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A multiple criteria group decision-making approach

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PROPOSAL OF A GREEN INDEX FOR SMALL AND MEDIUM-SIZED ENTERPRISES: A MULTIPLE CRITERIA GROUP DECISION-MAKING APPROACH

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ABSTRACT

The impact of small and medium-sized enterprises’ (SMEs) activities on the environment has proved to be negative in certain contexts, since these companies have not, for the most part, included environmentally sustainable practices in their processes, strategies, or long-term vision. Therefore, SMEs need to start adopting more environmentally-friendly behaviors to ensure a better future for coming generations. SMEs have failed to do this until now – despite making a significant effort – in part because dealing with this issue is a quite subjective process and a variety of aspects need to be considered. The current study sought to address this problem through the integrated application of cognitive mapping and the Analytic Hierarchy Process (AHP). Based on a constructivist approach, group sessions involving a panel of entrepreneurs and environmental experts created, tested, and validated a green index for SMEs that addresses two of the major limitations of current evaluation approaches. The first limitation is the manner in which evaluation criteria have been defined within the scope of SME environmental conduct assessments, while the second is the method with which these same criteria’s weights – or trade-offs – are calculated. The proposed index produced promising results when used to identify the most environmentally-friendly SMEs in a sample of firms. These results can be used as benchmark data for environmental improvement initiatives, and the findings confirm that the methodologies underlying the proposed model-building process facilitate a clearer understanding of how to evaluate SMEs’ pro-environmental behaviors. The advantages and limitations of the proposed index are also discussed.

Keywords: Sustainability, Corporate Social Responsibility (CSR), SME Environmental Conduct, Cognitive Map, Multiple Criteria Decision Analysis (MCDA), Green Index.
1. INTRODUCTION

Sustainable development, at its core, reflects long-term processes that ensure continuous improvement in the three components of sustainability: economic equity, social justice, and environmental preservation (Brundtland Report, 1987). As far as the last of these components is concerned (i.e., environmental preservation), it is worth noting that, with the global population explosion and expansion of science and technology, the resources of our planet appear increasingly limited and even close to depletion. Primarily because of greenhouse gas emissions and air and water pollution, several studies have concluded that environmental degradation has an impact on climate change and that this phenomenon threatens humankind’s survival (see Zobel, 2008; Ahmadi, 2015; Thollander and Palm, 2015; Luís et al., 2018). To control these problems, a long-term vision is needed to ensure the status quo is organizationally and environmentally sustainable, thus guaranteeing a better future for coming generations (Brundtland Report, 1987; Shi et al., 2008; Govindan et al., 2017).

In the business sector, investments made in sustainable environmental practices by companies are associated with increased competitiveness, even under unfavorable economic conditions (Ahmadi, 2015). This is largely because these practices have a positive, direct, and significant influence on companies’ image, effectiveness, and relational marketing, which suggests that environmental practices should be implemented whenever strategically relevant (Morrow and Rondinelli, 2002; Thanki et al., 2016).

Small and medium-sized enterprises (SMEs) have long been recognized as a driving force of economic development. Europe, for instance, has over 21 million SMEs employing 88.8 million people and generating a total of 3,666 billion euros in added value within the European economy (European Commission, 2015). Significant interest in the topic of SMEs’ environmental conduct in recent decades is thus unsurprising, with much of the relevant literature focusing on how to measure SMEs’ environmental conduct and its impact on the surrounding environment (Guinée et al., 1992; Lundberg et al., 2005; Zobel, 2008).

Despite this issue’s importance, many proposed solutions to date are considered restricted by the type of method used to determine environmental evaluation criteria and the limited analysis of cause-and-effect relationships among these criteria. This underlines the need for new methodological approaches in this context (Ferreira, 2016;...
The present study sought to address these limitations – and research gap – specifically through an integrated use of cognitive mapping and the Analytic Hierarchy Process (AHP).

Cognitive mapping brings together uncertainty, different perspectives, conflicts of interest, and multiple decision makers, using evaluation criteria to represent the values of individuals and their organizations and structure complex decision problems (Ferreira et al., 2016a). The AHP method, in turn, facilitates work on abstract, subjective, or non-quantifiable evaluation criteria by structuring them into hierarchies (Saaty, 1990). This structuring procedure produces a clearer understanding of the interconnections between alternative choices, evaluation criteria, and final goals (Russo, 2015; Stefanovic et al., 2016).

Given this research context, the present study sought to answer two interrelated questions:

- How can SMEs’ environmental conduct be measured?
- What qualitative and quantitative metrics can be used?

Our research design thus combined cognitive mapping and AHP to create a measure of SME environmental conduct (i.e., a green index) that could serve as an evaluation and decision support tool for strategic planning in the SME sector. Even though this approach produced quite focused results, the process-oriented nature of the methodologies used means they can be replicated and used to produce parallel findings anywhere in the world. Thus, the green index can be employed not only as a complement to previous work on SMEs’ environmental conduct (see, for instance, Shi et al., 2008; Thanki et al., 2016; Singh et al., 2018) but also as a springboard for additional, potentially comparative studies.

With adequate adjustments, the procedures followed could be used in other contexts and/or with other participants to create appropriate assessment measures of environmental practices. This would then facilitate theoretical and practical developments in the areas of corporate social responsibility (CSR), performance evaluation, and operational research/management science (OR/MS). We found no evidence of prior studies reporting the integrated use of these two well-established, soft OR/MS techniques (i.e., cognitive mapping and AHP) in this study context, which confirms the novelty of our study’s contributions.

The next section presents a summary of the relevant literature on social responsibility, environmental conduct, and SMEs, while section three provides the
methodological framework of the techniques applied. Section four then discusses the results, highlighting the practical/managerial implications of the insights obtained. The concluding section offers the study’s contributions and limitations and lays out a roadmap for future research.

