# Sustainable Circular Supplier Selection Criteria: An Empirical Study

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## Abstract

Recently, Sustainable Supply Chain Management (SSCM) has garnered considerable attention due to intensified sensitivity towards environmental protection and social responsibility. Since that the suppliers are at the first entity any supply chain network, organization should carefully select their suppliers towards sustainability to achieve SSCM. Moreover, in recent years, an increasing awareness has encouraged the incorporation of sustainability and circular economy (CE) thinking in supply chain paradigms. Therefore, this study conducted upon reviewing literature a list of 23 supplier selection criteria towards sustainability performance in the context of CE with four dimensions (Economic, Environment, Social, and Circular). In order to evaluate the literature gap in practice, an empirical analysis about the process of selecting suppliers towards sustainability and CE in practice is verified through five in-depth interviews in large multinational firms in different sectors followed by undertaking a questionnaire survey with 46 experts in the field of supply chain management to measure the importance levels of the proposed criteria and to what extent they can be used in real-life practice. To analyze the data of the questionnaire, various statistical techniques were applied (Relative Importance Index (RII) and Mann-Whitney U-test). The results of the RII showed that the 23 criteria categorized as High and High-Medium levels. Furthermore, according to the analysis of Mann-Whitney U test, it showed that there is a significant relationship between the importance levels of the proposed criteria and the applicability of them to be implemented in real-life corporate practices.

## Keywords
Sustainable Supply Chain Management, Sustainable Supplier Selection and Circular Economy.

## 1. Introduction

Nowadays, particularly with the competitive worldwide showcase, most of the business organizations have emphasized how it is imperative to their business to engage to sustainability in their operations (Gaziulusoy and Brezet, 2015). This is due to the increasing of customer knowledge and awareness beside the ecological pressures from markets and various stakeholders (Luthra et al., 2017). In addition, there have been new regulations for carbon and waste management which increase the awareness about the sustainability issues which force such organizations to reconsider their supply chains with respect to the sustainability objectives 'Economic, Social and Environmental'(Vahidi et al., 2018). Supply chains are arrangements of firms that work together in a network that continuously need to overhaul their operations both upstream and downstream(Mavi and Shahabi, 2015).

Coordination between supply chain partners within the frame of effective communication is a must for effective supply chain towards sustainability (Kusi-Sarpong et al., 2019). Moreover, organizations have to coordinate sustainability on their supply chains as a cruel of managing their supply chain risks such as environmental harms and work debate, which may result in supply chain disruption (Gouda and Saranga, 2018). While managing the supply chain, the process of supplier selection is one of the critical issues faced the purchasing managers to assist organizations retain their competitive position (Chen, Lin and Huang, 2006). Moreover, commodity and price-based supplier relationships are no longer acceptable for suppliers of critical materials or for organizations that seek to introduce innovative supply chain management issues, especially those that focus on sustainability concern (Bai and Sarkis, 2010). Therefore, supplier selection has received broad consideration in the literature (Gold and Awasthi, 2015; Orji and Wei, 2015; Li, Diabat and Lu, 2020). Simultaneously, in recent years, an increasing awareness has encouraged the incorporation of sustainability and circular economy (CE) thinking in supply chain paradigms (Chain and Zanin, 2019; Pieroni,

Mcaloone and Pigosso, 2019). Thus, CE criteria have rarely started to be considered also in the supplier selection problem (Kusi-Sarpong, S.; Gupta, H., Khan, S.A.; Chiappetta Jabbour; C.J., Rehman; S.T. and Kusi-Sarpong, 2019). Despite these attempts, small attention has been paid to the development of a framework for sustainable supplier selection (SSS) in the context of CE.

The aim of this research, hence, is to develop a list of supplier selection criteria towards sustainability performance in the context of CE with four dimensions (Economic, Environment, Social, and Circular). Specifically, this paper will address the following objectives:

a) To review recent published academic research concerned the SSS problem in the context of CE.
b) To conduct a list of supplier selection criteria by considering previous literature, classified into four main dimensions; economic, environment, social and CE to achieve the full view of evaluating and selecting suppliers' performance towards sustainable CE.
c) To investigate the real practices of how industrial firms are selecting and evaluating their suppliers towards sustainability and CE, and
d) To determine the relative importance of the proposed list of criteria followed by measuring the applicability level of each criteria, and then assess the statistical correlation between them to generate useful insights on how to manage these criteria.

