the cause group factor, which will affect the 'profitability' and 'stakeholders' role'. Managers may improve the profit margins

and lower the costs by implementing sustainable practices in business.

6.1. Implications for managers

The authors discussed the findings with the experts and they found the results very relevant for change management for organizational sustainability in HAIs. This research offers a structured approach to managers to prioritize the factors in implementing SOM practices. Moreover, the explored cause and effect relationships will help the experts in identifying the cause factors to target the effect group factors. Practicing managers of HAIs admit that operational, human and technological aspects play a crucial role in adopting SOM practices in its business levels.

Corporate houses had been exploiting the natural resources since so long for the financial gains. In this era of globalization, organizations are seeking to adopt sustainable business practices to protect the natural resources and serve the common good of the society (Wu and Pagell, 2011). Gopalakrishnan et al. (2012) advocated that resource depletion is an important dimension for supply chain sustainability. Organizations in HAIs should adopt Sustainable consumption and Organizations patterns for resource management (Mangla et al., 2017). In addition, sustainable production should develop the eco-friendly product and lean operations for manufacturing to consider the resource depletion as well as environmental impacts (Kleindorfer et al., 2005; Vinodh and Rajanayagam, 2010). Life cycle assessment tool provides the interface, which helps in designing products while minimizing their impact on the environment (Rebitzer et al., 2004). Researchers are now focusing on designing parameters for ensuring the products recovery through reverse supply chains. According to Linton et al. (2007), adding remanufacturing and recycling into the existing supply chain network will add extra burden and operational costs for the short-term. However, it will further help in targeting sustainability and open opportunities for improvement in business (Corbett and Klassen, 2006).

Technological innovations have been the main source for the sustained growth of the organizations (Hall and Martin's, 2005). However, radical technological innovations sometimes lead to the obsolescence of the frequently developed technology, resulting in wastage of funds, and affect the environment negatively. Hence, HAIs should invest more in developing the green product and process, which can sustain for comparatively longer. Sustainability is not only concerned with the product design, but also includes the by-products produced during the transformation process and after their end of life (Linton et al., 2007) and how these by-products can be handled through reverse supply chain operations, which includes: remanufacturing, repairing and disposal of some waste components (Govindan et al., 2015; Mangla et al., 2016a,b). Human resource dimension is key to adopt change management for sustainability for business organizations. Employees of the organization are the key drivers for implementing sustainable practices through the whole supply chain. Recently, Yadav et al. (2018) highlighted the importance of human resource function to develop sustainability concepts in an organizational context. Management should focus on human skills development, leadership and team management, etc for higher sustainable performance. Büyüközkan and Berkol (2011) highlighted that sustainable organizations recruit talented human skills, which focus on the environmental aspect of the business and improves the productivity of the employees. Additionally, managers may also organize the education and training programs with the collaboration of academic institutions for implementing SOM practices at their premises.

6.2. Theoretical contributions

This study seeks to offer following contributions:

- Recognizing and validating the factors to SOM practices in manufacturing organizations particularly in HAI in Indian context.
- The finalized factors were prioritized using fuzzy-AHP. This will facilitate managers to plan SOM orientation decision in their value chains.
- The finalized factors were evaluated to examine their causal relationships, using fuzzy-DEMATEL. This would help managers to coordinate their efforts in efficient SOM adoption.

7. Conclusions

This work identifies and prioritizes the dimensions of SOM particularly with human-operational-technical aspects in manufacturing organizations specifically in the home appliances companies. This work listed 28 key factors under eight dimensions to SOM using literature, which are validated through expert's opinions. The study applies combined fuzzy AHP - DEMATEL for ranking the key factors and analyzing further the cause-effect relationships among the listed factors. Based on findings, 'Environmental aspects', 'Innovation and technological aspects' and 'Resources recovery management' dimensions were prioritized with the high weightage. This implies that managers should focus primarily on these three dimensions in implementation of SOM practices.

Additionally, 'Innovation and technological aspects', 'Resources recovery management', and 'Human resources' dimensions were identified as the cause group factors and remaining five ('Supply chain and logistics management', 'Production management', 'Environmental aspects', 'Social aspects', and 'Economic issues') are placed in the effect group. The cause-effect diagrams will assist managers to implement SOM practices in their organizations.

This study identifies the key drivers for implementing the SOM practices in HAIs. The study can be enhanced to set the SOM practices by considering these factors, for attaining the long-term sustainable business success in the related industries. These dimensions can be further analyzed for different types of industries for their sustainable business development. The present study's scope is limited to HAIs, which includes the judgments of the experts working in India. Since India is a developing nation, hence, the factors may differ, if we compare with the developed economy, where they have more advanced technologies. Therefore, the challenges for developing nations like India, where SOM practices are still emerging, are different. The present study focuses on the SOM practices at five manufacturing firms, which can be extended to include SOM practices at all the supply chain partners (like: raw material suppliers, sub-assembly partners, logistic partners etc.). Hence, the dimensions of SOM can be considered for all the partners involved in the journey of a particular product life cycle.

Appendix D. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclepro.2018.12.201.