2. RELATED LITERATURE

Social responsibility has been the subject of increasing discussion in the scientific community, especially since no widely accepted conceptualization is yet available (Govindan et al., 2014). Throughout the years, this term’s definition has been changed and refined to match better the realities to which it has been applied. One of the first references to social responsibility was made by Bowen (1953), who claimed that this comprises the obligations of business persons to pursue policies and/or follow lines of action that are considered desirable with regard to society’s objectives and values. Subsequently, other authors began to distinguish the use of this term in business contexts from the more common concept of social responsibility, thereby developing a new concept applicable especially to organizations (i.e., CSR) (see Trianni et al., 2017). Govindan et al. (2016) and Thanki et al. (2016), for instance, claim that consumers look beyond product quality, financial performance, and fair prices for products to companies’ relationships with clients, employees, investors, suppliers, and the environment.

To understand the concept of environmental conduct more fully, researchers have necessarily looked at actions that contribute to environmental preservation and conservation (Axelrod and Lehman, 1993). According to Milfont and Duckitt (2010), Calabrese et al. (2016), and Piekarski et al. (2016), environmental conduct refers to actions carried out by any human that have positive impacts on the environment. Since SMEs account for a significant share of economies and 70% of all pollution produced worldwide (Parker et al., 2009), these firms must adopt a long-term vision to create environmentally and organizationally sustainable processes (Shankar et al., 2017). In this way, SMEs can contribute to a better future for coming generations through environmental preservation and sustainable consumption of resources (Brundtland Report, 1987; Liu and He, 2005; Ahmad, 2009; Fonseca and Ferro, 2015; Jorge et al., 2015; Luís et al., 2018). Effective sustainable initiatives need to be implemented
because ecosystems cannot tolerate companies’ current economic activities and consumption of energy and resources (Beer and Friend, 2006; Thollander and Palm, 2015; Govindan et al., 2017; Mathivathanan, et al., 2018).

In this context, measuring environmental behaviors facilitates an understanding of how certain problems such as energy waste or inefficiency can be avoided. Assessments also show how more favorable conditions for companies, including, among others, sustainable investment or energy efficiency measures, can be maintained or achieved (Hartig et al., 2001; Cooremans, 2012; Thollander and Palm, 2015; Neri et al., 2016; Trianni et al., 2017; Cagno et al., 2018; Singh et al., 2018). According to Garcia et al. (2016) and Venturelli et al. (2017), the better firms’ environmental conduct is, the better are their results in terms of environmental impacts, thereby ensuring operations will continue into the future.

Since the 1970s, firms’ environmental conduct has been gaining increasing importance. Early on, Maloney and Ward (1973) argued that long-term solutions to environmental problems could not be based solely on the creation and implementation of new technologies such as new, less polluting fuels; innovative engines; biodegradable detergents; and filtering and recycling systems. The cited authors highlighted the role of human behaviors, stating that a basic reconceptualization of this topic in terms of human behaviors dictates solutions that alter these behaviors (Maloney and Ward, 1973). Kaiser et al. (1999) and Kaiser and Wilson (2000) later also pointed out that measuring environmental behaviors is an essential precondition for positive changes in paradigms in society today. As Kaiser (1998) suggests, the reason for measuring and managing environmental behaviors is to determine whether an individual or firm that generally behaves in more environmentally responsible ways is more likely to behave this way than another individual or firm that is less responsible. This comparison is made in terms of sets of specific environmentally-friendly behaviors.

According to Brío and Junquera (2003), Shi et al. (2008), and Garcia et al. (2016), some obstacles that prevent SMEs from developing environmentally-friendly behaviors are, among others, limited financial resources, type of organizational structure, and poor training in environmental issues. Other impediments are managers’ lack of a long-term vision and employees’ erratic participation in processes related to pro-environmental behaviors (Shi et al., 2008; Luís et al., 2018). The latter cited authors propose mechanisms that would enable SMEs to reduce their environmental impacts,
give them access to technology consultants, provide them with preventive approaches, and inform SMEs about the most advantageous suppliers.

Klassen and Whybark (1999) and Noci and Verganti (1999) further suggest that SMEs’ main strategies for dealing with environmental issues can be classified into two categories. First, the strategies that are environmentally reactive are implemented by companies seeking only to comply with legislation. Second, the strategies that are environmentally proactive and innovation-based make companies pioneers in the use of new, more efficient technology, thereby creating competitive advantages. Maas and Reniers (2014) observe that management systems (i.e., the International Organization for Standardization (ISO)) are used when organizations begin to feel the need to improve their environmental and/or social efficiency. However, these systems can be seen as a way to legitimize organizations’ environmental performance without necessarily implying substantive environmental commitment (see Vílchez, 2016). Environmental certification can thus be perceived as a marketing tool (Oliveira et al., 2016).

Given that the complexity of measuring environmental behaviors has increased over time (Garcia et al., 2016), many models of how to measure and evaluate these behaviors accurately have been proposed (Tallis et al., 2010; Romero et al., 2011; Murray et al., 2016). Thus, the literature includes various forays into the issue of how to measure firms’ environmental impacts and, in particular, develop measurement tools for their assessment, some of which are presented in Table 1.
Table 1. Assessment Methods, Contributions, and Limitations

<table>
<thead>
<tr>
<th>Authors</th>
<th>Methods and Techniques</th>
<th>Contributions</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guinée et al. (1992)</td>
<td>Dominance and marginal analysis methods, as well as quantitative multiple criteria analysis</td>
<td>Proposed tool that facilitates organizations’ improvement of products and productive processes: life-cycle assessment (LCA) (i.e.,) a method of evaluating the impact of a product on the environment during its entire life</td>
<td>Limitations on available scientific information on LCA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Process of defining criteria weights unclear</td>
</tr>
<tr>
<td>Morrow and Rondinelli (2002)</td>
<td>Questionnaires and case studies</td>
<td>Identification of motivations that lead companies to implement and certify their environmental management systems (EMSs)</td>
<td>Information collected on only five companies, so more research needed on a larger number of companies</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Process of defining criteria unclear</td>
</tr>
<tr>
<td>Lundberg et al. (2005)</td>
<td>Various methods such as questionnaires, interviews, and participatory observation</td>
<td>Proposed mechanism that identifies environmental aspects to be considered when using an EMS system</td>
<td>Model developed created specifically for the organization under studied, so non-reproducible in other organizations</td>
</tr>
<tr>
<td>Zobel (2008)</td>
<td>Qualitative research such as multiple case studies, interviews, documentation study, questionnaires, and observation in study sites</td>
<td>Characterization of implementation of environmental policies in organizations with EMS systems</td>
<td>Version of ISO 14001 used not the latest</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Criteria used from ISO 14001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No quantification of environmental objectives to be attained</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Practical side and applicability of indicators obtained in organizations not considered</td>
</tr>
</tbody>
</table>
The studies summarized in Table 1 demonstrate the importance of measuring organizations’ environmental behaviors and the growing interest in this topic. This research highlights individuals and organizations’ increasing awareness of environmental behavior assessment. However, as Iraldo et al. (2009) note, EMSs have not yet reached a high degree of maturity in their implementation. As such, they are not yet fully integrated, which suggests that further studies need to be carried out in this field.

