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Sustainable supply chain management in stakeholders: supporting from sustainable supply and process management in healthcare industry in Vietnam

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Abstract

Prior studies are presented the sustainable supply chain management practices, but an approach from stakeholders is still untapped. The interaction between forward and reverse flows also needs to be involved in investment recovery. Sustainable supply chain management is an increasing concern in the environmental, social and economic performance. This study uses fuzzy Delphi method to valid a set of criteria and uses exploratory factor analysis to confirm the aspects. This study applies stakeholder theory in combination with fuzzy set theory and decision making trial and evaluation method to explore the interrelationships among attributes. The results show sustainable supply management and process management are the major cause aspects. Investment recovery has not been noticed in the healthcare industry, reflected in the weak interaction. The top five criteria are supplier assessment, environmental management systems, green certification of supplier, supplier collaboration and health and safety certifications. This study provides theoretical and managerial implications.

Keywords: customer green management; investment recovery; stakeholder theory; sustainable supply chain management; sustainable supply management; sustainable process management; triple bottom line

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1. Introduction

The healthcare industry in Vietnam is important in public treatment of diseases and ensures a healthy life for people in socio-economic development. The intensification of healthcare industrial competition and customer awareness is forced industry to perform their environmental sustainability. Firms are relied on the supply chain network to comply with sustainable requirements as well as achieving the economic benefits, environment, and social impacts to meet the demands from customer, governments, and society (Silvestre et al., 2018). Tseng et al. (2019) emphasized that sustainable development requires the closely cooperation among supply chain participants and it encourages the adoption of SSCM throughout the firm's supply chain. Shou et al. (2019) argued that SSCM enables firms align stakeholders into sustainable activities and then fulfill their stakeholders' expectation of environmental and social responsibilities; hence, firms must concern about SSCM in order to successfully achieve sustainability. Moreover, the fact that firms have to take a total SSCM implies that the interaction between forward and reverse flows has to be considered, and this requires the involvement of investment recovery (de Oliveira et al., 2019; Engeland et al., 2020; Lin et al., 2019). Therefore, an understanding of SSCM related to stakeholders along with investment recovery as SSCM practice are needed to guarantee SSCM in general and especially in healthcare industry.

Prior studies are carrying out sustainable practices in a firm is to effectively manage the stakeholder relationships (Tseng et al., 2019; Kannan, 2018). Stakeholder theory is used to clarify the interrelationships between different participants in the supply chain and to highlight the SSCM appearance when the participants are affected by their own business activities (Touboulic et al., 2015). Stakeholder theory reflects the impact of a firm's activities on both internal and external partners, and it supports the notion that a firm exists only if it meets stakeholders' requirements because stakeholders contribute to a firm's ability to create wealth and ensure its survival in long-term. In addition, the triple bottom line (TBL) is a concept used in SSCM studies including environmental, social and economic aspects. Prior studies are applying TBL into stakeholder theory. Firms are aware of the SSCM benefits, but there are a few shortcomings to understand clearly and implement SSCM (Mathivathanan et al., 2018). Firms must understand the practices that need to be implemented throughout the supply chain in the process.

The SSCM process is attained when firms involve their stakeholders' attention towards TBL issues and manages their relationships effectively (Lan et al., 2019; Mathivathanan et al., 2018; Wu et al., 2010). Supplier, customer, employee are important stakeholders of firms; hence, this study proposes using sustainable supply management, sustainable process management, and customer green management to conceptualize SSCM. Moreover, as environmental and economic concerns increase, the value of products, materials and resources needs to be maintained while still controlling the impact of supply chain's activities on environment; thus, this involves higher level recovery options (Engeland et al., 2020). For this objective, investment recovery is considered as applicable practice due to recovering, redeploying, and reselling existing surplus materials, used products and idle or redundant equipment (Foo et al., 2018). Hu et al. (2019) discussed investment recovery as practice which aims to recover the value of surplus assets to reduce the waste of initial investment, thereby reducing the price of services and products offered to the market. Investment recovery is argued to be one necessary SSCM practice because of the impact on improving the economic or financial efficiency of a firm.

Hu et al. (2019) argued that a theoretical basis for SSCM has been provided and there is a limited studies related to SSCM in the service industry, especially healthcare industry. Healthcare industry does not have full advantage to develop sustainably because it has difficulties in safety, quality and inspection, patient care, commitment and human resource management. To promote the development and sustainability of supply chain management, decision-maker at each node of supply chain has to understand the right practices that need to be implemented. The decision is made based on qualitative information. Hence, fuzzy set theory is proposed for this study to defuzzify qualitative information (Tseng et al., 2018; Lin et al., 2019). This study applied exploratory factor analysis (EFA) to perform to the analytical structure; still, fuzzy Delphi method (FDM) is to screen out the lesser important criteria before EFA. The decision-making trial and evaluation laboratory (DEMATEL) method is used to exploit the interrelationships (Lan et al., 2019). As a result, the objectives of this study are as follows. (1) to define a set of SSCM attributes in practices; (2) to find out the interrelationship among these practices with linguistic preferences; and (3) to propose managerial implications for decision-makers in healthcare industry.

The purpose of this study is to encourage the sustainable development of healthcare industry by suggesting suitable activities for participants in supply chain. This study achieve the above objectives by answering the following research questions:

RQ1: What are SSCM attributes in practices?

RQ2: Is there any interrelationship among these SSCM practices?

RQ3: What are managerial implications for the participants in healthcare industry?

This study has three contributions include (1) proving a set of SSCM attributes through a qualitative information assessment; (2) proposing the interrelationship among SSCM practices through linguistics preferences; and (3) providing suggestion for healthcare industry. The conformity SSCM practices lead to outstanding outcome in supply chain, environmental protection and local community development. This study provides findings that decision makers can apply into increasing supply chain performance in Vietnam healthcare industry. These attributes represent for the main practices that ensure the sustainability in supply chain.

This study is presented as follow: the following section provides the background for SSCM and SSCM practices, proposed methodology and proposed measures for each attribute; third section mentions an explanation of the method using in this study and the process of collecting experts' opinions; forth section analyzes the results; next section presents the theoretical and managerial implications; finally, section five includes conclusions, limitations and suggestion for future study.

2. Literature review

This section presents the theory of SSCM as well as the interrelationship among attributes. In addition, the method and measurement used in this study are also mentioned.

2.1. Theoretical framework

The theory of triple bottom line (TBL) builds upon three key dimensions of sustainability including economic, social and environmental aspects (Azevedo et al., 2019; Lin et al., 2019; Elkington, 1998). While the profit-making capability of a firm is mentioned in the economic aspect, the social aspect refers to a firm's activities to support the stakeholders and community. At last, the environmental aspect relates to the environment-oriented activities of a firm through its operation. A firm is considered to be able to achieve completely sustainability if it concurrently complies with all these three dimensions (Sivarajah et al., 2019). Therefore, applying TBL theory in strategic decision making is important for sustainable supply chain management as it enables a firm to identify clear objectives and necessary activities. Moreover, the definition of TBL is the theoretical basis for a firm to absolutely understand its obligations not only to shareholders but also to broader stakeholders such as the community in society and other environmental aspects.

In stakeholder theory, stakeholders are understood as individuals, groups or organizations upon which the direct or indirect conduct of the firm has an impact (Bahadorestani et al., 2020). Firm needs to pay attention to stakeholder concerns on different aspects, instead of simply increasing the profit for shareholders because stakeholders is considered to have power of affecting community's opinions to a firm's sustainability performance. Furthermore, the implicit and explicit costs of negotiation and transaction are also reduced when firm has mutual trust and cooperation with stakeholders. Stakeholder theory includes three primary perspectives: (1) a theoretical structure positing an imperative for managers to take care of the interests of various stakeholders, rather than acting solely as the agents of firm's shareholders; (2) a description of stakeholders, their interests as well as the relationship with the focal firm; (3) a useful tool to investigate the connection between firm's stakeholder management and firm's outcomes (Rose et al., 2018). Stakeholder theory suggests firms increasingly implement sustainability practices based on the requirements of various groups of stakeholders (e.g. consumers, employees, investors, communities, government, etc.), and these practices are influenced by the strong belief that stakeholders progressively favor firms with an outstanding sustainability performance (Gong et al., 2019).