Appendix A. Defuzzification steps followed in fuzzy AHP

i) Normalization of TFN

Let x be a TFN with membership function (a_1, a_2, a_3).

$$a_{1ij} = \left(a_{1ij} - min_j a_{1ij}\right)/\Delta_{min}^{max} \quad (A.1)$$

$$a_{2ij} = \left(a_{2ij} - min_j a_{2ij}\right)/\Delta_{min}^{max} \quad (A.2)$$

$$a_{3ij} = \left(a_{3ij} - min_j a_{3ij}\right)/\Delta_{min}^{max} \quad (A.3)$$

where,

$$\Delta_{min}^{max} = \left(max_j r_{ij} - min_j l_{ij}\right) \quad (A.4)$$

$max_j r_{ij}$represents the maximum right limit of TFN assigned by the particular expert.$min_j l_{ij}$ is the minimum left limit of TFN assigned by the particular expert.

ii) Right and left normalized values:

$$\text{Right normalized value} = r_{ij} = a_{3ij}/\left(1 + a_{3ij} - a_{2ij}\right) \quad (A.5)$$

$$\text{Left normalized value} = l_{ij} = a_{2ij}/\left(1 + a_{2ij} - a_{1ij}\right) \quad (A.6)$$

iii) Total normalized crisp value

$$x_{ij} = \left[l_{ij}\left(1 - l_{ij}\right) + r_{ij} \times r_{ij}\right]/\left(1 - l_{ij} + r_{ij}\right) \quad (A.7)$$

So, total normalized crisp value is

$$w_{ij} = min\ a_{ij} + x_{ij}\Delta_{min}^{max} \quad (A.8)$$

iv) Average crisp values from all the experts

Calculate the average crisp value for each comparison by aggregating n number of experts by using following equation:

$$w_{ij}^n = 1/n\left(w_{ij}^1 + w_{ij}^2 + \ldots . w_{ij}^n\right) \quad (A.9)$$

Appendix B. Pairwise comparison of factors of SOM, resulted from five brain-storming sessions (B1–B8)

Appendix C. Cause and effect digraphs for all the factors under eight dimensions of SOM (C1–C8)

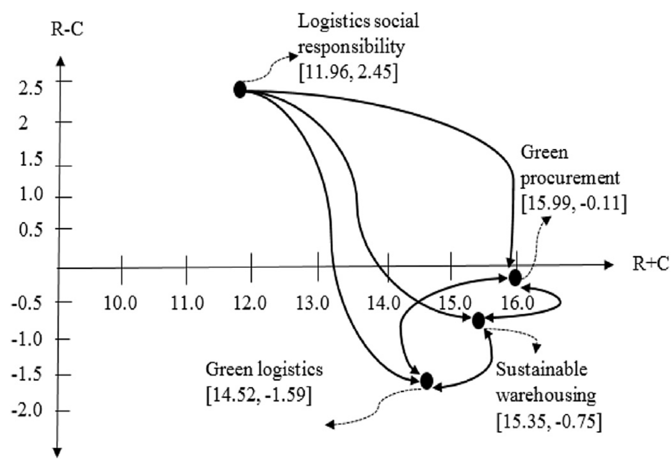


Fig. C1. Digraph depicting relationships among factors under SCLM

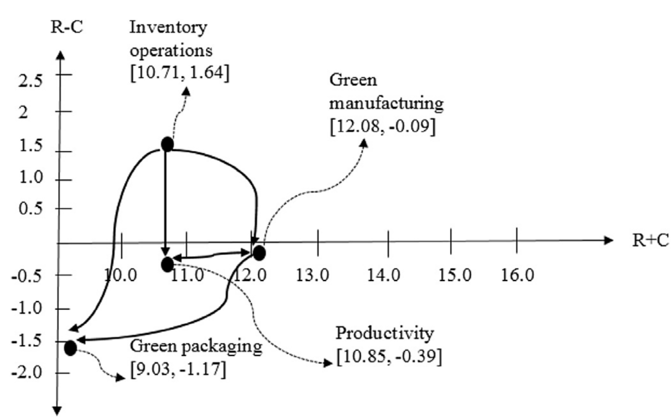


Fig. C2. Digraph depicting relationships among factors under PM3

Table B1
Pair-wise comparison matrix for four factors under SCLM

	SCLM1	SCLM2	SCLM3	SCLM4
SCLM1	(1, 1, 1)	$\tilde{3}^{-1}, \tilde{4}^{-1}, \tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{3}^{-1}$	$\tilde{2}^{-1}, \tilde{1}^{-1}, \tilde{3}^{-1}, \tilde{3}^{-1}, \tilde{2}^{-1}$	$\tilde{4}^{-1}, \tilde{5}^{-1}, \tilde{2}^{-1}, \tilde{4}^{-1}, \tilde{3}^{-1}$
SCLM2		(1, 1, 1)	$\tilde{4}, \tilde{5}, \tilde{3}, \tilde{4}, \tilde{3}$	$\tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{3}^{-1}, \tilde{4}^{-1}, \tilde{3}^{-1}$,
SCLM3			(1, 1, 1)	$\tilde{5}^{-1}\ \tilde{4}^{-1}, \tilde{5}^{-1}, \tilde{3}^{-1}, \tilde{5}^{-1}$
SCML4				(1, 1, 1)