The remainder of the paper is arranged as follows: **Section 2** discusses the literature in relation to three main topics including (1) Some definitions about Sustainable Supply Chain Management and CE are presented, (2) Approaches and methods of supplier selection regarding sustainability and CE, (3) Conducting a list of criteria for supplier selection. **Section 3** explains the research methodology including data collection. **Section 4** presents main findings from the questionnaire and the in-depth interviews. **Section 5** concludes this paper together with future research direction and discuss the limitation of the study.

## 2. Literature review

### Supplier Selection (SS)

Recently, SS and evaluation literature is widespread. SS process considered as one of the most significant processes in the purchasing and supply management function, and extensively understood as a vital management responsibility (Wetzstein et al., 2016). Moreover, SS plays a vital role of the economic condition of any organizations, as practitioners argue that 60% of manufacturing cost is dependent on the raw material suppliers (Arabsheybani et al., 2018). Additionally, Luthra et al. (2017) mentioned that SS considered as a strategic decision and organizations overall supply chain performance heavily depends on the supplier's performance. Hence, appropriate supplier's selection and bidding process is required for organizations to remain highly competitive in the market and deliver products to customers on a timely basis(Kusi-Sarpong et al., 2019). However, to select the right supplier, various criteria should be considered and evaluated with respect to each supplier's attribute. Therefore, supplier selection is considered a multi-criteria decision making (MCDM) problem (Khan et al., 2018).

#### Sustainable Supplier Selection (SSS) in the context of Circular Economy (CE)

Selecting suppliers in the context of sustainability becomes more intensified and a complex task due to the many and conflicting criteria involved such as cost of the product, quality of products, delivery lead-time, flexibility, environmental requirement of the suppliers, etc. (Trapp and Sarkis, 2016). As a result, purchasing managers are facing critical challenge, which is how to evaluate and select suppliers within the scope of sustainability (Amindoust et al., 2012). Thoughtfulness of sustainability issues in supplier evaluation also helped organizations achieve other benefits such as; improved financial performance, fairness to the suppliers and customers, positive corporate reputation, social change, good human relations, and inter-organizational learning (Baskaran et al., 2012). The decision of selecting sustainable supplier through competitive bidding processes for partnering is highly important, as it affects the overall sustainability performance of organizations (Cheraghalipour and Farsad, 2018). Concerning the alignment of sustainability and CE concepts in SS process, there is still very rare appearance in the current literature. Kusi-Sarpong et al. (2019) proposed a decision framework based on industry 4.0 initiatives within circular economy implementation to evaluate and select sustainable suppliers. Moreover, Govindan et al. (2020) proposed a strategic operational level hybrid approach based on Fuzzy-DEMATEL, FANP, and mathematical programming for circular supplier evaluation, selection and order allocation. Additionally, Kannan et al. (2020) combined the fuzzy BWM and the interval VIKOR technique to evaluate and prioritize sustainable suppliers in circular supply chains.

Accordingly, the previous review shown that there is still a gap in developing a sustainable circular supplier selection combining the four dimensions; economic, environment, social, and circular to achieve the full viewpoint if sustainable circular supplier selection criteria of which will be fulfilled by this study in the following sections.