The investment recovery was introduced early in the prior studies as one of the firms' critical supply chain practices and is usually implemented at the end of supply chain (Tseng et al., 2019; Sheyadi et al., 2019; Fang et al., 2018). Investment recovery refers to as a practice of promoting the selling of excess materials, decreasing energy consumption from equipment and machines and recycling used products. Its objective is to encourage the recycling of used products into other variable materials so as to reduce their unfavorable influences on environment (Fang et al., 2018). Moreover, it aims to get back the value of surplus inputs to cut the waste of initially investment, which in turn lowers the cost of the product or service supplied for customers (Hu et al., 2019; Wu et al., 2010). In many cases, this practice also has a beneficial environmental impact due to redirecting excess materials and surplus equipment to other firms, extending their life cycle and usefulness (Piyathanavone et al., 2019). Hence, investment recovery is related to both environmental and economic aspects.

To fulfill the gap in SSCM, this study integrates the above theories including TBL and stakeholder theory to identify important attributes and the interrelationship among them.

2.2. Sustainable supply chain management

In the last decades, several academics and practitioners have paid attention to the definitions and practices of sustainable supply chain management (Junior et al., 2020). The pressures from being sustainability have led firms to implement SSCM. Based on the stakeholder theory and TBL, the SSCM definition involves ensuring that every stage and activity in the supply chain contributes to a positive impact on society, environment and economy by managing material, information and capital flows as well as cooperation within supply chain while achieving goals from all three dimensions of sustainable development which are stemming from customer and stakeholder requirements (Giannakis et al., 2020; Lin et al., 2019). Hu et al. (2019) argued that the SSCM adoption in companies requires all participants in supply chain including firms, suppliers, customers and other stakeholders make the joint efforts. In addition, SSCM includes firms' strategies on both internal and external participants that make the supply chain develop in accordance with the perspective of sustainability's dimensions including: environmental, social and economic component (Li et al., 2019). Many SSCM aspects have been explored by researchers and practitioners in different contexts including sharing economy, circular economy (Koberg et al., 2019; Gardas et al., 2019; Moktadir et al., 2018).

The study recently proposed two different groups of internal and external SSCM practices including sustainable supply management (SSM) and sustainable process management (SPM). Some authors argue that the implementation of SPM enables firms to effectively balance their priorities and therefore, have an impact on SSM (Gong et al., 2019; Wu et al., 2010). However, the others have shown the development of partnership with suppliers is the basis for firms to quickly acquire new technologies in order to promote their internal activities. For instance, Shou et al. (2019) argued that suppliers have a significant role in firms' manufacturing process; hence, SSM is the factor that affects SPM. Studying the relationship between these two SSCM practices is needed to clarify which aspect actually benefits the other, so that improve the SSCM implementation. In addition, customers are important stakeholders of the company as they contribute to the company's development. As firms rely more on their stakeholders to obtain sustainable SSCM, sustainable practices have been extended from firms to the whole supply chain (Wang et al., 2018).

In SSCM, one of the critical practices is to make a choice of first-rate suppliers. Li et al. (2019) argued that the suppliers who implement SSCM enable firms to increase performance across the supply chain. Example which refer to sustainability misconduct at supplier premises demonstrate that firms must find out a way to reduce their uncertainty about the working conditions in their supply chain networks as a vital antecedence for sustainable supply chain management (Foerstl et al., 2018). Shou et al. (2019) pointed out that SSM relates to the extent that companies incorporate TBL into their supply chain management. In other word, SSM is interpreted as the practices to which firm integrates TBL concept into the selection, assessment and collaboration with its suppliers (Giacomo et al., 2019). Therefore, when cooperating with suppliers, firms need to take into account all the environmental social and economic issues other than traditional economic drivers. Existing studies have identified a number of important premises for SSM practices and assess the effectiveness of their implementation. Specifically, other studies have shown the role of pressures from institution, middle managers in purchasing customers, innovativeness on implementing SSM practices (Sancha et al., 2015). Moreover, the performance effects of SSM practices has been studied in several studies in all environmental, economic and social aspects (Esfahbodi et al., 2016). Hence, with the importance contribution in SSCM, SSM practices need to be further investigated in relation to other practices.

Sustainable internal process practices which use technique to evaluate environmental impacts related to all stages of a product's life cycle, efficiently using of the secondary products and involving in production with less pollution and waste (Mathivathanan et al., 2018). These initiatives lead to sustainable output or processes such as a set of activities may be established to apply sustainability into traditional process (Ni et al., 2019). This practice is considered serious for the improvement of firm's performance because it comprises environmental and social activities that are generally implemented by firm (Mumtaz et al., 2018). Sustainable process management is an extension of internal green management which serves as activities independently applied by individual firms to enhance their environmental outcome and amplify a firm's individual performance without direct supplier involvement

(Brömer et al., 2019; Hu et al., 2019). It includes commitments from senior management on environmental issues, apparent and inclusive environmental administration and effective staff engagement in environmental improvement (Zhang et al., 2018). It shows the ability of a firm to reduce pollution due to its routine business activities (Zhang et al., 2018). It can be seen that SPM is mainly related to the environmental aspect of SSCM practices.

Zhang et al. (2018) defined customer green management (CGM) as the environmental activities that are jointly implemented with customers. Some studies argued CGM is crucial in adopting efficient SSCM to decrease the negative influence on environment (Hu et al., 2019). Customer green management is also referred to cooperation with customers to lower the environmental effect on product design, manufacture, package and logistics (Agarwal et al., 2018). Sellito et al. (2019) described cooperation with customers as practice involving collaborative efforts, such as technical and education support addressing at reducing environmental effects from products and services provided by the supply chain. This aspect aims to build environmental association with customers on the supply chain's downstream part, through agreement to collective goals on environment (Yu et al., 2020). Prior studies prove that this aspect supports firms to improve their economic outcome (Kazancoglu et al., 2018; Zhu et al., 2017). Moreover, it also benefits to promote environmental performance (Kazancoglu et al., 2018; Islam et al., 2018; Laari et al. 2016). While cooperation with customers is considered one part among many different GSCM practices, GSCM is extended into SSCM through expending the environmental aspects to both social and economic aspects as well (Yu et al., 2020; Li et al., 2019). From the above information, this study proposes that CGM is practice that can ensure sustainability for supply chain.

Due to economic outcome, environmental protection and social pressure, firms need to undertake or support another firm to undertake re-manufacturing operations including different practices such as recovery activities, used-product acquisition, reverse logistics or product disposition (Sun et al., 2018). These practices require the involvement of investment recovery into supply chain. Investment recovery is the firm's process of maximizing the value of surplus or excess assets through effective reuse or divestiture. The disposal of excess materials, inventories and used products not only enables firms recover capital but also limits harmful wastes that pollute the environment or affect the community.

In summary, SSCM includes internal activities within the firm and external activities related to stakeholders, as we call sustainable supply management, sustainable process management and customer green management. Investment recovery are also considered essential practices that enable firms to reach the SSCM goal during supply chain's value. The impact of these practices on supply chain management and the interrelationship between them is analyzed in next sections.

2.3. Proposed method

Prior studies use qualitative methods based on literature review to explore the composition of SSCM and the best practice (Esfahbodi et al., 2016; Lin et al., 2019). For instance, Koberg et al. (2019) presented a systematic review of SSCM in global supply which mentioned about some of SSCM practices. Scavarda et al. (2018) proposed a healthcare supply chain management framework based on qualitative information in the emerging economies. Case study method is also used in studying SSCM field in some countries (Azevedo et al., 2019; Sellitto et al., 2019).