Table B2
Pair-wise comparison matrix for four factors under PM

	PM1	PM2	PM3	PM4
PM1	(1, 1, 1)	$\tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{2}^{-1}$	$\tilde{4}^{-1}, \tilde{5}^{-1}, \tilde{4}^{-1}, \tilde{3}^{-1}, \tilde{5}^{-1}$	$\tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{2}^{-1}, \tilde{4}^{-1}, \tilde{3}^{-1}$
PM2		(1, 1, 1)	$\tilde{4}, \tilde{5}, \tilde{3}, \tilde{4}, \tilde{5}$	$\tilde{2}, \tilde{4}, \tilde{3}, \tilde{4}, \tilde{2}$
PM3			(1, 1, 1)	$\tilde{2}^{-1} \tilde{4}^{-1}, 2^{-1}, \tilde{3}^{-1}, \tilde{2}^{-1}$
PM4				(1, 1, 1)

Table B3
Pair-wise comparison matrix for four factors under ITA

	ITA1	ITA2	ITA3	ITA4
ITA1	(1, 1, 1)	$\tilde{3}, \tilde{2}, \tilde{3}, \tilde{2}, \tilde{2}$	$\tilde{4}, \tilde{5}, \tilde{4}, \tilde{3}, \tilde{2}$	$\tilde{5}, \tilde{4}, \tilde{3}, \tilde{4}, \tilde{5}$
ITA2		(1, 1, 1)	$\tilde{3}, \tilde{4}, \tilde{3}, \tilde{2}, \tilde{3}$	$\tilde{4}, \tilde{3}, \tilde{5}, \tilde{4}, \tilde{2}$
ITA3			(1, 1, 1)	$\tilde{3}, \tilde{2}, \tilde{3}, \tilde{4}, \tilde{2}$
ITA4				(1, 1, 1)

Table B4
Pair-wise comparison matrix for four factors under RRM

	RRM1	RRM2	RRM3	RRM4
RRM1	(1, 1, 1)	$\tilde{3}, \tilde{2}, \tilde{3}, \tilde{4}, \tilde{2}$	$\tilde{4}, \tilde{5}, \tilde{4}, \tilde{3}, \tilde{5}$	$\tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{2}^{-1}$
RRM2		(1, 1, 1)	$\tilde{3}, \tilde{4}, \tilde{3}, \tilde{2}, \tilde{3}$	$\tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{4}^{-1}, \tilde{2}^{-1}, \tilde{4}^{-1}$
RRM3			(1, 1, 1)	$\tilde{3}^{-1}, \tilde{5}^{-1}, \tilde{4}^{-1}, \tilde{5}^{-1}, \tilde{5}^{-1}$
RRM4				(1, 1, 1)

Table B5
Pair-wise comparison matrix for three factors under HR

	HR1	HR2	HR3
HR1	(1, 1, 1)	$\tilde{4}, \tilde{5}, \tilde{3}, \tilde{4}, \tilde{5}$	$\tilde{2}, \tilde{3}, \tilde{4}, \tilde{3}, \tilde{2}$
HR2		(1, 1, 1)	$\tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{3}^{-1}$
HR3			(1, 1, 1)

Table B6
Pair-wise comparison matrix for three factors under EA

	EA1	EA2	EA3
EA1	(1, 1, 1)	$\tilde{3}, \tilde{2}, \tilde{3}, \tilde{4}, \tilde{2}$	$\tilde{4}, \tilde{5}, \tilde{4}, \tilde{3}, \tilde{5}$
EA2		(1, 1, 1)	$\tilde{3}, \tilde{4}, \tilde{3}, \tilde{2}, \tilde{3}$
EA3			(1, 1, 1)

Table B7
Pair-wise comparison matrix for three factors under SA

	SA1	SA2	SA3
SA1	(1, 1, 1)	$\tilde{4}, \tilde{5}, \tilde{5}, \tilde{4}, \tilde{5}$	$\tilde{2}, \tilde{3}, \tilde{1}, \tilde{3}, \tilde{2}$
SA2		(1, 1, 1)	$\tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{3}^{-1}, \tilde{1}^{-1}, \tilde{2}^{-1}$
SA3			(1, 1, 1)

Table B8
Pair-wise comparison matrix for three factors under EI

	EI1	EI2	EI3
EI1	(1, 1, 1)	$\tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{3}^{-1}, \tilde{1}^{-1}, \tilde{4}^{-1}$	$\tilde{2}, \tilde{3}, \tilde{4}, \tilde{3}, \tilde{2}$
EI2		(1, 1, 1)	$\tilde{4}, \tilde{3}, \tilde{4}, \tilde{5}, \tilde{3}$
EI3			(1, 1, 1)