## Sustainable Circular Supplier Selection (SCSS) Criteria:

According to the research objectives, by considering previous literatures, criteria are classified into four main dimensions; Economic, Environmental, Social, and CE, to achieve to achieve the full view of evaluating and selecting suppliers' performance towards sustainable CE as shown in Table 1**.**

Table 1. Sustainable Circular Supplier Selection Criteria

| | |
|---|---|
| **ECONOMIC** | |
| Cost | The factors that show all expenditures and price of purchased material (Fallahpour, 2016). |
| Quality | The degree of excellence of supplied material (Fallahpour, 2016). |
| Delivery time and services | The effort of supplier in delivering the material and solving its related problems to the customer (Fallahpour, 2016). |
| Flexibility | The level of flexibility of supplier in supplying material and price of material (Fallahpour, 2016). |
| Financial Stability | (Amindoust et al., 2012) |
| **ENVIRONMENTAL** | |
| Environmental Management System (ISO 14001) | Efforts of supplier in environmental management and the certification related environmental management systems (Fallahpour, 2016). |
| Green Products/Design | To what extend the supplier produce green products (Fallahpour, 2016) |
| Green transportation | Minimizing the environmental pollution when transporting the needed order (Fallahpour, 2016) |
| Green technology | The technology used to provide producing green products.(Fallahpour, 2016) |
| GHG emissions/effect | Gases and substances emitted from the manufacture and transport the products. (El Mariouli and Abouabdellah, 2019) |
| Carbon Disclosure Report | Reports regarding GHG emissions. (Hsu et al., 2013) |
| Life cycle cost management | Incorporating life cycle cost management into GHG emissions mitigation, companies gain a tool for an insightful analysis of carbon management from a cost-effective perspective.(Hsu et al., 2013) |
| **SOCIAL** | |
| Training related carbon management | Employee awareness of carbon management practices, relevant education and training need to be launched to promote environmental consciousness.(Hsu et al., 2013) |
| Workers' rights | The supplier's respect of its worker's rights; employment insurance, standard working hours, employments compensations (Fallahpour, 2016). |
| Occupational health & safety systems | Efforts of supplier to provide health and safety for employees at work; medical insurance, training for safety at work, providing appropriate equipment. (Fallahpour, 2016) |
| Society's rights / social responsibilities | Suppliers' competency in improving sustainability, such as; social responsibilities, cleaner environmental/production (Büyüközkan and Çifçi, 2011) |
| Information disclosure | Providing information to the supplier's customer and stakeholders regarding material used, carbon emissions and toxins released during production. (Luthra et al., 2017) |
| **CIRCULAR** | |
| Eco-friendly raw materials | Utilizing recyclable raw materials in producing products (Govindan et al., 2020). |
| Respecting environmental standards and regulations in the process of recycling | Utilization of the environmental standards in recycling process (Govindan et al., 2020). |
| Air pollution resulting from recycling process | Consideration of minimizing air pollution in the operation of recycling the products (Govindan et al., 2020). |
| Clean technology for recycling | Employing proper and green technology for recycling the returned products (Govindan et al., 2020). |
| Eco-friendly packaging | Using recyclable materials in packaging (Govindan et al., 2020). |
| | (Govindan et al., 2020; Kannan et al., 2020) |

After reviewing the literature of most recent academic papers in the area of SSS in the context of circular economy using keywords, such as "SSCM", "CE" and "sustainable supplier selection" the authors noted that there is still a need for developing supplier selection criteria that integrate the three main pillars of sustainability (Economic, Environment, and Social) in addition to the CE dimension. Therefore, an assessment of the penetration of sustainable circular issues in the corporate process of supplier selection was performed in this study.

## 3. Research Methodology

To accomplish the research objectives, methodologies taken were dual: Delphi multiple case study research strategy to explore and investigate the sustainable supplier selection in the context of circular economy, followed by a survey questionnaire to assess the importance and applicability levels of the proposed criteria to related experts in the field of supply chain management.

The first part of the methodology was the multiple case studies. They were five companies located in Egypt, they were selected using the following criteria: large enterprises, association with significant carbon emissions across their whole supply chains, extended experience in adopting SSCM, certified ISO 14001 as an environmental system, and the accessibility of the researcher. According to Gustafsson (2017), using multiple case studies, researcher can understand the similarities and differences between the cases; therefore, he/she can provide the literature with important influences. The in-depth semi-structured interviews were divided into three main sections, as shown in Table 2.