In addition, prior studies used quantitative method in studying SSCM, especially SSCM practices. For instance, Hu et al. (2019) investigated the relationship between SSCM and customer intention in the context of sharing economy. With the objective to investigate the impacts of customer and cost drivers on green supply chain management practices and environmental performance, the partial least square (PLS) and structural equation modeling (SEM) technique are employed (Wang et al., 2018). In addition, Das (2017) developed and validated a scale for measuring SSCM practices and performance.

While these studies mentioned above used only methods and tools which lack of linguistics preferences, a few articles used ISM method or fuzzy DEMATEL to study about SSCM but not focused on its practices (Lin et al., 2018). Moreover, the evaluation of both qualitative and quantitative aspects in emerging area encourages the use of fuzzy set theory in this study. Fuzzy set theory is used in Prior studies to deal with problem related to the uncertainty of human assessment in ambiguous environment, and DEMATEL is used to build up the framework of cause-and-result relationship. As a result, this study applied fuzzy DEMATEL method to identify SSCM and analyze the interrelationship among practices as well as propose assessment using linguistics preferences (Tseng et al., 2018). More specifically, this study uses the fuzzy DEMATEL method to scrutinize the relationship between the attributes under studying, revisiting verbal descriptions of qualitative information from experts in healthcare industry, as well as develop a causal framework between the proposed attributes (Tseng et al., 2018). This study has built measurement scales for attributes that facilitate the exploration of their importance and influence in the industry by combining fuzzy theory and DEMATEL methods together.

2.4. Proposed measures

Prior studies have pointed out a variety of practices. However, it is important to select attributes based on proper evaluation of the multifaceted nature of SSCM. Hence, this study proposes the criteria to measure to the industry as indicated in Table 1.

Sustainable supply management relates to the suppliers, which are the first stakeholder of firms. Suppliers are at the very beginning of the supply chain, so their environmental, social and economic performance has a critical impact on those at the downstream of the supply chain (Hofstetter, 2018; Sarkis and Dhavale, 2015). Managing suppliers sustainably ensures companies' sustainable development prospects (Li et al. 2019). Four attributes have been selected (Ni et. al., 2019; Hu et al., 2019; Koberg et al., 2018). Supplier assessment (C1) means the focal firm gathers information to check whether suppliers follow firm's codes of conduct and private policy and evaluate their environmental and social outcome. Supplier collaboration (C2) is the direct participation of the firm in its supplier's activities in order to support suppliers to enhance the positive performance from their products and operations and decrease negative effects on environment and society such as carrying out mutual development, reducing waste of production, sponsoring for suppliers' convention. Green certification of supplier (C3) means the focal company closely collaborate with suppliers that are ISO 14,000 certificated. Environmental supplier selection (C4) is the process in which firm makes a choice of supplier based on its competitive requirement and environmental performance objective.

Sustainable process management is a practice of SSCM which reflects the activities implemented within the company without the direct relationship with supplier. This practice extends the objective of GSCM due to achieve company-specific internal goals established by top management or firm's policies and focus on internal activities to obtain better environmental, social and economic outcome (Zhang et al. 2018). Four attributes are defined regarding this aspect including environmental management system; environmentally friendly eco-design; health and safety certifications and internal training/ involvement program. Environmental management systems (C5) provides a framework that enables management board to better control the firm's environmental impacts such as commitment and policy on planning, implementation, measurement, evaluation and improvement. Environmentally friendly eco-design (C6) is a method used to reduce environmental impacts along the entire product life cycle from exploitation of the raw materials to the disposal of waste. Health and safety certifications (C7) is a set of interrelated requirements employed to build occupational health and safety policy and objectives within the firm and give instruction to achieve those objectives (like OHSAS 18001). Internal training/ involvement program (C8) is a practice which requires firms to organize official sustainability-oriented training and encourage their employees to take part in these programs.

Customer green management is an integral part of green supply chain management, so it supports to SSCM practices. Since the very first studies, the measurement scale of customer green management was proposed under the concept as "cooperation with customer". Adopting the result of Prior study, in this study we used three attribute regarding this aspect containing of cooperation for eco-design (C9) encourages firms to cooperate with customers in creating eco-friendly design for products or services; cooperation for cleaner production (C10) requires firms work collaboratively with customers to clarify and implement the idea about clean production; and cooperation for green packaging (C12) requires firms to change their packaging in an environment-oriented way based on customer suggestions (Hu et al., 2019; Zhu et al., 2013). After that, Zhang et al. (2018) is cooperation for saving the resource (C11) that requires firms cooperate with customers for reducing energy consumption during product manufacture and transportation. The three attributes (C9), (C10), (C11), (C12) form the construct of customer green management aspect.

SSCM leads to the “interactive and mutually reinforcing areas” of sustainable development such as economic growth, social stability, and environmental protection. While the first three aspects relates to the internal and external activities that ensure the environmental and social issues, the last aspect - investment recovery – not only relates to environmental and social aspects but also preferably mentions the economic aspect of SSCM practices. This last practice is constructed by four attributes including sale of excess material/inventories; sale of scrap/used materials; sale of excess capital equipment; recycling system establishment. The attribute of investment recovery was mentioned in several studies (Zhu et al., 2013, 2008, 2004) including three elements that require firms to have better utilization of excess material/ inventories (C13), scrap/used materials (C14) and excess capital equipment (C15). Agarwal et al. (2018) added one more attribute to the construct of investment recovery which is recycling system establishment (C16). SSCM requires the firms establish a system to recycle used and damaged products.

(INSERT Table 1 HERE- Table 1. Proposed criteria)

3. Methods

3.1. Industry background

Vietnam's healthcare industry has great potential with people's healthcare costs estimated at 16.1 billion USD per year, accounting for about 7.5% of GDP. During the period of 2011-2015, Vietnam was one of the fastest growing healthcare markets in Asia. Economic and population growth is driving the demand for health care services throughout Vietnam, especially in the economic centers. Experts believe that this growth rate is maintained in the next 20 years. Health service and health care industry have been forecast to reach USD 22.7 billion by 2021 (World Bank, 2018). However, healthcare services are water and energy intensive, consume a great deal of hazardous and non-hazardous materials and are responsible for producing polluting emissions. In addition, upgrading infrastructure, facilities, implementing a clean and green hospital program, enhancing the application of information technology are also challenges for healthcare industry. In the Hospital Management Asia 2019, the Minister of Health acknowledged that despite remarkable results, Vietnam was still a middle-income country with limited health resources. The aggravation of this concern has led to the requirement of SSCM.

SSCM needs a set of criteria to measure to the industry and the respondents should have abundant knowledge about interrelationships among the measures. In this study, 11 experts were chosen for interviews. There are 9 experts with more than 15 years experience in healthcare industry, among them 6 experts are in charge of high position in the organization. The other respondents are 2 experts with more than 10 years of research experience in healthcare area.

3.2 Fuzzy set theory

During the assessment, experts encounter the difficulty to state their judgments into precise numbers. Linguistic variables are adopted to solve this difficulty for enhancing the efficiency of assessment. However, these variables possess the qualitative feature that requires to transfer into comparable numbers. Thus, triangular fuzzy numbers (TFN) are proposed to deal with this transformation as Table 1 shown (Wu et al., 2017). Assuming there are e experts are requested to make the assessment. These assessments are presented in the linguistic variables, which can be demoted as a_{bc}^{e}. It expresses b^{th} criterion affected to c^{th} criterion that evaluated by the e^{th} expert. However, these linguistic variables require to transfer into triangular fuzzy numbers $(\ell_{bc}^{e}, m_{bc}^{e}, r_{bc}^{e})$. The related defuzzification and aggregation procedures are listed as follows.