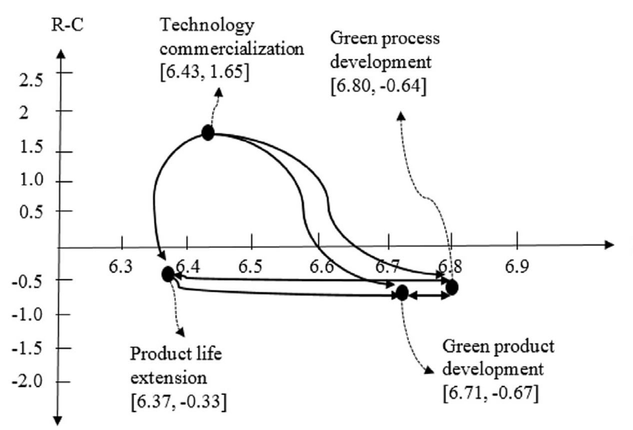


Fig. C3. Digraph depicting relationships among factors under ITA4

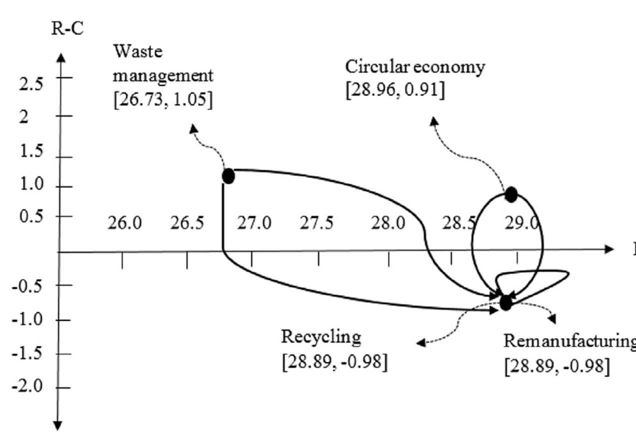
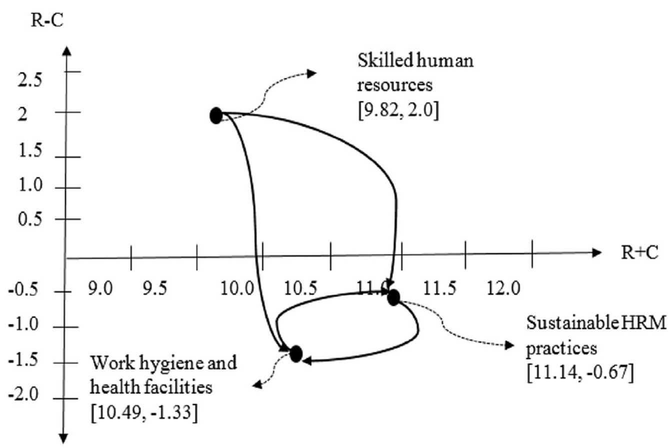


Fig. C4. Digraph depicting relationships among factors under RRM5



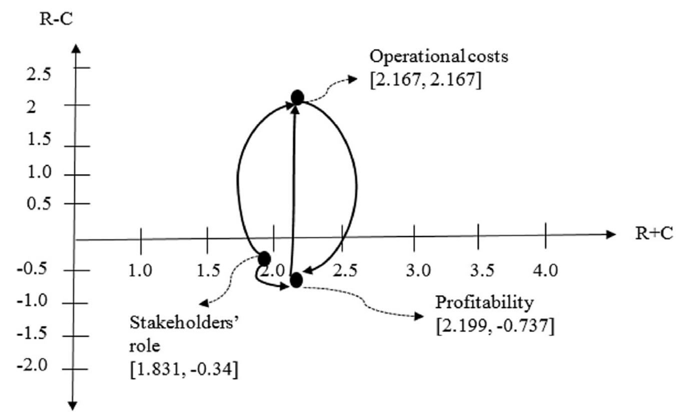


Fig. C8. Digraph depicting relationships among factors under EI9

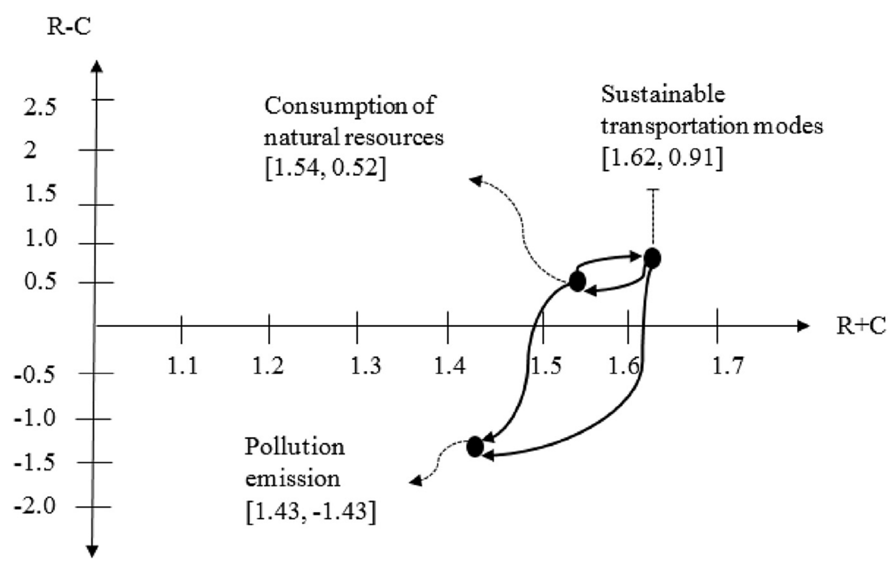


Fig. C6. Digraph depicting relationships among factors under EA7

Fig. C5. Digraph depicting relationships among factors under HR6

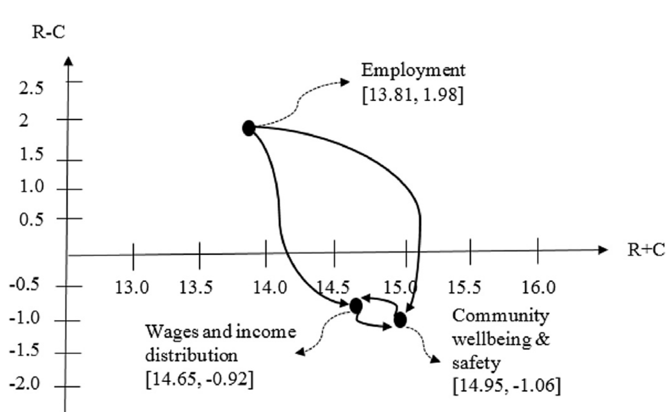


Fig. C7. Digraph depicting relationships among factors under SA8

References

Abdullah, L., Zulkifli, N., 2015. Integration of fuzzy AHP and interval type-2 fuzzy DEMATEL: an application to human resource management. Expert Syst. Appl. 42 (9), 4397–4409.