Table 2. Semi-structured interview design:

| Interview Stages | Contents |
|---|---|
| 1st Section | SSCM investigation.<br>Drivers and Barriers of implementing SSCM |
| 2nd Section | Asking about managing CE in their operations |
| 3rd Section | Investigating their current Suppliers' Performance Evaluation Process |

The second part of the methodology was the questionnaire. The objective of the questionnaire was for assessing the importance and applicability levels of the proposed list of criteria, with five Point Likert scale, which had been conducted through previous literature and the experts' opinions. The questionnaire was presenting 23 criteria. It was sent to 80 experts from academia and industry within the MENA (Middle East and North Africa) region. The selected academics professionals were selected upon their experience and contributions in the field of supply chain management. On the other hand, the industrial experts were selected based on their positions and years of experience. Of the 80 sent questionnaires, only 46 % were accomplished and returned. This is an acceptable level as referred to Gunasekaran, et al. (2004) as 14% considered as an adequate level.

Concerning the results of the questionnaire, firstly Relative Importance Index (RII) was used to determining the relative importance of the proposed criteria. The RII ranges from 0 to 1 with 0 not inclusive. It displays that higher the value of RII, more important was the sustainable circular criteria and vice versa. The formula of RII as follows:

$$RII = \frac{\sum w}{A \times N} \quad (1)$$

Where, W= weighting that is assigned to each variable by the respondent, A = highest weight and N = total number of respondents. According to Chen et al. (2010) five important levels are transformed from RI values: high (H) ($0.8 \leq RI \leq 1$), high-medium (H–M) ($0.6 \leq RI \leq 0.8$), medium (M) ($0.4 \leq RI \leq 0.6$), medium-low (M-L) ($0.2 \leq RI \leq 0.4$) and low (L) ($0 \leq RI \leq 0.2$).

Meanwhile, another statistical analysis was performed to determine the relationship between the importance and applicability levels of the proposed criteria. Despite that the distribution of the data sets (importance and applicability) is not normal; therefore, "Mann–Whitney U test," was used to test the null hypothesis: No significant difference exists between the two sets of data (importance and applicability). The Mann–Whitney U test was independently developed by Mann and Whitney (1947). Additionally, a reliability test was performed to ensure that the data collected were reliable for further examination. According to Yahya et al. (2021) Cronbach's alpha is the most common analysis for multiple Likert questions to determine whether the scale is reliable. Therefore, an internal

reliability assessment using Cronbach's alpha was conducted for both data sets (importance and applicability). Statistical Package for the Social Sciences (SPSS) software was applied to run all these statistical analyses.

# 4. Findings And Discussion

## 4.1 Case Studies Results

First, the interview focused on understanding the companies' main business and analyzing the status of achieving sustainability across their supply chains, especially the upstream part. This is because the overall sustainability performance of any firm starts by its suppliers' sustainability performance. Each company employs at least 1500 staff. Table 3 summarizes the profiles of the interviewees.

Table 3. Summary profiles of the Interviewees

| Company Code | Job Title | Years of Experience | Main Business |
|---|---|---|---|
| A | 1st Interviewee: Section Head of Tendering & Practices Sector | 15 | Petrochemicals |
| | 2nd Interviewee: Procurement Specialist, General Department of Material | 8 | |
| B | 1st Interviewee: Purchasing Manager | 14 | Metal products |
| | 2nd Interviewee: Procurement Specialist | 9 | |
| C | Head of Quality Department | 10 | Sanitary Ware and Ceramic Tiles |
| D | Purchasing Manager | 18 | Petrochemicals |
| E | Procurement Head | 20 | Operation and Maintenance Management Company |

### Implementing sustainable supply chain management (SSCM)

The interviewees were first asked whether their companies adopt sustainability practices across their supply chain activities and the reasons behind adopting it. This is essential before discussing supplier selection and the main drivers and obstacles for implementing sustainability. This part of the questions indicated whether the companies implement sustainability dimensions in their management of supply chain activities. All the interviewees answered **YES**; that is, their firms follow sustainable practices across their supply chain activities. However, the reasons were varied, as shown in Table 4. All the interviewees have agreed that one of the most important reasons is to acquire the "ISO 14001 and OHSAS 18001 requirements Certificate." This result is consistent with Rao (2007), who clarified that certifications are necessary because the buyer firms are in a distant place, typically, overseas. Therefore, confirming and monitoring the supplier's environmental performance is impossible without that certification. Additionally, Scur and Barbosa (2017) stated that the buyer firms prefer to deal with suppliers with international accreditation certificates, such as ISO 14001, to ensure good environmental performance.