(INSERT Table 2 HERE- Table 2. Fuzzy linguistics references)

Triangular fuzzy numbers normalization

$$\tilde{\ell}_{bc}^{e} = \frac{(\ell_{bc}^{e} - min\, \ell_{bc}^{e})}{d_{bc}^{e}} \quad (1)$$

$$\tilde{m}_{bc}^{e} = \frac{(m_{bc}^{e} - min\, m_{bc}^{e})}{d_{bc}^{e}} \quad (2)$$

$$\tilde{r}_{bc}^{e} = \frac{(r_{bc}^{e} - min\, r_{bc}^{e})}{d_{bc}^{e}} \quad (3)$$

where $d_{bc}^{e} = max\, r_{bc}^{e} - min\, \ell_{bc}^{e}$

Left (L_{bc}^{e}) and right (R_{bc}^{e}) normalized value generation

$$L_{bc}^{e} = \frac{\tilde{m}_{bc}^{e}}{(1 + \tilde{m}_{bc}^{e} - \tilde{\ell}_{bc}^{e})} \quad (4)$$

$$R_{bc}^{e} = \frac{\tilde{r}_{bc}^{e}}{(1 + \tilde{r}_{bc}^{e} - \tilde{m}_{bc}^{e})} \quad (5)$$

Total normalized crisp values acquisition CV_{bc}^{e}

$$CV_{bc}^{e} = \frac{[L_{bc}^{e} \times (1 - L_{bc}^{e}) + (R_{bc}^{e}) \times (R_{bc}^{e})]}{(1 - L_{bc}^{e} + R_{bc}^{e})} \quad (6)$$

Crisp values aggregation

$$CV_{bc} = \frac{\sum_{b,c=1}^{e} (CV_{bc}^{e})}{e}, e = 1,2,3, \cdots, f \quad (7)$$

3.2 Decision-making and trial evaluation laboratory

DEMATEL enables to assist assessor to identify the cause and effect criteria through mapping it into diagram (Zhou et al., 2018). This diagram provides visual analysis with enhancing the better understanding for dealing with the interdependence relations. Before generating the diagram, the aggregated crisp values CV_{bc} require rearranging into direct relation matrix as $DR = [CV_{bc}]_{g \times g}$; thereinto, g represents the numbers of proposed criteria. However, the direct relation matrix has to be normalized through employing the following equation.

$$\widetilde{DR} = \alpha \times DR \tag{8}$$

where $\alpha = \frac{1}{\max\limits_{1 \le b \le g} \sum_{c=1}^{g} CV_{bc}}$.

The following equation is used for obtaining the total relation matrix (TR).

$$TR = \widetilde{DR} \times \left(U - \widetilde{DR}\right)^{-1} \tag{9}$$

where U is the unit matrix.

Consequently, the equations as below are employed to attain the vector i and j of cause and effect diagram.

$$TR = [\overline{CV}_{bc}]_{g \times g}, b, c = 1,2,3, \cdots, g \tag{10}$$

$$i = \left[\sum_{b=1}^{g} (\overline{CV}_{bc})\right]_{g \times 1} = [\overline{CV}_b]_{g \times 1} \tag{11}$$

$$j = \left[\sum_{c=1}^{g} (\overline{CV}_{bc})\right]_{1 \times g} = [\overline{CV}_c]_{1 \times g} \tag{12}$$

Adopting vertical axis $(i - j)$ and horizontal axis $(i + j)$ maps the criteria into cause and effect diagram. If the criterion locates $(i - j) > 0$, it means that the criterion possesses the causal feature to affect other criteria. Once the criterion falls into $(i - j) < 0$, criterion has effect feature, which is affected by the causal criterion. Moreover, $(i + j)$ represents the importance of criterion, it has higher importance if the criterion has higher values.

3.3 Proposed Analytical Procedures

1. Initial proposed criteria are screened out from literature review for ensuring the reliability and EFA to confirm the aspects These proposed measures have to confirm with experts for reflecting the real situation and enhancing the validity. The selected experts must have the related experiences with at least seven years. Requesting experts make the assessment of these proposed measures.
2. Experts' assessments have to transfer into TFN based on Table 2. These TFN need to normalize through Eqs. (1) – (3). Eqs. (4) – (7) enable to use for generating the crisp values.
3. These crisp values need to rearrange into direct relation matrix and normalize it by

applying Eq. (8). Utilizing Eqs. (9) – (12) acquire the vector i and j.

4. Base on the axis $(i - j)$ and horizontal axis $(i + j)$ maps the criteria into cause and effect diagram. Quadrant I called driving area, it means that located criterion with higher causal and important features to affect other criteria. Quadrant II named Voluntary area, the criterion falls into this area with lower importance, but possesses the higher causal feature. Independent area is quadrant III, criterion belongs to this area with lower causal and important feature. Quadrant IV is the core problem area; criterion is the core problem but can't be improved by itself in this area, it relies on the causal criterion to make its improvement.

4. Results

1. This study mentioned 20 practices referring to five aspects to evaluate. The FDM process is presented through Tables 3, 4 and 5 as well as their weight and threshold to filter out attributes. Expert respondents evaluated the initial set of SSCM depended on their experience of the healthcare industry. After evaluating attributes, the qualitative information is transferred into triangular fuzzy numbers as show in Table 1. The FDM is applied to define the critical criteria, which are displayed in Table 3 with the threshold of 0.7387. There are 16 criteria are accepted and presented in Table 3.

(INSERT Table 3 HERE- Table 3. FDM for criteria)

EFA is applied to confirm the reliability and the aspects retained was determined. The eigenvalues for the first five factors were 5.21, 4.33, 3.04, and 2.92. The next three factors had the eigenvalues of 1.92, 1.31, and 1.14. Total 82.1% percentage of variance explained and KMO value at 0.64. The experts continue to redefine 5 proposed aspects. Table 4 presented there are 4 aspects, named sustainable supply management (A1- Cronbach α 0.93), sustainable process management (A2- Cronbach α 0.88), customer green management (A3- Cronbach α 0.82) and investment recovery (A4- Cronbach α 0.76).

(INSERT Table 4 HERE- Table 4. EFA Results)
(INSERT Table 5 HERE- Table 5.Defuzzification procedure from Expert 1)

2. Table 5 presented experts fuzzy linguistics NI to VH as shown in Table 2. These qualitative information is transferred into triangular fuzzy numbers. The triangular fuzzy number is defuzzified into crisp value using Eqs. (4)-(7).

3. These fuzzy numbers are incomparable and incomputable; thus, the procedure is continued to convert these vague values to precise crisp values. Table 6 and 7 present this procedure using Eqs. (9)-(12).

(INSERT Table 6 HERE- Table 6. Crisp values for aspects)
(INSERT Table 7 HERE- Table 7.Total interrelationship matrix of aspects)

4. Table 8 presented *i* as the sum of the values in one row and *j* as the sum of the values in one column. These two sets of values are employed to reflect the driving and dependence power (or causal effect). (i-j) is a positive value and sustainable supply management (A1), and sustainable process management (A2) are classified into cause groups; otherwise, customer green management (A3) and investment recovery (A4) are classified into effect groups. The dataset on (i+j), (i-j) is used to map the causal diagram, showed in Figure 1.
(INSERT Table 8 HERE- Table 8.Cause and effect among aspects)
(INSERT Figure 1 HERE- Figure 1. Causal diagram among the aspects)

This study are repeated the four steps for criteria assessment. Table 9 shows the crisp values and Table 10 shows the total interrelationship of criteria. Driving and dependence power for the criteria is calculated and presented in Table 11. Then, the causal effect diagram of the criteria is generated in Figure 2 which supplier assessment (C1), environmental management systems (C5), green certification of supplier (C3), supplier collaboration (C2) and health and safety certifications (C7) are figured out as the top five causal criteria for SSCM.
(INSERT Table 9 HERE- Table 9. Crisp values of criteria)
(INSERT Table 10 HERE- Table 10. Criteria crisp values)

Figure 2 indicated the 16 criteria are categorized into four groups. Autonomous factor quadrant includes C9, C11, C13, C14, C15 and C16 with weak driving and dependence power which means rather disconnected from the system and effects on others are very limited. C7 and C10 belong to dependent factor quadrant. With weak driving power, these criteria affect the system less while they are easily influenced by other criteria due to strong dependence power. Third quadrant includes independent factors such as C4, C6, C8 and C12 with considerable driving power but limited dependence power. And C1, C2, C3 and C5 belong to linkage quadrant with high driving power and dependence. These criteria significantly impact others; hence, improving these criteria can have ongoing and feedback effects on others. Therefore, these four criteria are considered the most influencing practices of SSCM.
(INSERT Table 11 HERE- Table 11. Criteria driving and dependence power)

(INSERT Figure 2 HERE- Figure 2. Criteria driving and dependence power diagram)

5. Implications

This section presents the theoretical and managerial implications.