Previous studies’ limitations are quite evident, falling into two broad categories: how evaluation criteria are defined within the scope of environmental conduct assessments and how these same criteria’s weights – or trade-offs – are calculated. A wide-range of different green performance indicators can be found in the literature, including, among others, rates of air and water pollution, carbon productivity, land resources usage, green innovation initiatives, and environmental taxes (for more examples of green indicators used in current assessment systems, see Shi et al. (2008), Rodrigues et al. (2016), Vílchez (2016), and Luís et al. (2018)). However, researchers seldom present a rational explanation for the inclusion and aggregation of these indicators in the respective assessment mechanisms (Fernandes et al., 2016).

In this regard, Schaltegger and Burritt (2010) argue that the multiple perspectives on sustainability and the variety of goals and stakeholders involved in evaluation processes make an approach aiming for a single overarching measure an illusion. This is true no matter how technically sophisticated the approach might be, which suggests that potentially important evaluation criteria have not been considered in previous research, thereby affecting the proposed models’ explanatory power. Following this, no perfect methodology has been devised, and the choice of approach is strongly dependent on the decision problems’ context (Weber and Borcherding, 1993).

To address these issues, and develop a new green index, the present study used two methods in combination (i.e., cognitive mapping and AHP). The former was applied to enable a comprehensive definition of criteria to be included in the evaluation framework in question. The latter method structured these criteria into a hierarchy by defining the relative, global weight of each criterion. Notably, the environmental conduct of SMEs has an impact on a wide range of different stakeholders – governments and society included – and the perceptions of these stakeholders often conflict. For instance, when tax rates or budget restrictions negatively affect SMEs’ desirable environmental conduct (Shi et al., 2008; Luís et al., 2018), these stakeholders’
perceptions should be considered in order to develop an assessment system capable of evaluating SMEs in that study context (for further discussion, see also Murray et al. (2016), and Neri et al. (2016)).

The integrative approach proposed in the present study can integrate the perceptions of different stakeholders and build a consensus on how to evaluate SMEs’ environmental conduct. This should thus be a welcome addition to the current assessment practices. The complementary stance of our framework needs to be highlighted here, as the objective was to add to the existing evaluation methods rather than to replace them, thereby facilitating the development of a more transparent, well-informed, and innovative green index.

3. METHODOLOGICAL BACKGROUND

3.1 Cognitive Mapping

Cognitive mapping is one of the best known techniques used to capture and clarify individuals’ ideas and perceptions and thus promote collaborative problem-solving (Ackermann and Eden, 2001; Eden, 2004). As Özesmi and Özesmi (2003) note, the development of cognitive maps can be helpful in terms of both obtaining the support of decision makers involved in decision-making processes and comparing the similarities and differences among groups of stakeholders. According to the cited authors, this method may also help these groups make decisions together and accept the results more easily. These benefits show how useful cognitive maps are to those seeking to structure complex decision problems.

The technique’s main objective is, therefore, to reduce multidisciplinary conflicts, explain complex phenomena, and generate more informed decision-making processes. This is done by broadly encompassing all decision makers’ values and experiences and defining their current and future needs or priorities (Doudoras and James, 2007; Jalali et al., 2016). Cognitive maps are made up of a network of ideas connected by arrows, in which direct cause-and-effect relationships are shown by intertwined concepts – or evaluation criteria – that represent links. Ferreira et al. (2016b) explain that a concept at the tip of an arrow (i.e., head) is a consequence of the concept at the other end (i.e., tail). If a minus sign (−) appears at the end of the arrow,
this indicates a negative cause-and-effect link between the connected concepts. *Figure 1* is a general representation of the functional logic of cognitive maps (for real examples, see Eden, 2004; Jalali *et al.*, 2016; Martins *et al.*, 2015; Ribeiro *et al.*, 2017).

![Figure 1. Functional Logic of Cognitive Maps](image)

*Source: Eden (2004, p. 676)*

The literature includes two approaches to working with these maps: top-down and bottom-up. In both cases, objectives are placed at the top, strategic issues in the center, and potential options leading to solutions at the bottom.

As Ackermann and Eden (2001) point out, cognitive mapping can be used to reduce the number of omitted criteria in decision-making processes and to develop a fuller understanding of cause-and-effect relationships among evaluation criteria, among other possible applications. Eden (2004) further notes that these maps can reduce cognitive load, thereby enhancing the recall and acquisition of information about evaluation criteria and their respective cause-and-effect relationships.

### 3.2 AHP Principles

The AHP technique developed by Saaty (1980) is useful particularly when abstract, subjective, or non-quantifiable evaluation criteria are involved. The method has been
considered by many authors, such as Podvezko (2009), Longo et al. (2015), and Martins et al. (2015), to be simple, transparent, and/or easily comprehensible, as well as solidly supported by a mathematical component. This technique can be used to evaluate both quantitative and qualitative criteria.

According to Vaidya and Kumar (2006), AHP makes the incorporation of any group consensus into decision-making processes easier as this technique facilitates pairwise comparisons and the calculation of geometric means to arrive at a final solution. The technique’s natural evolution started with a variant called the analytic network process (ANP). This method’s conceptualization of a network includes that its components (i.e., the counterpart of levels in a hierarchy) are not arranged in any particular order. Thus, influence can be evaluated in terms of importance, preference, or likelihood (Saaty, 2001). In the current study, because the cognitive map developed presents well-defined clusters, we decided to use a more traditional procedure, in which each element in the hierarchy is considered to be independent. A battery of tests was carried out to guarantee this characteristic of mutual preferential independence, as recommended by Belton and Stewart (2002).