Table 4**.** Interview statements related to SSCM implementation:

| Co. code | Statement |
|---|---|
| (A) | "Yes, as our company is ISO certified for many certificated related to sustainability, such as ISO 14001:2015 (Environmental Management System), OHSAS 18001:2007 Certificate (Occupational Safety and Health Management System), ISO 50001:2011 Certificate (Energy Management System)" |
| (B) | "Environmental protection is a passion at the company. Investing in sustainable development is as much a priority as investing in our production improvements. The company's environmental management system is ISO 14001 accredited, and its safety management system is OHSAS 18001 certified" |
| (C) | "as we are ISO 14001 and ISO 18001 certified, we strive to uphold sustainability standards in all our operations, this done by minimizing the use of all materials, supplies and energy, and use renewable and recyclable material. Also, we are promoting products that contribute to energy conservation and do not damage the environment. Moreover, are adopting environmentally sound transport policy. As |

| | |
|---|---|
| | our company currently exports to 50 countries worldwide, our buyers/customers require the sustainability adoption as a major condition to make the business with us". |
| (D) | "as we are ISO 14001, OHSAS 18001, and ISO 50001:2011 certified, our company takes all possible measures to maintain a healthy and safe working condition, and ensures compliance with the local laws, regulations and standards related to occupational health, safety and environmental protection"." |
| (E) | "As our company believes that the implementation of a good (Health, Safety, and Environment) HSE system will in return contribute/determine the success and continues development of the business. Also because of ISO 14001, and OHSAS 18001 requirements" |

Source: Research Data

## Managing Circular Economy (CE)

Interviewees were then asked if their companies consider measuring CE in their operations. They also explained the reason behind their yes or no response. All the interviewees agreed that their companies have their own philosophies regarding circularity, as shown in Table 5.

Table 5. Interview statements related to managing CE:

| Co. code | Statement |
|---|---|
| (A) | "Sure, indeed, our company provides the newest technology in the industrial wastewater treatment and reuse it |
| (B) | "Yes, via recycling solid waste and consider them for use as raw materials for another industries, also we have water-treatment facility for recycling water. |
| (C) | "Yes, our company seek to use recyclable or/and renewable materials wherever possible to align our environmental policy. |
| (D) | "Yes, as our company is ISO 14001 certified, so we are having our waste management philosophy. We are trying to avoid waste through operations or management, reuse the materials or products that are already made as reusable, converts the waste into usable forms. |
| (E) | "Yes, as we are complying the country environmental law regarding disposal of hazardous material, so we are selling the non-hazardous waste to one of our contractors to be recycled, and the hazardous wastes send to a landfill area. |

Source: Research Data

## Supplier Selection

Based on the previous discussion with the interviewees, it had been shown that all of them are considering sustainability and circularity in their operations. Therefore, the questions were deeply gone for understanding how these companies are currently selecting and evaluating their suppliers and do they are considering both concepts (sustainability and circularity) in their process of selecting suppliers. The results of the discussion showed that all the interviewees mentioned that they use a "checklist" and specific form to ensure and check some criteria such as constant supply, product quality, delivery times, and payment methods. Some interviewees' responses are presented in Table 6.

Table 6. Interviewees' statements about selecting suppliers:

| Company code | Statements |
|---|---|
| (A) | "Mainly we evaluate our suppliers through a checklist considering their Quality of the products, Price, payment method and Delivery time. However, as our company support the purchase of energy-efficient products and services and promoting green economy to ensure sustainability, we consider some environmental measures in monitoring our suppliers". |
| (B) | "we are evaluating our suppliers via inspection of incoming shipments for quality checks, audit the suppliers' sites through visits, and monitor the product performance and lifetime after installation. |