Ahi, P., Searcy, C., 2013. A comparative literature analysis of definitions for green and sustainable supply chain management. J. Clean. Prod. 52, 329–341.

Amui, L.B.L., Jabbour, C.J.C., de Sousa Jabbour, A.B.L., Kannan, D., 2017. Sustainability as a dynamic organizational capability: a systematic review and a future agenda toward a sustainable transition. J. Clean. Prod. 142, 308–322.

Ananda, J., Herath, G., 2009. A critical review of multi-criteria decision making methods with special reference to forest management and planning. Ecol. Econ. 68 (10), 2535–2548.

Andersen, M., Skjoett-Larsen, T., 2009. Corporate social responsibility in global supply chains. Supply Chain Manag.: Int. J. 14 (2), 75–86.

Andiç, E., Yurt, Ö., Baltacıoğlu, T., 2012. Green supply chains: efforts and potential applications for the Turkish market. Resour. Conserv. Recycl. 58, 50–68.

Badurdeen, F., Iyengar, D., Goldsby, T.J., Metta, H., Gupta, S., Jawahir, I.S., 2009. Extending total life-cycle thinking to sustainable supply chain design. Int. J. Prod. Lifecycle Manag. 4 (1–3), 49–67.

Balde, C.P., Forti, V., Gray, V., Kuehr, R., Stegmann, P., 2017. The global e-waste monitor 2017: Quantities, flows and resources. United Nations University, International Telecommunication Union, and International Solid Waste Association.

Belvedere, V., Grando, A., 2017. Sustainable Operations and Supply Chain Management. John Wiley and Sons.

Brandenburg, M., Govindan, K., Sarkis, J., Seuring, S., 2014. Quantitative models for sustainable supply chain management: developments and directions. Eur. J. Oper. Res. 233 (2), 299–312.

Buckley, J.J., 1985. Fuzzy hierarchical analysis. Fuzzy Set Syst. 17 (1), 233–247.

Büyüközkan, G., Berkol, Ç., 2011. Designing a sustainable supply chain using an integrated analytic network process and goal programming approach in quality function deployment. Expert Syst. Appl. 38 (11), 13731–13748.

Büyüközkan, G., Çifçi, G., 2012. A novel hybrid MCDM approach based on fuzzy DEMATEL, fuzzy ANP and fuzzy TOPSIS to evaluate green suppliers. Expert Syst. Appl. 39 (3), 3000–3011.

Carter, C.R., Jennings, M.M., 2002. Logistics social responsibility: an integrative framework. J. Bus. Logist. 23 (1), 145–180.

Carter, C.R., Rogers, D.S., 2008. A framework of sustainable supply chain management: moving toward new theory. Int. J. Phys. Distrib. Logist. Manag. 38 (5), 360–387.

Chou, S.-W., Chang, Y.-C., 2008. The implementation factors that influence the ERP (enterprise resource planning) benefits. Decis. Support Syst. 46 (1), 149–157.

Chou, Y.C., Sun, C.C., Yen, H.Y., 2012. Evaluating the criteria for human resource for science and technology (HRST) based on an integrated fuzzy AHP and fuzzy DEMATEL approach. Appl. Soft Comput. 12 (1), 64–71.

Ciliberti, F., Pontrandolfo, P., Scozzi, B., 2008. Investigating corporate social responsibility in supply chains: a SME perspective. J. Clean. Prod. 16 (15), 1579–1588.

Corbett, C.J., Klassen, R.D., 2006. Extending the horizons: environmental excellence as key to improving operations. Manuf. Serv. Oper. Manag. 8 (1), 5–22.

Curkovic, S., Sroufe, R., 2011. Using ISO 14001 to promote a sustainable supply chain strategy. Bus. Strateg. Environ. 20 (2), 71–93.

De Brito, M.P., Carbone, V., Blanquart, C.M., 2008. Towards a sustainable fashion retail supply chain in Europe: organisation and performance. Int. J. Prod. Econ. 114 (2), 534–553.

Deakin, E., 2001. Sustainable Development & Sustainable Transportation: Strategies for Economic Prosperity, Environmental Quality, and Equity.Deakin, E. (2001). Sustainable Development and Sustainable Transportation: Strategies for Economic Prosperity, Environmental Quality, and Equity, Working Paper. University of California at Berkeley. Institute of Urban and Regional Development.

Drake, D.F., Spinler, S., 2013. OM forum—sustainable operations management: an enduring stream or a passing fancy? Manuf. Serv. Oper. Manag. 15 (4), 689–700.

Farahani, R.Z., Elahipanah, M., 2008. A genetic algorithm to optimize the total cost and service level for just-in-time distribution in a supply chain. Int. J. Prod. Econ. 111 (2), 229–243.

Fischer-Kowalski, M., Madlener, R., Payer, H., Pfeffer, T., Schandl, H., 1995. Soziale Anforderungen an eine nachhaltige Entwicklung. iff. Institut für interdisziplinäre Forschung und Fortbildung der Universitäten Insbruck. Klagenfurt und Wien, Vienna.