5.1. Theoretical implication

Sustainable process management is in the causal group and has the strong influence on sustainable supply management. The finding indicates that sustainable process management through applying environmental management system and health and safety certification guidance firms to define standards that are needed from their suppliers. The relationship between two first aspects also confirms the argument of Gong et al. (2019). Besides, sustainable supply management also belongs to causal group. As the importance of suppliers increases, sustainable supply management is considered as key activities that enable the firm to achieve success in its efforts towards sustainability (Shou et al., 2019). Sustainable supply management ensures that firms have quality inputs to meet environmental standards of manufacturing process and increase the ability of designing eco-friendly products, as well as maintain a safe working environment for employees. Sustainable supply management also impacts sustainable process management; however, the impact level is still weak. This result partly confirms the argument of Shou et al. (2019). Investment recovery belongs to the effect group means that the performance of the two causal attribute impact the firm's way of recovering initial investment. However, the influence is weak while in Prior study, investment recovery is considered to enhance the activities of all stakeholders in the supply chain; so it does not affirm the argument of Engeland et al. (2020). The result is suitable in Vietnam's healthcare industry where people care about the manufacturing process and product more than how to reuse or recycle.

Sustainable process management refers to internal practices among the firm and is composed of four social and environmental practices that are generally implemented without direct supplier participation, including (1) environmental management systems; (2) environmentally friendly eco-design on the environmental side; (3) health and safety certifications and (4) internal training/ involvement program on social side (Brömer et al., 2019; Gualandris et al., 2014). Sustainable process management leads to quality products that meet customer demand, increases company profits and satisfies stakeholder requirements. In addition, the application of environmental, safety and health standards to production processes requires the firm to pay attention to these standards in its suppliers, thereby increases sustainable supply management. Sustainable process management has impact on customer green management and investment recovery, but these impacts are quite weak. Again, it shows that in the healthcare industry, the firm's sustainable process management is not enough to involve customers into these activities; as well as recovering capital from surplus assets or excess materials to avoid waste and contribute to environmental protection.

Sustainable supply management is the second aspect of causal group. While one of the most vital challenges related to sustainable supply chain is that social and environmental behavior in the supply networks cannot be openly observed, it requires firms to implement sustainable supply management through encompassing supplier selection, assessment as well as collaboration (Foerstl et al., 2018). Such sustainable supply management practices not only lessen the risk of reputation damage and financial loss, but also allow firms to make difference in the marketplace through protecting green suppliers, manufacturing sustainable products and ensuring end-to-end sustainable supply chain processes (Blome et al., 2017). The result also show that sustainable supply management has a strong impact on customer green management. This proves that in the healthcare industry, when firms sustainably manage their suppliers, they also work closely with their customers to obtain ideas on eco-design, green packaging and manufacturing process and operations so as to ensure a sustainable interrelationship between key participants in the supply chain. The impact of sustainable supply management on investment recovery is weak, proving that the relationship with suppliers hardly affects the firm's capital recovery decisions.

Customer green management is the effect attribute in promoting practices of SSCM. The result points out that customer green management has no impact on the other aspects. However, that does not mean the firms should ignore this aspect. Customer is critical stakeholder of firms because they are at the downstream of supply chain and consume the firms' product; while investment recovery relates to community. Agarwal et al. (2018) argued that customer green management was also referred to as cooperation with customers. Due to increasing environmental pressures from stakeholders in the modern global market and supply chains, firms must cooperate with customers to create ecological designs, achieve environmental goals collectively, reduce overall environmental impacts and develop mutual environmental planning (Yu et al., 2020). This result encourage the argument in Prior studies which considered customer green management as an important attribute in adopting effective SSCM (Hu et al., 2019).

5.2. Managerial implication

This section suggests the managerial implications for firms and their stakeholders in the supply chain. The finding proposes four quadrants based on the driving and dependence power of criteria. The linkage quadrant includes criteria that have the strong causal effect such as supplier assessment (C1), environmental management systems (C5), green certification of supplier (C3) and supplier collaboration (C2). These criteria enhances SSCM in healthcare industry and are explored as the following.

The first practice mentioned is related to the supplier management. Supplier assessment (C1) in which the firm gathers information to control and evaluate supplier social and environmental performance; then, comply with the firm's codes of conduct and private standards plays the most important role in SSCM as it increases the quality of the stakeholder in the upstream of one supply chain. Periodic supplier assessment ensures that firms have qualified inputs; as well as they can support their suppliers in time when suppliers encounter difficulties in the production or transportation process. In order to make a good assessment of products and suppliers, it is necessary to set up and implement the supplier assessment in a structured way such as requiring proper information about the product, the production process and the way in which established risks are controlled by the supplier. It is also important from time to time to reassess the status of all suppliers. This reassessment is preferable to be inserted into the yearly cycle in which the evaluation of complaints and the management review are carried out. Finally, firms need to regularly visit suppliers to assess whether they can meet their obligations in the field of production or not. The crucial thing when evaluating the suppliers is that the outcome is not only related to economic benefits between the two parties, but also to the environmental and social practices impacted by the firm's operations and their suppliers.

Besides supplier assessment, supplier collaboration is an essential practice in sustainable supply management because it strengthens the relationship between firms and their suppliers. Supplier collaboration (C2) requires firms to engage directly with its suppliers to support and enable them to improve the environmental and social impacts of their products and operations. First, the company needs to undertake joint development efforts by identifying supplier expectations, their culture and timely information sharing. Among them, information-sharing is an inextricable part of supplier collaboration and firms need to determine what data and designs they can share with suppliers without posing a risk to their intellectual property or trade secrets. The second is the cooperation with suppliers to reduce logistical waste during the transportation of raw materials to the factory. Firms should negotiate with their suppliers about the delivery location so as to minimize transportation routes, and support appropriate means of transportation to minimize waste to the environment. In addition, firms need to sponsor and participate in supplier's conferences and summits in order to convey sustainability message to not only the management board but also the entire employees. From there the suppliers are more connected with the company's sustainable development objectives.

Selecting a supplier is extremely important in SSCM as it enables firms to reduce costs, improves quality and maintains long-term relationships with its suppliers. Supplier selection is not a simple practice, since different potential suppliers may have similar characteristics or provide similar input products. For many years, companies have traditionally chosen suppliers based on quality, cost and lead time. However, due to increasing environmental concerns, this is no longer enough at the moment and companies have had to incorporate environmental issues into common supplier selection criteria. Green certification of supplier (C3) relates to the selection of suppliers but focuses more on the sustainability of the suppliers as shown by the certifications they obtain (e.g. ISO 14,000 certification). When selecting suppliers, especially in the healthcare industry with quality and safety requirements that need to be put on top, the selection process must be even more stringent. In addition to verifying the suppliers' green certificates, firms need to understand these certification, such as their meaning, origin, validity, and value compared to other certificates. However, for suppliers who have passed the quality test of input products but do not have the necessary certifications, firms should not refuse to collaborate immediately, but to find out the reason in order not to ignore really good suppliers.