| | |
|---|---|
| | We are doing annual performance evaluation of suppliers, regarding the following criteria: Completeness of shipment quantity, On-time delivery, Quality level. As our quality assurance begins with the selection of raw material, we evaluate our suppliers' purity level of their ingredients". |
| (C) | "Evaluating our suppliers is regularly and randomly many times per year or when needed using specific form to check supplying constancy in term of several factors: Credibility and continuity of supplying companies, Quality of goods and constancy in the quality level, Prices of goods. However, these factors may differ in its importance according to the supplied materials itself, as the main element in evaluation is "WASTE DECREASE" after the final production stages and getting the best quality against the main cost of raw material" |
| (D) | "our company regularly evaluate the suppliers through evaluating the quality of goods and constancy in the quality level and the commitment of response time. We ensure the commitment of all our suppliers to continual improvement by applying methodologies that transcend quality, energy, and Health and Safety Executive to sustainability and business excellence. Moreover, we are auditing the packaging as it is especially important for exporting requirements". |
| (E) | "By testing suppliers' performance through a checklist considering quality, prices, and product specification conformance. Regarding sustainability, we are choosing our suppliers according to their conformance to the highest standards of environmental management and health and safety. We require a code of performance from our suppliers to ensure that all equipment, material, plants, machinery are safe for health, safety and environment and maintained to an acceptable standard. At some cases, our technical department deal directly with the suppliers on site for auditing". |

Source: Research Data

The results also show that all interviewees are considering sustainability in their selecting and evaluating, but they do not depend on specific, clear criteria in their supplier's evaluation forms according to their suppliers' evaluation forms and selecting application forms. Consequently, in corporate practice there is still a lack of application of considering sustainable circular supplier selection criteria. Hence, this reflects that there is a gap in real life corporate practice for the contribution of this study, which is proposing a list of supplier selection criteria towards sustainable circular economy.

## 4.2 Questionnaire Results

The questionnaire was provided to measure the degree of importance and applicability of the proposed list of sustainable supplier selection criteria, including CE criteria, in real life context. The importance level was analyzed to determine the degree of perceived importance, whereas the applicability showed whether the criteria could be applied in real practice. To measure the importance and applicability levels, this study uses a 5-point Likert scale. The five point-rating scales reduce the confusion of the interviewees and increase the response rate (Taherdoost, 2019). Concerning the importance, the scale ranges from 1 = not at all important to 5= extremely important. For the applicability, the scale ranges from 1 = not applicable to 5 = extremely applicable. Reliability test and descriptive statistics were used to analyze the data.

As mentioned before, the reliability test was conducted to check whether the data collected were reliable for further examination. Cronbach's alpha was used for both data sets (importance and applicability). This method was developed by Cronbach (1951). As suggested by Nunnally (1978), the data are considered to have good reliability if Cronbach's alpha is greater than 0.7. The results showed that the Cronbach's alpha for importance level was 0.862 and the applicability level was 0.884. Therefore, the results for both sets (importance and applicability) showed that the alpha was above the accepted level (0.7).

Relative index analysis was conducted to rank the criteria according to their relative importance. **Table 7** shows the ranking results for each category by using RII in **Eq (1)**.