Applying AHP is quite simple, producing robust results based on a process with three main phases: structuring, evaluation, and recommendations (Vargas, 1990). In the first phase, the decision problem is structured into hierarchical levels, revealing the links between alternative choices, evaluation criteria, and final decision goals. This is when the AHP method becomes particularly useful since it helps decision makers to organize and prioritize alternative choices and evaluation criteria (Russo, 2015). After this phase, decision makers perform pairwise comparisons between criteria to determine their trade-offs (Martins et al., 2015). The alternatives and evaluation criteria then are compared using a measurement scale (i.e., Saaty’s fundamental scale) with which they are ranked from 1 to 9 (Saaty, 2008). Table 2 presents this scale’s definitions and meanings.
Table 2. Fundamental Scale of Absolute Numbers

<table>
<thead>
<tr>
<th>Intensity of Importance</th>
<th>Definition</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equal importance</td>
<td>Two activities contribute equally to the objective.</td>
</tr>
<tr>
<td>2</td>
<td>Weak or slight</td>
<td>Experience and judgment slightly favor one activity over another.</td>
</tr>
<tr>
<td>3</td>
<td>Moderate importance</td>
<td>Experience and judgment strongly favor one activity over another.</td>
</tr>
<tr>
<td>4</td>
<td>Moderate plus</td>
<td>An activity is favored very strongly over another; its dominance is demonstrated in practice.</td>
</tr>
<tr>
<td>5</td>
<td>Strong importance</td>
<td>The evidence favoring one activity over another is of the highest possible order of affirmation.</td>
</tr>
<tr>
<td>6</td>
<td>Strong plus</td>
<td>A better alternative way to assigning the small decimals is to compare two close activities with other widely contrasting ones, favoring the larger one a little over the smaller one when using the 1–9 values.</td>
</tr>
<tr>
<td>7</td>
<td>Very strong or demonstrated importance</td>
<td>When activities are very close a decimal point is added to 1 to reflect their difference as appropriate.</td>
</tr>
<tr>
<td>8</td>
<td>Very, very strong</td>
<td>If activity i has one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i.</td>
</tr>
<tr>
<td>9</td>
<td>Extreme importance</td>
<td>A logical assumption.</td>
</tr>
</tbody>
</table>

1.1–1.9

When it is desired to use such numbers in physical applications. Alternatively, often one estimates the ratios of such magnitudes by using judgment.

Source: Saaty (2008, p. 257)

The AHP method relies on comparisons of peer-to-peer alternatives by constructing matrices with i rows and j columns. In this way, the importance of a particular criterion $C_i$ relative to another criterion $C_j$ can be seen, as shown in Formula (1) (Saaty, 1988; Podvezko, 2009; Martins et al., 2015):

$$
A = [a_{ij}] = \begin{bmatrix}
1 & a_{i2} & a_{i3} & \ldots & a_{ij} \\
1/a_{i2} & 1 & a_{i3} & \ldots & a_{2j} \\
1/a_{i3} & 1/a_{23} & 1 & \ldots & a_{3j} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
1/a_{ij} & 1/a_{2j} & 1/a_{3j} & \ldots & 1
\end{bmatrix}
$$

(1)

Since the array of comparisons has a feature of reciprocity, only half of its elements must be determined since “the numbers in the lower triangular part of the matrix are simply the reciprocals of the numbers in the upper triangular part” (Saaty and
Vargas, 2012, p. 306). However, the conditions presented in Formula (2) need to be respected (Brunelli, 2015):

\[
\text{If } a_{ij} = a, \text{ then } a_{ji} = 1/a, \ a \neq 0; \\
\text{If } C_i \text{ is as relevant as } C_j, \text{ then } a_{ij} = 1, \ a_{ji} = 1 \& a_{ii} = 1, \ \forall i. \ \ (2)
\]

At this point, the use of a mathematical technique called eigenvector becomes quite important. This allows semantic judgments to be converted into numerical values and calculates the weight \( w \) of each criterion in a given hierarchical level (Saaty, 1988). This technique can be applied using Formula (3):

\[
w_i = \left( \prod_{i=1}^{n} a_{ij} \right)^{1/n} \quad (3)
\]

After the eigenvector technique is applied, the results must be standardized. This process consists of calculating the relative proportion of each element and the average value of each criterion, dividing each element in the matrix by the sum of the column in which it is placed, as per Formula (4):

\[
T = \left| \frac{W_1}{\sum W_i} \ldots \frac{W_n}{\sum W_i} \right| \quad (4)
\]

This formula ensures the normalization of eigenvectors \((T)\) and seeks to answer the following questions (Martins et al., 2015):

- Which of the two alternatives is more important in terms of the criteria?
- How strong is that importance?

The importance’s strength should be directly assessed by the decision makers according to their value judgments and preferences. The eigenvectors thus establish a hierarchy of priorities for the criteria, after which the quality and consistency of the obtained solution needs to be tested. Saaty (2008) proposes the following procedures:

- Estimate the eigenvector, which can be obtained through Formula (5), in which \( w \) is calculated using the sum of the columns of the matrix of comparisons:
\[ \lambda_{\text{max}} = T.w \]  

- Compute the consistency index (CI) using Formula (6), in which \( n \) represents the order of the matrix:

\[ CI = \frac{\lambda_{\text{max}} - n}{n - 1} \]  

- Calculate the consistency ratio (CR) through Formula (7), in which the random index (RI) depends on the order of the matrix (see Table 3):

\[ CR = CI / RI \]  

According to Saaty (1990), a CR is considered acceptable when its value is lower than 0.10. For values greater than this, the cited author suggests the matrix of comparisons be revised.