Gandhi, S., Mangla, S.K., Kumar, P., Kumar, D., 2015. Evaluating factors in implementation of successful green supply chain management using DEMATEL: a case study. Int. Strat. Manag. Rev. 3 (1–2), 96–109.

Gandhi, S., Mangla, S.K., Kumar, P., Kumar, D., 2016. A combined approach using AHP and DEMATEL for evaluating success factors in implementation of green supply chain management in Indian manufacturing industries. Int. J. Logist. Res. Appl. 19 (6), 537–561.

Genovese, A., Acquaye, A.A., Figueroa, A., Koh, S.L., 2017. Sustainable supply chain management and the transition towards a circular economy: evidence and some applications. Omega 66, 344–357.

Geyer, R., Van Wassenhove, L.N., Atasu, A., 2007. The impact of limited component durability and finite life cycles on remanufacturing profit. Manag. Sci. 53 (1), 88–100.

Gnoni, M.G., De Felice, F., Petrillo, A., 2011. A multi-criteria approach for strategic evaluation of environmental sustainability in a supply chain. Int. J. Bus. Inf. Technol. 3.

Gold, S., Seuring, S., Beske, P., 2010. Sustainable supply chain management and inter-organizational resources: a literature review. Corp. Soc. Responsib. Environ. Manag. 17 (4), 230–245.

Golicic, S.L., Smith, C.D., 2013. A meta-analysis of environmentally sustainable supply chain management practices and firm performance. J. Supply Chain Manag. 49 (2), 78–95.

Gopalakrishnan, K., Yusuf, Y.Y., Musa, A., Abubakar, T., Ambursa, H.M., 2012. Sustainable supply chain management: a case study of British Aerospace (BAe) Systems. Int. J. Prod. Econ. 140 (1), 193–203.

Govindan, K., Cheng, T.C.E., 2015. Sustainable supply chain management. Comput. Oper. Res. 54 (C), 177–179.

Govindan, K., Soleimani, H., 2017. A review of reverse logistics and closed-loop supply chains: a Journal of Cleaner Production focus. J. Clean. Prod. 142, 371–384.

Govindan, K., Soleimani, H., Kannan, D., 2015. Reverse logistics and closed-loop supply chain: a comprehensive review to explore the future. Eur. J. Oper. Res. 240 (3), 603–626.

Gupta, S., Palsule-Desai, O.D., 2011. Sustainable supply chain management: review and research opportunities. IIMB Manag. Rev. 23 (4), 234–245.

Hall, J.K., Martin, M.J., 2005. Disruptive technologies, stakeholders and the innovation value-added chain: a framework for evaluating radical technology development. R D Manag. 35 (3), 273–284.

Hart, S.L., Milstein, M.B., 2003. Creating sustainable value. Acad. Manag. Exec. 17 (2), 56–67.

Hediger, W., 2000. Sustainable development and social welfare. Ecol. Econ. 32 (3), 481–492.

Hernandez-Vivanco, A., Bernardo, M., Cruz-Cázares, C., 2018. Sustainable innovation through management systems integration. J. Clean. Prod. 196, 1176–1187.

Hodges, C.P., 2009. Sustainability "How-to Guide" Series. Getting Started. IFMA Foundation, 1E Greenway Plaza, Suite., p. 1100

Howarth, G., Hadfield, M., 2006. A sustainable product design model. Mater. Des. 27 (10), 1128–1133. http://ec.europa.eu/environment/waste/weee/index_en.htm. (Accessed July 2018).

Jabbour, C.J.C., de Sousa Jabbour, A.B.L., 2016. Green human resource management and green supply chain management: linking two emerging agendas. J. Clean. Prod. 112, 1824–1833.

Jabbour, C.J.C., de Sousa Jabbour, A.B.L., Govindan, K., Teixeira, A.A., de Souza Freitas, W.R., 2013. Environmental management and operational performance in automotive companies in Brazil: the role of human resource management and lean manufacturing. J. Clean. Prod. 47, 129–140.

Jabbour, C.J.C., Jugend, D., de Sousa Jabbour, A.B.L., Gunasekaran, A., Latan, H., 2015. Green product development and performance of Brazilian firms: measuring the role of human and technical aspects. J. Clean. Prod. 87, 442–451.

James, K., Fitzpatrick, L., Lewis, H., Sonneveld, K., 2005. Sustainable packaging system development. In: Handbook of Sustainability Research. Peter Lang Scientific Publishing, Frankfurt.

Kabra, G., Ramesh, A., 2015. Analyzing drivers and barriers of coordination in humanitarian supply chain management under fuzzy environment. Benchmarking Int. J. 22 (4), 559–587.

Kannan, D., de Sousa Jabbour, A.B.L., Jabbour, C.J.C., 2014. Selecting green suppliers based on GSCM practices: using fuzzy TOPSIS applied to a Brazilian electronics company. Eur. J. Oper. Res. 233 (2), 432–447.

Keating, B., Quazi, A., Kriz, A., Coltman, T., 2008. In pursuit of a sustainable supply chain: insights from Westpac Banking Corporation. Supply Chain Manag.: Int. J. 13 (3), 175–179.

Kemp, R., 1994. Technology and the transition to environmental sustainability: the problem of technological regime shifts. Futures 26 (10), 1023–1046.