Table 7. Results of RII and Mann-Whitney U test

| Dimension | Criteria | RII | Ranking | Importance Level | P-Value |
|---|---|---|---|---|---|
| Economic | Cost | 0.86 | 6 | H | 0.141 |
| | Quality | 0.95 | 1 | H | 0.596 |
| | Delivery time and services | 0.82 | 10 | H | 0.667 |
| | Flexibility | 0.71 | 20 | H-M | 0.596 |
| | Financial Stability | 0.69 | 22 | H-M | 0.711 |
| Environmental | Environmental Management System | 0.9 | 2 | H | 0.096 |
| | Green Product | 0.86 | 7 | H | 0.078 |
| | Green Transportation | 0.70 | 21 | H-M | 0.865 |
| | Green Technology | 0.75 | 16 | H-M | 0.254 |
| | GHG Emissions | 0.87 | 4 | H | 0.1902 |
| | Carbon Disclosure and report | 0.76 | 14 | H-M | 0.109 |
| | Life cycle cost management | 0.54 | 23 | M | 0.332 |
| Social | Training related carbon management | 0.73 | 19 | H-M | 0.058 |
| | Workers' rights | 0.74 | 17 | H-M | 0.105 |
| | Occupational Health & Safety | 0.75 | 15 | H-M | 0.207 |
| | Society's rights/Social responsibilities | 0.74 | 18 | H-M | 0.138 |
| | Information Disclosure | 0.78 | 11 | H-M | 0.067 |
| Circular | Eco-friendly raw materials | 0.86 | 5 | H | 0.065 |
| | Respecting environmental standards and regulations in the process of recycling | 0.88 | 3 | H | 0.068 |
| | Air pollution resulting from recycling process | 0.82 | 9 | H | 0.105 |
| | Clean technology for recycling | 0.78 | 12 | H-M | 0.429 |
| | Eco-friendly packaging | 0.85 | 8 | H | 0.087 |
| | Reverse Logistics | 0.76 | 13 | H-M | 0.417 |

Based on the results shown in Table 7, it had been showed that 10 criteria were highlighted to have "H" importance levels is sustainable circular supplier selection criteria with RII value between 0.80 and 0.95. These 10 criteria are Cost, Quality, Delivery time and services, Environmental Management System, Green Product, GHG Emissions, Eco-friendly raw materials, Eco-friendly packaging, Respecting environmental standards and regulations in the process of recycling, and Air pollution resulting from recycling process. The results also showed that the "Quality" criteria was highlighted the most important criteria with RII for 0.95, this revealed to a previous study done by (Stevic, 2017). Moreover, it had been noticed that 12 criteria were underlined to have "M-H" levels with RII value between 0.69 and 0.78, presented in Flexibility, Financial Stability, Green Transportation, Green Technology, Carbon Disclosure, and report, Training related carbon management, Workers' rights, Occupational Health & Safety, Society's rights/Social responsibilities, Information Disclosure, Clean technology for recycling, and Reverse Logistics. The remaining criteria was highlighted "M" importance RII levels, which is Life cycle cost management with RII score 0.54.

Regarding the results of the Mann-Whitney U test which indicated the relationship between the two sets (importance and applicability), it had been showed that of all the 23 criteria were positive, as the p-value of both sets exceeds 0.05. This implies that when the importance level of specific criteria increases, the applicability level also increases, and vice versa. Hence, the questionnaire results showed that proposed list of criteria can be applied in real-life corporate practices as they gained high importance levels except.

## 5. Conclusion

This study investigated, for the first time in literature, the process of sustainable circular supplier selection in real-life corporate practices through multiple case studies with five multinational firms in four different sectors:

Petrochemicals, Metal products, Sanitary Ware and Ceramic Tiles and Operation and Maintenance Management Company. In addition, based on a thorough literature review and experts' opinions this study identified a set of 23 sustainable circular supplier selection criteria with four main categories presented in Economic, Environmental, Social, and Circular and assessed their relative importance levels as well as the relation between their importance and their applicability to be used in real-life corporate practices through a questionnaire with 46 industrial experts from the MENA region. The results of the case studies indicate that there is a lack of a proper tool to manage sustainable circular supplier selection, therefore this paper tries to solve that issue by developing the proposed list of criteria.
Concerning assessing the listed criteria, the results showed that the RII of 22 criteria categorized as H and H-M levels. The criteria "Quality" was at the top ranking with the RII score 0.95. Moreover, only one criterion that categorized as M level and the least RII ranking score which called "Life cycle cost management" with RII score 0.54. Furthermore, according to the analysis of Mann-Whitney U test, it showed that there is a significant relationship between the importance levels of the proposed criteria and the applicability of them to be implemented in real-life corporate practices.

## 6. Research Limitations And Future Work

The limitation of this research is that the result could not be generalized because the study is conducted in MENA region. Consequently, it could not be applied in other regions such as Europe. As a practicable extension to this work, a sustainable circular supplier selection approach integrating MCDM techniques, such as FANP or FDEMATAL must be developed to measure the interdependencies between the proposed criteria.

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