Environmental management system (C5) such as the ISO 14001 provides a set of instruction that enables firm to better control its environmental impacts as well as practical tools for firm to manage its environmental responsibilities. This practice maps out a framework that any firms regardless of their activity or sector need to follow to establish an effective environmental management. Using environmental management system provides assurance to firm's management and employees as well as external stakeholders that environmental impact is being measured and improved. The first thing to build an environmental management system is to define the company's goals for environmental issues, namely which environmental activities the firm needs to improve and how they support other activities. The next step is to obtain the commitment from top management to support the development and implementation of environmental management system by explaining the strengths and weaknesses of firm's current approach and how financial and environmental outcomes are impacted by those limitations; thereby, convincing the management of benefits of this practice. Select an environmental management system champion to set up an implementation team and involve employees is the following step that need to be taken. Finally, the firm need to regularly check the progress against their goals and project plan, and inform this progress within the firm.

Although health and safety certifications attribute does not belong to linkage quadrant which has strong driving power and dependence but it is also in causal group and one of sustainable process management criteria. Thus, this criterion has impact on SSCM and need to be analyzed. Health and safety certifications (C7) are certifications from Occupational Health and Safety System which is a set of interrelated elements. This system give instruction for firms to establish occupational health and safety policy and objectives, and to achieve those objectives (like OHSAS 18001). Health and safety certifications attribute increases a safe and healthy working environment by providing a model that firms should apply to identify and control risks of health and safety, reduce potential accidents, support the compliance with legal issues and improve overall activities. Following the standards of health and safety in the firm is done through 4 main steps Plan - Do -Check - Act. In the Plan step, the firm needs to define the safety and health standards that is applied, establish objectives and procedure in compliance with the firm's policy. The firm implements the procedure as planned in the Do step, and then observes and measures activities and progress with regard to the health and safety policy and objectives, and report the results in the Check step. In the final step, the firm takes actions to continually improve the health and safety practice to achieve the intended performance.

6. Conclusions

While SSCM was mentioned in several studies, it has been pointed out that SSCM in service industry remains unclear and the relationship between its attribute was not explored. For instance, the connection between main stakeholders and their practices leading to the sustainable supply chain management has not been studied and reached full conclusions. Moreover, this study also argued about investment recovery as a practice which supports supply chain to reach objective under TBL concept. To find out the answer, this study offered a set of attribute to explore what are the most effective practices in SSCM using linguistic preferences. The result comes up with practical implications that is helpful for decision makers in the supply chain including focal firms, suppliers, customers and other stakeholders. This also proposes analytical method to evaluate SSCM performance for future studies.

The findings propose attributes with the best contribution in encouraging SSCM and can be used as practical tools to set up plans that satisfy stakeholder's requirement. This finding can be applied into healthcare industry to strengthen causal attributes and from that, enhance supply chain sustainability. This study indicates that sustainable supply management and sustainable process management take the important role to SSCM as these aspects belong to the causal group and have a strong effect on customer green management. It is inferred that managing process sustainably ensures sustainable supply management and then, develop cooperation with customer. More specifically, 16 criteria were divided into four groups based on their dependence and driving power such as autonomous group, dependent group, independent group and linkage group. The top causal criteria have the strongest effect on SSCM including supplier assessment, environmental management systems, green certification of supplier, supplier collaboration and health and safety certifications. These criteria could be employed as tools to develop SSCM in healthcare industry.

This study contributes to SSCM by providing the guideline for promoting sustainable practices to support healthcare supply chain. From the finding, two most crucial practices relate to the process and supplier, hence, firms need to focus on these issues when planning SSCM strategy. Specifically, to ensure sustainable process management, companies need to pay attention to two main issues, one is to apply an appropriate management system according to environmental standards and the other is to implement and enhance the health and safety certification to improve environment for employees in the company. On other hand, suppliers are important in the firm's supply chain because they ensure the inputs for the production to meet market and society requirements. In order to promote sustainable supply management, firm needs to conduct three main activities. The first is to regularly re-evaluate suppliers on the quality of the material they provide as well as their social and environmental performance; the second is to collaborate with the suppliers to decrease the impact of their products and operations on the environment and society; and the third is to make a selection of suppliers based on the green standards and certifications they achieve. Sustainable supply management also has a strong impact on the firms' cooperation with the customers.

This study still has several limitations. Firstly, healthcare industry involves many types of organizations, such as hospital - in both public and private areas, healthcare center, healthcare clinic, healthcare institute, etc. However, this study only interviewed experts from some of these organizations. The future study could be widen the result by approaching more experts from different healthcare organizations. Secondly, SSCM is related to many stakeholders, such as suppliers, customers, government officials, local communities. Nonetheless, this study just focuses on expert in healthcare organizations. Collecting data from experts in other organizations could bring a more complete overview of SSCM in future study. Thirdly, this study has a limitation on the number of respondents. In future studies, the sample of expert respondent should be enlarged to further explore the interrelationship between attributes based on DEMATEL framework using linguistics preferences. Moreover, a comparative study on the viewpoint of different experts could examine the proposed framework using various attribute. Finally, future studies should employ hybrid method approaches to investigate the SSCM practices.

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Table and Figures

Table 1. Proposed criteria

Measures (Criteria)		References
C1	Supplier assessment	Hu et al. (2019)
C2	Supplier collaboration	Koberg et al. (2019)
C3	Green certification of supplier	Ni et al. (2019)
C4	Environmental supplier selection	Gualandris et al. (2014)
C5	Environmental management systems	
C6	Environmentally friendly eco-design	Ni et al. (2019)
C7	Health and safety certifications	Gualandris et al. (2014)
C8	Internal training/ involvement program	
C9	Cooperation for eco-design	Hu et. al. (2019)
C10	Cooperation for cleaner production	Zhang et al. (2018)
C11	Cooperation for saving the resource	Xu and Gursory (2015)
C12	Cooperation for green packaging	Zhu et al. (2013)
C13	Sale of excess material/inventories	
C14	Sale of scrap/used materials	Hu et al. (2019)
C15	Sale of excess capital equipment	Argawal et al. (2018)
C16	Recycling system establishment	Zhu et al. (2013)

Table 2. Linguistic variables for corresponding TFN

Linguistic preferences	Meanings	Corresponding TFN
NI	No influence/importance	(0.0, 0.1, 0.3)
VL	Very low influence/importance	(0.1, 0.3, 0.5)
M	Medium influence/importance	(0.3, 0.5, 0.7)
HI	High influence/importance	(0.5, 0.7, 0.9)
VH	Very high influence/importance	(0.7, 0.9, 1.0)

Table 3. FDM for criteria

Initial practices	ℓ_{bc}^{e}	m_{bc}^{e}	r_{bc}^{e}	Decisions
C1	0.3337	0.9162	0.7775	Accepted
C2	0.3488	0.9011	0.7674	Accepted
C3	0.3226	0.9273	0.7848	Accepted
C4	0.3444	0.9055	0.7703	Accepted
C5	0.2997	0.9502	0.8001	Accepted
C6	0.3226	0.9273	0.7848	Accepted
C7	0.3113	0.9386	0.7924	Accepted
C8	0.3226	0.9273	0.7848	Accepted
C9	0.3444	0.9055	0.7703	Accepted
C10	0.3226	0.9273	0.7848	Accepted
C11	0.3226	0.9273	0.7844	Accepted
C12	0.3113	0.9386	0.7924	Accepted
C13	0.3549	0.8950	0.7633	Accepted
C14	0.3444	0.9055	0.7703	Accepted
C15	0.3549	0.8950	0.7633	Accepted
C16	0.2997	0.9502	0.8001	Accepted
C17	0.0377	0.8372	0.6414	Unaccepted
C18	0.01584	0.8591	0.6561	Unaccepted
C19	0.02512	0.8498	0.6499	Unaccepted
C20	0.01771	0.5345	0.3333	Unaccepted
Threshold			0.7387	

Table 4. EFA Results

Aspects		Criteria	Factor Loadings
Sustainable supply management (A1) Cronbach α 0.93	C1	Supplier assessment	0.952
	C2	Supplier collaboration	0.947
	C3	Green certification of supplier	0.924
	C4	Environmental supplier selection	0.910
Sustainable process management (A2) Cronbach α 0.88	C5	Environmental management systems	0.909
	C6	Environmentally friendly eco-design	0.982
	C7	Health and safety certifications	0.978
	C8	Internal training/ involvement program	0.966
Customer green management (A3) Cronbach α 0.82	C9	Cooperation for eco-design	0.890
	C10	Cooperation for cleaner production	0.888
	C11	Cooperation for saving the resource	0.872
	C12	Cooperation for green packaging	0.862
Investment recovery (A4) Cronbach α 0.76	C13	Sale of excess material/inventories	0.821
	C14	Sale of scrap/used materials	0.806
	C15	Sale of excess capital equipment	0.792
	C16	Recycling system establishment	0.785

Note: total 82.1% percentage of variance explained and KMO value at 0.64. The Cronbach α is 0.93 and 0.76.