**Table 3. Order of Matrix (First Line) and Average RI (Second Line)**

<table>
<thead>
<tr>
<th>Order of matrix</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI</td>
<td>0</td>
<td>0</td>
<td>0.52</td>
<td>0.89</td>
<td>1.11</td>
<td>1.25</td>
<td>1.35</td>
<td>1.40</td>
<td>1.45</td>
<td>1.49</td>
</tr>
</tbody>
</table>

Source: Saaty (1994)

Once the relative importance of the alternatives is determined, this process ends with an overall evaluation of each alternative – in this study SMEs (hereafter referred to as “Alphas”) – which facilitates the definition of each element’s contribution within the AHP hierarchy. This step can be achieved by using an additive model, as presented in Formula (8) in which \( V(a) \) stands for the overall score of an SME \( a \), \( w_i \) is the weight of criterion \( i \), and \( v_i \) is the partial performance of that SME in criterion \( i \):

\[ V(a) = \sum_{i=1}^{n} w_i v_i(a); \text{ with } \sum_{i=1}^{n} w_i = 1 \text{ and } 0 < w_i < 1 \ (i = 1, \ldots, n) \]  

(8)
4. IMPLEMENTATION

Based on the literature on multiple criteria decision analysis (MCDA) (Belton and Stewart, 2002), the decision-making process followed in the present study included three major phases: (1) structuring the decision problem using cognitive mapping; (2) evaluating value preferences and constructing performance scales using AHP; and (3) making recommendations based on the results obtained. Figure 2 presents the sequence of the methodological procedures followed.

![Figure 2. Structure of Methodological Processes](image)

Source: Adapted from Ensslin et al. (2000)

The structuring phase, therefore, focused on defining the evaluation criteria for the decision problem in question. In the present study, the objective was to use cognitive mapping to identify evaluation criteria that – from the decision makers’ perspective – can be used to measure SMEs’ environmental behaviors. The evaluation phase sought to define the relative and global weight of each criterion using the AHP method. The recommendations phase involved a critical analysis of the results of the two previous phases to identify possible limitations and formulate recommendations.

Three group sessions were conducted with a panel of eight decision makers with different profiles: three SME employees, two consultants, a family business manager, and two experts on environmental issues. The panel was formed to bring together the
knowledge and experience of experts in relevant fields to create new insights and use these to construct an evaluation framework. According to the literature, no ideal number of members has yet been defined for decision-maker groups, but it should be between 5 and 12 (Ackermann and Eden, 2001; Jalali et al., 2016). Each session lasted for an average of four hours, and two trained facilitators coordinated the entire process.

The methods (i.e., cognitive mapping and AHP) were selected not to achieve representativeness or to form generalizations but rather to maintain a strong focus on process. The objective was to bring together a knowledgeable, experienced group of experts to formulate new insights and reflect, in this case, on the determinants of SMEs’ environmental conduct. Although this means the results are connected to a specific context, the constructivist, process-oriented nature of the proposed approach and the procedures followed – when correctly adjusted – can work well with different panels and in varied contexts (see Bell and Morse, 2013; Ormerod, 2013).

4.1 Structuring Phase

The structuring phase involved two sessions. The first session started with an explanation of the methodology, after which the following trigger question was asked: “Based on your values and professional experience, what should be the characteristics and/or best practices of the most environmentally-friendly SME?”. This defined the central issue for the group, which was invited to write the evaluation criteria that should be included in the discussion on stickers (i.e., post-its).

Having shared their experiences and values and written the evaluation criteria on post-its, the participants defined and grouped the criteria by areas of interest. Four clusters were identified, after which the decision makers tackled the task of organizing the evaluation criteria by order of priority. Next, the Decision Explorer software (www.banxia.com) was used to develop a cognitive map, which was presented to the panel for a discussion of how the decision problem had been structured. Figure 3 shows this cognitive map’s final version, which was discussed and confirmed by the participants in a collective validation process. Size restrictions prevent the inclusion of a clearer version of the map in this paper, but an editable version can be obtained from the corresponding author upon request.
Figure 3. Cognitive Map
Following Keeney’s (1992) methodological guidelines (see also Langley et al., 1995), four major lines of thought were identified based on the cognitive map. These results were used to create the value tree – or tree of criteria – presented in Figure 4. More specifically, this value tree resulted from an analysis of the cognitive branches in the cognitive map so that each evaluation criterion (CTR) represents one of the four major clusters in the cognitive structure. These cognitive branches were identified in a thorough discussion and validation process by the panel members as a group.

![Figure 4. Value Tree](image)

Although the transition from the collective cognitive map to the tree of criteria was not entirely smooth due to the subjective nature of the processes involved, the cognitive map constructed proved to be a valuable tool. This was used to both structure and improve the panel’s understanding of how SMEs’ environmental behaviors can be assessed. In addition, the iterative and inclusive nature of the methodology allowed the panel members to share their perspectives and experiences, and explore new, previously overlooked, points of view.

From the decision makers’ collective perspective, Management (CTR01) refers to company missions, leaders’ values, administrators’ environmental attitudes, environmental practices, and the behaviors that managers foster in their business environment. For example, companies need to consider not only the financial but also the environmental impacts of all management decisions and establish environmental and sustainable criteria in their choice of suppliers (Kannan, 2018). Firms also should incorporate environmental practices in the planning phase and constantly monitor the indicators that these companies use to evaluate their performance.

Workers (CTR02) includes employee characteristics and behaviors that have direct implications for their company’s environmental conduct. For instance, companies need to reduce waste, promote biking to work, post reminders that encourage good
practices, create incentives to car share when commuting to work, and periodically train workers in environmental disclosure. Although in some cases these initiatives can be proposed by the management team, workers can also develop their own initiatives, and the last word in the practical application of these initiatives belongs to them. *Infrastructure, Equipment, and Production Systems* (CTR03) comprises evaluation criteria that impel or restrict companies’ physical and production characteristics. These criteria may include controlling raw materials, using acoustic and thermal insulation, installing atmospheric filters, and implementing photovoltaic energy production. Finally, *Relationships with the Community and Economic Agents* (CTR04) covers the support, settings, and incentives that the surrounding community can provide companies, thereby improving their environmental behaviors. For example, these criteria include encouraging awareness of environmentally-friendly practices, ensuring that public institutions recognize and reward “green” companies, and rewarding the adoption of best practices and partnerships with local institutions.