Kleindorfer, P.R., Singhal, K., Wassenhove, L.N., 2005. Sustainable operations management. Prod. Oper. Manag. 14 (4), 482–492.

Lee, W.S., Huang, A.Y., Chang, Y.Y., Cheng, C.M., 2011. Analysis of decision making factors for equity investment by DEMATEL and Analytic Network Process. Expert Syst. Appl. 38 (7), 8375–8383.

Lin, R.J., 2013. Using fuzzy DEMATEL to evaluate the green supply chain management practices. J. Clean. Prod. 40, 32–39.

Linton, J.D., Klassen, R., Jayaraman, V., 2007. Sustainable supply chains: an introduction. J. Oper. Manag. 25 (6), 1075–1082.

Lovrić, M., Li, T., Vervest, P., 2013. Sustainable revenue management: a smart card enabled agent-based modeling approach. Decis. Support Syst. 54 (4), 1587–1601.

Luthra, S., Govindan, K., Kannan, D., Mangla, S.K., Garg, C.P., 2017. An integrated framework for sustainable supplier selection and evaluation in supply chains. J. Clean. Prod. 140, 1686–1698.

Mangla, S., Madaan, J., Chan, F.T., 2013. Analysis of flexible decision strategies for sustainability-focused green product recovery system. Int. J. Prod. Res. 51 (11), 3428–3442.

Mangla, S.K., Kumar, P., Barua, M.K., 2014. Flexible decision approach for analysing performance of sustainable supply chains under risks/uncertainty. Global J. Flex. Syst. Manag. 15 (2), 113–130.

Mangla, S.K., Govindan, K., Luthra, S., 2016a. Critical success factors for reverse logistics in Indian industries: a structural model. J. Clean. Prod. 129, 608–621.

Mangla, S.K., Kumar, P., Barua, M.K., 2016b. A fuzzy DEMATEL-based approach for evaluation of risks in green initiatives in supply chain. Int. J. Logist. Syst. Manag. 24 (2), 226–243.

Mangla, S.K., Kumar, P., Barua, M.K., 2015. Risk analysis in green supply chain using fuzzy AHP approach: a case study. Resour. Conserv. Recycl. 104, 375–390.

Mangla, S.K., Govindan, K., Luthra, S., 2017. Prioritizing the barriers to achieve sustainable consumption and production trends in supply chains using fuzzy Analytical Hierarchy Process. J. Clean. Prod. 151, 509–525.

Mangla, S.K., Luthra, S., Rich, N., Kumar, D., Rana, N.P., Dwivedi, Y.K., 2018. Enablers to implement sustainable initiatives in agri-food supply chains. Int. J. Prod. Econ. 203, 379–393.

Manomaivibool, P., 2009. Extended producer responsibility in a non-OECD context: the management of waste electrical and electronic equipment in India. Resour. Conserv. Recycl. 53 (3), 136–144.

Margolis, J.D., Elfenbein, H.A., Walsh, J.P., 2009. Does it Pay to Be good … And Does it Matter? a Meta-analysis of the Relationship between Corporate Social and Financial Performance.

Markley, M.J., Davis, L., 2007. Exploring future competitive advantage through sustainable supply chains. Int. J. Phys. Distrib. Logist. Manag. 37 (9), 763–774.

Min, H., Kim, I., 2012. Green supply chain research: past, present, and future. Logist. Res. 4, 39–47.

Mollenkopf, D., Stolze, H., Tate, W.L., Ueltschy, M., 2010. Green, lean, and global supply chains. Int. J. Phys. Distrib. Logist. Manag. 40 (1–2), 14–41.

Mutti, D., Yakovleva, N., Vazquez-Brust, D., Di Marco, M.H., 2012. Corporate social responsibility in the mining industry: perspectives from stakeholder groups in Argentina. Resour. Pol. 37 (2), 212–222.

Norman, W., MacDonald, C., 2004. Getting to the bottom of "triple bottom line". Bus. Ethics Q. 14 (2), 243–262.

Olivier, J.G., Peters, J.A., Janssens-Maenhout, G., 2012. Trends in Global CO2 Emissions 2012 Report.