Table 5.Defuzzification procedure from Expert 1

		A1					A2					A3					A4			
A1	[	1.000	1.000	1.000	]	[	0.700	0.900	1.000	]	[	0.500	0.700	0.900	]	[	0.500	0.700	0.900	]
A2	[	0.700	0.900	1.000	]	[	1.000	1.000	1.000	]	[	0.500	0.700	0.900	]	[	0.700	0.900	1.000	]
A3	[	0.500	0.700	0.900	]	[	0.500	0.700	0.900	]	[	1.000	1.000	1.000	]	[	0.300	0.500	0.700	]
A4	[	0.500	0.700	0.900	]	[	0.300	0.500	0.700	]	[	0.300	0.500	0.700	]	[	1.000	1.000	1.000	]
		ℓ_{bc}^{e}	m_{bc}^{e}	r_{bc}^{e}			ℓ_{bc}^{e}	m_{bc}^{e}	r_{bc}^{e}			ℓ_{bc}^{e}	m_{bc}^{e}	r_{bc}^{e}			ℓ_{bc}^{e}	m_{bc}^{e}	r_{bc}^{e}	
A1	[	1.000	0.600	0.200	]	[	0.571	0.571	0.429	]	[	0.286	0.286	0.286	]	[	0.286	0.286	0.286	]
A2	[	0.400	0.400	0.200	]	[	1.000	0.714	0.429	]	[	0.286	0.286	0.286	]	[	0.571	0.571	0.429	]
A3	[	0.000	0.000	0.000	]	[	0.286	0.286	0.286	]	[	1.000	0.714	0.429	]	[	0.000	0.000	0.000	]
A4	[	0.000	0.000	0.000	]	[	0.000	0.000	0.000	]	[	0.000	0.000	0.000	]	[	1.000	0.714	0.429	]
		L_{bc}^{e}	R_{bc}^{e}				L_{bc}^{e}	R_{bc}^{e}				L_{bc}^{e}	R_{bc}^{e}				L_{bc}^{e}	R_{bc}^{e}		
A1		1.000	0.333				0.571	0.500				0.286	0.286				0.286	0.286		
A2		0.400	0.250				1.000	0.600				0.286	0.286				0.571	0.500		
A3		0.000	0.000				0.286	0.286				1.000	0.600				0.000	0.000		
A4		0.000	0.000				0.000	0.000				0.000	0.000				1.000	0.600		
		CV_{bc}					CV_{bc}					CV_{bc}					CV_{bc}			
A1		0.667					0.673					0.500					0.500			
A2		0.678					0.720					0.500					0.673			
A3		0.500					0.500					0.720					0.300			
A4		0.500					0.300					0.300					0.720			

Table 6. Crisp values for aspects

	A1	A2	A3	A4
A1	0.681	0.594	0.580	0.514
A2	0.596	0.705	0.493	0.477
A3	0.494	0.391	0.698	0.386
A4	0.445	0.373	0.391	0.712

Table 7.Total interrelationship matrix of aspects

	A1	A2	A3	A4
A1	2.677	2.469	2.577	2.452
A2	2.554	2.440	2.451	2.354
A3	2.163	1.974	2.215	1.989
A4	2.073	1.903	2.003	2.088

Table 8. Cause and effect among aspects

	i	j	i+j	i-j
A1	10.175	9.467	19.642	0.708
A2	9.799	8.786	18.585	1.013
A3	8.341	9.246	17.587	(0.905)
A4	8.068	8.884	16.952	(0.816)
Max			19.642	1.013
Min			16.952	(0.905)
Average			18.191	0.000

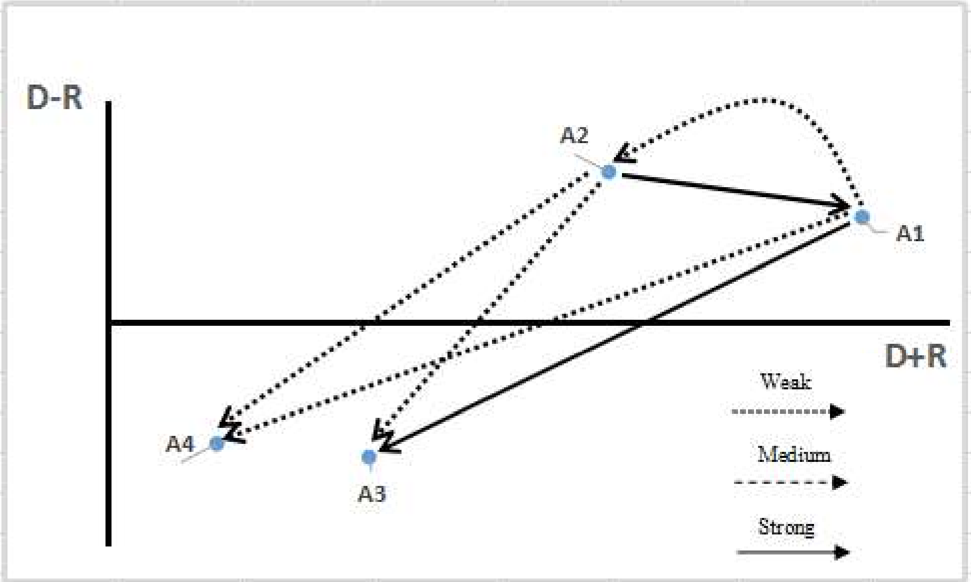

Figure 1. Causal interrelationships diagram among the aspects

Table 9. Crisp values of criteria

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16
C1	0.754	0.673	0.660	0.539	0.508	0.535	0.399	0.530	0.673	0.394	0.357	0.565	0.336	0.341	0.500	0.494
C2	0.690	0.720	0.692	0.692	0.691	0.698	0.514	0.521	0.673	0.521	0.521	0.321	0.312	0.321	0.500	0.321
C3	0.643	0.300	0.767	0.608	0.557	0.499	0.437	0.566	0.500	0.494	0.441	0.497	0.421	0.428	0.300	0.462
C4	0.611	0.300	0.596	0.767	0.471	0.429	0.402	0.461	0.500	0.464	0.444	0.446	0.264	0.359	0.300	0.305
C5	0.486	0.318	0.521	0.592	0.756	0.601	0.542	0.515	0.318	0.515	0.514	0.533	0.530	0.568	0.318	0.481
C6	0.438	0.300	0.455	0.471	0.560	0.764	0.509	0.480	0.300	0.426	0.462	0.513	0.508	0.550	0.300	0.532
C7	0.400	0.300	0.402	0.456	0.523	0.531	0.754	0.599	0.300	0.394	0.323	0.425	0.419	0.531	0.300	0.444
C8	0.559	0.300	0.454	0.525	0.472	0.425	0.490	0.769	0.300	0.393	0.356	0.390	0.417	0.377	0.300	0.445
C9	0.314	0.300	0.514	0.514	0.314	0.321	0.314	0.321	0.720	0.321	0.321	0.321	0.312	0.321	0.300	0.321
C10	0.490	0.300	0.561	0.474	0.436	0.427	0.335	0.358	0.300	0.779	0.497	0.465	0.353	0.288	0.300	0.375
C11	0.438	0.300	0.403	0.494	0.419	0.408	0.317	0.269	0.300	0.426	0.769	0.445	0.371	0.429	0.300	0.374
C12	0.525	0.300	0.419	0.421	0.489	0.478	0.351	0.270	0.300	0.412	0.461	0.769	0.353	0.445	0.300	0.464
C13	0.261	0.300	0.261	0.366	0.382	0.409	0.334	0.411	0.300	0.271	0.376	0.340	1.000	0.481	0.300	0.235
C14	0.264	0.300	0.314	0.318	0.418	0.497	0.298	0.412	0.300	0.324	0.412	0.447	0.424	0.771	0.300	0.372
C15	0.314	0.300	0.116	0.116	0.314	0.321	0.314	0.321	0.300	0.123	0.321	0.321	0.312	0.321	0.720	0.321
C16	0.435	0.300	0.318	0.334	0.384	0.447	0.403	0.444	0.500	0.340	0.321	0.377	0.297	0.463	0.300	0.771