To operationalize these CTRs, the panel participants were asked to identify the most important criteria within each cluster in the cognitive map, which could represent the entire cluster. Using an adapted version of Fiedler’s (1967) scale, the participants next defined partial performance levels for each descriptor (*i.e.*, a set of ordered partial performance levels $L_i$ with $i = \{1, 2, \ldots, n\}$), including creating *Good* and *Neutral* reference levels. In broad terms, $L_1$ represents the best possible partial performance level comprising a state in which a specific index (*i.e.*, the sum of the values assigned to each sub-criterion by the panel members using Fiedler’s (1967) scale) belongs to the maximum practicable range of values. In contrast, $L_n$ reflects an extremely low partial performance indicating a state classified as within the minimum range. *Figure 5* shows the descriptor for CTR01 and its respective levels of impact.

<table>
<thead>
<tr>
<th>Descriptor CTR01 - Management</th>
<th>Level (L_i)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total lack of training and assessment in accordance with social and environmental responsibility</td>
<td>1 2 3 4 5 6 7 8</td>
<td>Excellent training and evaluation of employees and managers in terms of social and environmental responsibility</td>
</tr>
<tr>
<td>Absence or non-compliance with the ecological criteria of sustainability from the suppliers</td>
<td>1 2 3 4 5 6 7 8</td>
<td>Total compliance with the ecological criteria and sustainability on the part of suppliers</td>
</tr>
<tr>
<td>Total lack of interest in obtaining environmental certification</td>
<td>1 2 3 4 5 6 7 8</td>
<td>Have the most appropriate and up-to-date environmental certifications for business</td>
</tr>
<tr>
<td>Contempt for the ecological impact in any management decision taken</td>
<td>1 2 3 4 5 6 7 8</td>
<td>Minimizing the ecological impact in any management decision taken</td>
</tr>
<tr>
<td>Lack of ecological evaluation of the company</td>
<td>1 2 3 4 5 6 7 8</td>
<td>Existence of very well articulated ecological indicators to periodically assess the company, establishing goals and plans for mitigation</td>
</tr>
<tr>
<td>Never consider the theme of Ecology</td>
<td>1 2 3 4 5 6 7 8</td>
<td>Full consideration of the theme of Ecology in drawing up the budget and strategic planning of the company</td>
</tr>
<tr>
<td>Total absence of ecological practices in strategic planning</td>
<td>1 2 3 4 5 6 7 8</td>
<td>Abundant inclusion of ecological practices in strategic planning</td>
</tr>
</tbody>
</table>

*Figure 5.* Descriptor and Impact Levels for CTR01
Because each descriptor represents a different evaluation dimension of the decision problem at hand, thereby presenting a different number of impact levels, this procedure was followed for the remaining three criteria. Once descriptors were defined for all criteria, the structuring phase ended, and the evaluation phase could start.

### 4.2 Evaluation Phase

The evaluation phase included the last group session. In the first part, a matrix of ordered criteria was created, in which the value of 1 was assigned to indicate when a criterion \( i \) (CTR\(_i\)) was generally preferred over a criterion \( j \) (CTR\(_j\)) \((i \neq j)\) – and a value of 0 otherwise. This matrix was completed using fictitious alternatives to compare the attractiveness of the “swings” of the CTRs, avoiding what is known as the “most common critical mistake” in decision analysis (for details and a technical discussion, see Keeney (1992) and Belton and Stewart (2002)). The discussion among the panel members and the creation of this matrix allowed the AHP method to be subsequently applied. After completing the matrix, the CTRs were ranked (see column R in Table 4) using the sum of the values assigned in each comparison. The result of the decision makers’ discussion is presented in Table 4.

<table>
<thead>
<tr>
<th></th>
<th>CTR01</th>
<th>CTR02</th>
<th>CTR03</th>
<th>CTR04</th>
<th>Total</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTR01</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>CTR02</td>
<td>0</td>
<td>-</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>CTR03</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>CTR04</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

To calculate the criteria’s weights – or trade-offs – the panel participants were asked to fill in a matrix of pairwise comparisons between criteria using Saaty’s scale (see Table 2 above). This matrix is shown in Figure 6, in which the trade-offs were calculated using the Super Decisions software (see https://www.superdecisions.com/).
The inconsistency index, which represents the measure of deviation from consistency in pairwise comparisons, is thus 0.04288 (i.e., below the 0.10 limit mentioned previously). CTR01 was assigned the greatest weight (i.e., 48.695%), and CTR03 has the lowest value (i.e., 7.052%). The resulting trade-offs were validated by the panel members in a group discussion.

The same procedure was followed to obtain local scales for each descriptor. Figure 7 displays the value judgments and scale for CTR01, in which a partial score of 44.67% was given to L1 (i.e., the best level) and a score of 2.587% was assigned to L6 (i.e., the worst possible level). The inconsistency index is 0.05517 (i.e., < 0.10).
The same procedure was followed for the remaining three criteria, all of which revealed inconsistency indices below 0.10. With this step, the first part of the evaluation phase was complete.

4.3 Practical Application

To evaluate the consistency of the environmental conduct evaluation system created, this assessment model was applied to eight Alphas (i.e., SMEs known to the panel members). The panel members were asked to analyze each of the Alphas considered and, using the descriptors defined during the structuring phase, define these experts’ collective perceptions regarding each Alpha’s local performance for the four CTRs. As discussed previously, the procedure’s purpose was not to achieve representativeness or to form generalizations but instead to test the proposed evaluation mechanism with actual data and in a real-life context (for further discussion, see Belton and Stewart, 2002; Ormerod, 2003). Table 5 shows the local performance levels of each Alpha, as well as their overall scores and respective ranking.