Ongondo, F.O., Williams, I.D., Cherrett, T.J., 2011. How are WEEE doing? A global review of the management of electrical and electronic wastes. Waste Manag. 31 (4), 714–730.
Pandey, A., Kumar, A., 2017. Commentary on "Evaluating the criteria for human resource for science and technology (HRST) based on an integrated fuzzy AHP and fuzzy DEMATEL approach". Appl. Soft Comput. 51, 351–352.
Parmigiani, A., Klassen, R.D., Russo, M.V., 2011. Efficiency meets accountability: performance implications of supply chain configuration, control, and capabilities. J. Oper. Manag. 29 (3), 212–223.
Rajeev, A., Pati, R., upesh, K., Pati, Sidhartha, Padhi, S., Padhi, Kannan Govindan, K., 2017. Evolution of sustainability in supply chain management: a literature review. J. Clean. Prod. 162, 299–314.
Ramudhin, A., Chaabane, A., Paquet, M., 2009. July). On the design of ustainable, green supply chains. In: Computers and Industrial Engineering, 2009. CIE 2009. International Conference IEEEon. IEEE, pp. 979–984.
Rebitzer, G., Ekvall, T., Frischknecht, R., Hunkeler, D., Norris, G., Rydberg, T., et al., 2004. Life cycle assessment: Part 1: framework, goal and scope definition, inventory analysis, and applications. Environ. Int. 30 (5), 701–720.
Rouhani, S., Ashrafi, A., Afshari, S., 2013. Segmenting critical success factors for ERP implementation using an integrated fuzzy AHP and fuzzy DEMATEL approach. World Appl. Sci. J. 22 (8), 1066–1079.
Sbihi, A., Eglese, R.W., 2007. Combinatorial optimization and green logistics. 4OR 5 (2), 99–116.
Schramm-Klein, H., Zentes, J., Steinmann, S., Swoboda, B., Morschett, D., 2016. Retailer corporate social responsibility is relevant to consumer behavior. Bus. Soc. 55 (4), 550–575.
Sepúlveda, A., Schluep, M., Renaud, F.G., Streicher, M., Kuehr, R., Hagelüken, C., Gerecke, A.C., 2010. A review of the environmental fate and effects of hazardous substances released from electrical and electronic equipments during recycling: examples from China and India. Environ. Impact Assess. Rev. 30 (1), 28–41.
Seuring, S., 2013. A review of modeling approaches for sustainable supply chain management. Decis. Support Syst. 54 (4), 1513–1520.
Seuring, S., Müller, M., 2008. From a literature review to a conceptual framework for sustainable supply chain management. J. Clean. Prod. 16 (15), 1699–1710.
Spangenberg, J.H., 2004. Reconciling sustainability and growth: criteria, indicators, policies. Sustain. Dev. 12 (2), 74–86.
Spence, L., Bourlakis, M., 2009. The evolution from corporate social responsibility to supply chain responsibility: the case of Waitrose. Supply Chain Manag.: Int. J. 14 (4), 291–302.
Srivastava, S.K., 2007. Green supply-chain management: a state-of-the-art literature review. Int. J. Manag. Rev. 9 (1), 53–80.
Sun, C.C., 2010. A performance evaluation model by integrating fuzzy AHP and fuzzy TOPSIS methods. Expert Syst. Appl. 37 (12), 7745–7754.
Tang, C.S., Zhou, S., 2012. Research advances in environmentally and socially sustainable operations. Eur. J. Oper. Res. 223 (3), 585–594.
Testa, F., Annunziata, E., Iraldo, F., Frey, M., 2016. Drawbacks and opportunities of green public procurement: an effective tool for sustainable production. J. Clean. Prod. 112, 1893–1900.
Thakur, V., Ramesh, A., 2017. Healthcare waste disposal strategy selection using grey-AHP approach. Benchmarking Int. J. 24 (3), 735–749.
Tseng, M.L., Lin, Y.H., Chiu, A.S., 2009. Fuzzy AHP-based study of cleaner production implementation in Taiwan PWB manufacturer. J. Clean. Prod. 17 (14), 1249–1256.
Tukker, A., 2015. Product services for a resource-efficient and circular economy—a review. J. Clean. Prod. 97, 76–91.
Ukidwe, N.U., Bakshi, B.R., 2005. Flow of natural versus economic capital in industrial supply networks and its implications to sustainability. Environ. Sci. Technol. 39 (24), 9759–9769.
Vafadarnikjoo, A., Mishra, N., Govindan, K., Chalvatzis, K., 2018. Assessment of consumers' motivations to purchase a remanufactured product by applying fuzzy delphi method and single valued neutrosophic sets. J. Clean. Prod. 196 (2), 230–244.
Vinodh, S., Rajanayagam, D., 2010. CAD and DFM: enablers of sustainable product design. Int. J. Sustain. Eng. 3 (4), 292–298.
Walker, H., Di Sisto, L., McBain, D., 2008. Drivers and barriers to environmental supply chain management practices: lessons from the public and private sectors. J. Purch. Supply Manag. 14 (1), 69–85.
Wu, H.H., Tsai, Y.N., 2012. An integrated approach of AHP and DEMATEL methods in evaluating the criteria of auto spare parts industry. Int. J. Syst. Sci. 43 (11), 2114–2124.
Wu, W.W., Lee, Y.T., 2007. Developing global managers' competencies using the fuzzy DEMATEL method. Expert Syst. Appl. 32 (2), 499–507.
Wu, Z., Pagell, M., 2011. Balancing priorities: decision-making in sustainable supply chain management. J. Oper. Manag. 29 (6), 577–590.
Yadav, M., Kumar, A., Mangla, S.K., Luthra, S., Bamel, U., Garza-Reyes, J.A., 2018. Mapping the human resource focused enablers with sustainability viewpoints in Indian power sector. J. Clean. Prod. 210, 1311–1323.
Ye, F., Wang, Z., 2013. Effects of information technology alignment and information sharing on supply chain operational performance. Comput. Ind. Eng. 65 (3), 370–377.
Zailani, S., Jeyaraman, K., Vengadasan, G., Premkumar, R., 2012. Sustainable supply chain management (SSCM) in Malaysia: a survey. Int. J. Prod. Econ. 140 (1), 330–340.
Zhou, X., Hu, Y., Deng, Y., Chan, F.T., Ishizaka, A., 2018. A DEMATEL-based completion method for incomplete pairwise comparison matrix in AHP. Ann. Oper. Res. 1–22.
Zhu, Q., Sarkis, J., Lai, K.H., 2007. Green supply chain management: pressures, practices and performance within the Chinese automobile industry. J. Clean. Prod. 15 (11), 1041–1052.