Table 10. Total interrelationship matrix of criteria

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16
C1	0.356	0.273	0.340	0.333	0.328	0.334	0.280	0.315	0.308	0.276	0.280	0.317	0.267	0.282	0.251	0.292
C2	0.364	0.289	0.360	0.368	0.366	0.370	0.308	0.329	0.321	0.306	0.314	0.304	0.278	0.294	0.262	0.285
C3	0.330	0.219	0.340	0.329	0.321	0.317	0.274	0.308	0.276	0.278	0.280	0.299	0.268	0.283	0.217	0.278
C4	0.302	0.201	0.296	0.323	0.286	0.283	0.247	0.271	0.255	0.253	0.257	0.269	0.227	0.250	0.199	0.237
C5	0.316	0.224	0.315	0.331	0.350	0.335	0.291	0.307	0.256	0.285	0.293	0.308	0.287	0.305	0.223	0.285
C6	0.292	0.209	0.289	0.298	0.309	0.336	0.271	0.285	0.239	0.258	0.271	0.289	0.269	0.287	0.208	0.276
C7	0.272	0.198	0.268	0.282	0.290	0.293	0.288	0.286	0.226	0.242	0.240	0.264	0.245	0.271	0.197	0.252
C8	0.289	0.197	0.272	0.288	0.280	0.277	0.254	0.303	0.225	0.239	0.241	0.257	0.242	0.248	0.195	0.249
C9	0.221	0.168	0.242	0.247	0.222	0.224	0.198	0.212	0.243	0.197	0.203	0.211	0.195	0.206	0.168	0.199
C10	0.274	0.191	0.278	0.274	0.268	0.269	0.227	0.246	0.219	0.279	0.253	0.259	0.227	0.230	0.190	0.234
C11	0.256	0.183	0.248	0.265	0.255	0.256	0.216	0.224	0.209	0.227	0.275	0.246	0.220	0.238	0.182	0.224
C12	0.277	0.191	0.260	0.267	0.274	0.276	0.229	0.235	0.218	0.235	0.248	0.295	0.227	0.250	0.190	0.245
C13	0.216	0.170	0.212	0.232	0.233	0.239	0.203	0.226	0.193	0.193	0.213	0.217	0.284	0.230	0.170	0.191
C14	0.223	0.174	0.225	0.232	0.244	0.256	0.204	0.232	0.198	0.205	0.223	0.236	0.218	0.270	0.174	0.214
C15	0.184	0.143	0.157	0.162	0.186	0.189	0.167	0.179	0.162	0.141	0.171	0.178	0.166	0.175	0.194	0.169
C16	0.253	0.182	0.235	0.243	0.249	0.259	0.225	0.245	0.232	0.214	0.219	0.236	0.209	0.241	0.181	0.270

Table 11. Driving and dependence power of criteria

	i	j	i+j	i-j
C1	4.830	4.424	9.255	0.406
C2	5.120	3.213	8.333	1.908
C3	4.617	4.337	8.955	0.280
C4	4.155	4.473	8.628	(0.318)
C5	4.711	4.460	9.172	0.251
C6	4.385	4.512	8.898	(0.127)
C7	4.114	3.881	7.996	0.233
C8	4.057	4.202	8.259	(0.146)
C9	3.356	3.781	7.138	(0.425)
C10	3.918	3.827	7.745	0.091
C11	3.726	3.982	7.708	(0.257)
C12	3.917	4.184	8.101	(0.267)
C13	3.422	3.829	7.252	(0.407)
C14	3.527	4.060	7.588	(0.533)
C15	2.721	3.201	5.922	(0.480)
C16	3.692	3.900	7.593	(0.208)
Max			9.255	1.908
Min			5.922	(0.533)
Average			8.034	(0.000)

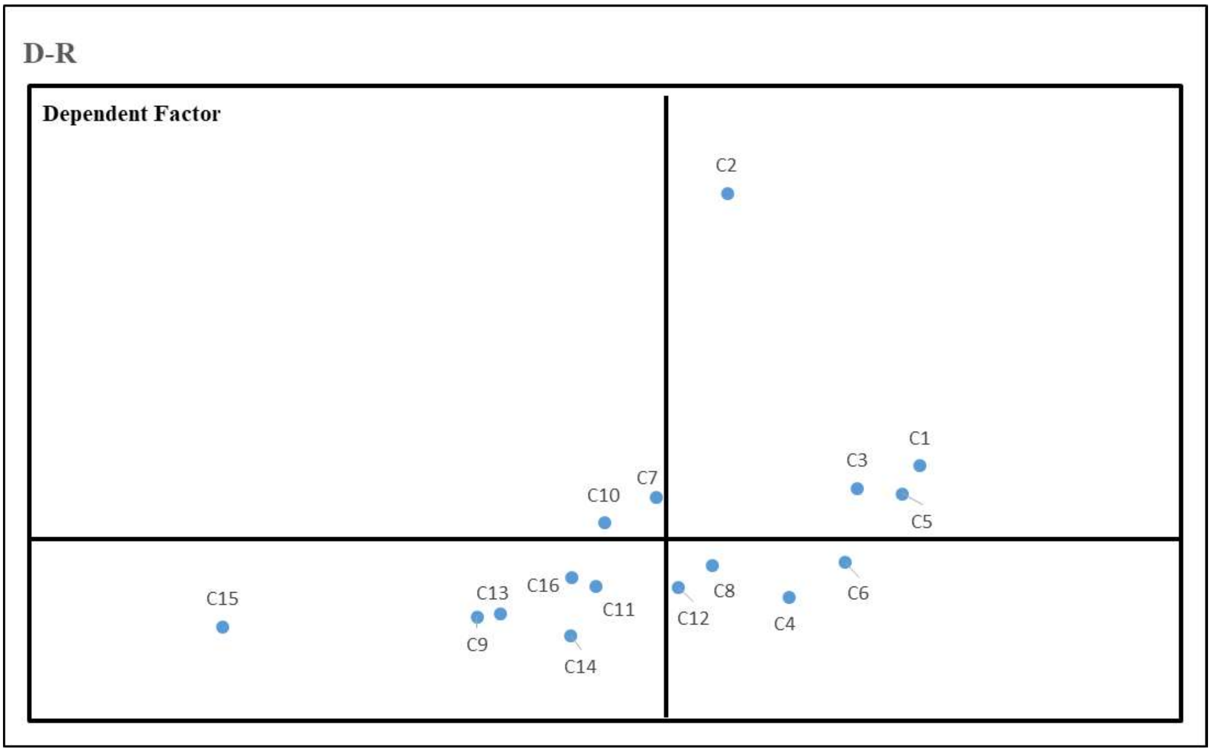

Figure 2. Criteria driving and dependence power diagram