Table 5. Partial and Overall Performance Levels of Alphas and their Rankings

<table>
<thead>
<tr>
<th>Alpha</th>
<th>CTR01</th>
<th>CTR02</th>
<th>CTR03</th>
<th>CTR04</th>
<th>Overall score</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha 1</td>
<td>Good</td>
<td>L3</td>
<td>Good</td>
<td>L1</td>
<td>0.307515461</td>
<td>1</td>
</tr>
<tr>
<td>Alpha 2</td>
<td>L3</td>
<td>L3</td>
<td>L3</td>
<td>Good</td>
<td>0.172135690</td>
<td>3</td>
</tr>
<tr>
<td>Alpha 3</td>
<td>L3</td>
<td>Neutral</td>
<td>Neutral</td>
<td>L5</td>
<td>0.099149673</td>
<td>7</td>
</tr>
<tr>
<td>Alpha 4</td>
<td>Neutral</td>
<td>Neutral</td>
<td>Neutral</td>
<td>Good</td>
<td>0.129970887</td>
<td>5</td>
</tr>
<tr>
<td>Alpha 5</td>
<td>L6</td>
<td>Neutral</td>
<td>L6</td>
<td>L6</td>
<td>0.035363300</td>
<td>8</td>
</tr>
<tr>
<td>Alpha 6</td>
<td>Good</td>
<td>Neutral</td>
<td>Good</td>
<td>Good</td>
<td>0.234282880</td>
<td>2</td>
</tr>
<tr>
<td>Alpha 7</td>
<td>L3</td>
<td>L3</td>
<td>L3</td>
<td>Neutral</td>
<td>0.125458802</td>
<td>6</td>
</tr>
<tr>
<td>Alpha 8</td>
<td>L3</td>
<td>Neutral</td>
<td>L3</td>
<td>Good</td>
<td>0.162927543</td>
<td>4</td>
</tr>
</tbody>
</table>

According to Table 5, the Alpha with the best environmental conduct is Alpha 1 since it received the best overall score (i.e., V(Alpha 1) = 0.307515461) when the simple additive model presented previously in Formula (8) was applied. The panel considered Alpha 5 the worst performer with an overall evaluation of 0.035363.

Once the overall indices were calculated, the next step was to conduct a sensitivity analysis assessing the implications of isolated variations in each CTR’s weight. In practical terms, this analysis determined whether a change in a CTR’s weight
influences the Alphas’ rankings and the evaluation model provides consistent and reliable results. According to the literature on AHP (Saaty and Vargas, 2012), a range of oscillation (i.e., margin of tolerance) should exist for each CTR, within which changes in the CTR’s weight does not change the Alphas’ ranking. The larger this range, the more stable the system is. Table 6 presents the sensitivity analysis carried out for CTR01. This procedure was also conducted with the remaining criteria, revealing that the model created is sufficiently stable to confirm the Alphas’ ranking and thus the decision makers’ value judgments.

Table 6. Sensitivity Analysis for CTR01

<table>
<thead>
<tr>
<th>CTR Weight</th>
<th>Alpha 1</th>
<th>Alpha 2</th>
<th>Alpha 3</th>
<th>Alpha 4</th>
<th>Alpha 5</th>
<th>Alpha 6</th>
<th>Alpha 7</th>
<th>Alpha 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.150070</td>
<td>0.228615</td>
<td>0.205581</td>
<td>0.053202</td>
<td>0.116083</td>
<td>0.031314</td>
<td>0.150556</td>
<td>0.087128</td>
<td>0.127522</td>
</tr>
<tr>
<td>0.200060</td>
<td>0.228461</td>
<td>0.201364</td>
<td>0.056064</td>
<td>0.113877</td>
<td>0.030862</td>
<td>0.154028</td>
<td>0.088414</td>
<td>0.126931</td>
</tr>
<tr>
<td>0.250050</td>
<td>0.228303</td>
<td>0.197051</td>
<td>0.058990</td>
<td>0.111622</td>
<td>0.030400</td>
<td>0.157578</td>
<td>0.089729</td>
<td>0.126327</td>
</tr>
<tr>
<td>0.350030</td>
<td>0.227977</td>
<td>0.188126</td>
<td>0.065047</td>
<td>0.106954</td>
<td>0.029444</td>
<td>0.164927</td>
<td>0.092449</td>
<td>0.125076</td>
</tr>
<tr>
<td>0.400020</td>
<td>0.227808</td>
<td>0.183506</td>
<td>0.068181</td>
<td>0.104539</td>
<td>0.028949</td>
<td>0.168730</td>
<td>0.093858</td>
<td>0.124429</td>
</tr>
<tr>
<td>0.450010</td>
<td>0.227635</td>
<td>0.178777</td>
<td>0.071390</td>
<td>0.102066</td>
<td>0.028443</td>
<td>0.172624</td>
<td>0.095299</td>
<td>0.123766</td>
</tr>
<tr>
<td>0.500000</td>
<td>0.227458</td>
<td>0.173934</td>
<td>0.074677</td>
<td>0.099533</td>
<td>0.027924</td>
<td>0.176611</td>
<td>0.096776</td>
<td>0.123087</td>
</tr>
<tr>
<td>0.599980</td>
<td>0.227071</td>
<td>0.163338</td>
<td>0.081867</td>
<td>0.093992</td>
<td>0.026789</td>
<td>0.185335</td>
<td>0.100006</td>
<td>0.121603</td>
</tr>
<tr>
<td>0.649970</td>
<td>0.226869</td>
<td>0.157831</td>
<td>0.085603</td>
<td>0.091112</td>
<td>0.026199</td>
<td>0.189869</td>
<td>0.101685</td>
<td>0.120831</td>
</tr>
<tr>
<td>0.699960</td>
<td>0.226663</td>
<td>0.152178</td>
<td>0.089440</td>
<td>0.088156</td>
<td>0.025593</td>
<td>0.194524</td>
<td>0.103408</td>
<td>0.120009</td>
</tr>
<tr>
<td>0.749950</td>
<td>0.226450</td>
<td>0.146371</td>
<td>0.093380</td>
<td>0.085119</td>
<td>0.024972</td>
<td>0.199304</td>
<td>0.105178</td>
<td>0.119225</td>
</tr>
</tbody>
</table>

According to Table 6, as CTR01’s weight increases, no major changes appear in the Alphas’ ranking, confirming the robustness of the proposed green index. These results were also strengthened by a battery of robustness analyses used to evaluate the impact of variations of different criteria’s weights simultaneously. A file containing all these analyses can be obtained from the corresponding author upon request. The expert panel not only actively participated during this evaluation mechanism’s development but also reported great satisfaction with the results obtained.
4.4 Final Validation, Recommendations, and Managerial Implications

Given the general satisfaction expressed by the panel of decision makers and the results of the tests carried out, we concluded that the outcomes of the processes followed to obtain the Alphas’ ranking were quite positive. The methodologies underlying the model-building procedures facilitated a more transparent process and clearer understanding of ways to evaluate SMEs’ environmental behaviors.

Although the results are encouraging, limitations were identified regarding the evaluation system developed. These included difficulty in finding experts to participate in group sessions without any type of compensation and in getting these experts together at the same time, as well as the contextualized nature of the evaluation system created. The latter prevents any generalization of the present results to other contexts and/or decision maker groups without proper adjustments. Nevertheless, the integrated use of cognitive mapping and AHP allows for updates and adjustments, which the panel members considered a welcome improvement on previous evaluation systems.

The proposed green index has managerial implications that stem from the insights gained through analyses of the cause-and-effect relationships between environmental factors and practices. These findings have great potential for guiding efforts to improve SMEs’ environmental behaviors, primarily because the analysis of each SME’s profile functions as a learning mechanism that facilitates the development of well-focused recommendations of improvements SMEs can make. By facilitating more solid, informed, and transparent analyses, the green index proposed in this study can contribute to a more accurate assessment of SMEs’ environmental conduct.

5. CONCLUSION

Environmental degradation has an impact on climate change – a phenomenon that threatens humankind’s survival (Ahmadi, 2015; Luís et al., 2018). This is a key concern of contemporary society and generations to come. Thus, alterations are needed in companies’ environmental behaviors, including using their current resources better without compromising the future of humankind. SMEs’ environmental conduct has been recognized as crucial to this process – as is understanding the determinants and
interconnections of these behaviors in the business sector. As a result, researchers must
determine the means that can best be used to assess SMEs’ environmental conduct.

The current study sought to address this issue through the integrated use of
cognitive mapping and the AHP method, which addressed our first research question:
How can SMEs’ environmental conduct be measured? The present approach was
constructivist in nature, that is, based on learning and formulated to capture and model
the inherent subjectivity of the decision problem in question (i.e., the assessment of
SMEs’ environmental behavior). The construction of a cognitive map allowed the
expert panel to structure this decision problem clearly and to identify, cluster, and order
evaluation criteria for SMEs’ environmental conduct.

The AHP in turn facilitated the process of attributing weights to these criteria
and thus calculating the trade-offs between them. The application of the AHP required a
well-informed cognitive structure to analyze the impact of each alternative for each of
the criteria considered. Thus, the interconnections between alternative criteria were
deeply discussed with and among the panel members, and the final results were
validated by them as a group. This process was a reflection of the constructivist stance
of the study, which also allowed adjustments to be made every time the decision makers
considered them necessary and appropriate.

As a result, we were also able to answer the second research question: What
qualitative and quantitative metrics can be used to assess SMEs’ environmental
behaviors? The construction of the group cognitive map, in particular, allowed the
opinions of different participants to be aggregated, creating a framework that was
shared by all and within which cause-and-effect relationships among criteria could be
detected and understood. This process provided insights into the role of key criteria in
the system and operationalized them using descriptors that could be qualitative,
quantitative, or both. Even though cognitive mapping is subjective in nature, it
promoted exchanges of ideas and experiences, boosted a deeper understanding of
decision situations, and uncovered cause-and-effect relationships among criteria,
allowing questions such as “why does this happen?” to be answered.

This combined approach resulted in the creation of a new green index that
aggregates different dimensions of SMEs’ environmental conduct (i.e., Management
(CTR01); Workers (CTR02); Infrastructure, Equipment, and Production Systems
(CTR03); and Relationships with the Community and Economic Agents (CTR04)). This
index is characterized by robustness, stability, simplicity, and transparency. The
robustness and stability of the evaluation system created are supported by the results of sensitivity analyses, an example of which is provided in Table 6. Regarding simplicity and transparency, these aspects were strengthened, as discussed above, by the use of cognitive mapping and by the panel members’ group work.

Multiple criteria methodologies, including the MCDA approach adopted in this study, are known for building realistic, consistent evaluation models because they are based on the combined skills and personal experiences of groups of experts in the area under study. In the present case, the evaluation framework created was validated by both the panel members and sensitivity analyses.

Models such as the one developed in the current research could be useful to those working in SMEs, as well as to public sector decision makers and society at large. In addition, due to the process-oriented and constructivist nature of our framework, the methodological procedures followed can be applied in different contexts and situations and/or with different decision makers (see Bell and Morse, 2013; Ormerod, 2013). This study thus sought not to achieve an “optimal solution” but rather to allow learning to emerge from knowledge sharing among panel participants.

Thus, the proposed green index’s contributions are theoretical and methodological in terms of the findings obtained. On a theoretical level, this framework is process-oriented and constructivist, meaning that the green index should be used as a learning mechanism. From a methodological perspective, this study’s contribution is two-fold. The first is the integration of different methodologies (i.e., cognitive mapping and AHP), which we understand to be innovative in this context. The second contribution is that the process followed can be easily replicated in other contexts and with different groups of experts.

Finally, although the findings are contextualized in that they are participant-dependent, they could serve as an important starting point for other researchers and/or practitioners seeking to identify and prioritize evaluation criteria of SMEs’ environmental conduct. These findings should complement previous studies in the field of sustainability, SME performance evaluation, and OR/MS (Shi et al., 2008; Thanki et al., 2016; Singh et al., 2018).

However, due to the present findings’ contextualized nature, extrapolations to other contexts need to be made with caution, including the necessary adjustments and new sensitivity analyses to guarantee the model’s robustness. This adaptation process could, nonetheless, prove an interesting avenue for future research. Further studies
could include replications of the proposed processes in different countries and/or applications of different MCDA techniques in calculations of trade-offs (for examples, see Belton and Stewart, 2002; Zavadskas et al., 2014). These would strengthen and complement the ongoing discussions about this research topic.

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REFERENCES


HIGHLIGHTS

- A green index is developed to measure SMEs’ environmental behaviors.
- The understanding of the cause-and-effect relationships is enhanced.
- Cognitive mapping improves the selection of evaluation criteria.
- The use of cognitive maps and AHP enhances environmental evaluations.