Environmental Impact Assessment Review 96 (2022) 106844

Contents lists available at ScienceDirect

Environmental Impact Assessment Review

journal homepage: www.elsevier.com/locate/eiar

Assessing social performance of construction companies in public-works procurement: Data envelopment analysis based on the benefit of the doubt approach

Laura Montalbán-Domingo [a,*], Tatiana García-Segura [a], Amalia Sanz-Benlloch [a], Eugenio Pellicer [a], Cristina Torres-Machi [b], Keith Molenaar [b]

[a] Construction Project Management Research Group, Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain

[b] Dept. of Civil, Environmental, and Architectural Engineering, Univ. of Colorado Boulder, 1111 Engineering Dr., Boulder 80309-0428, CO, United States

ARTICLE INFO

Keywords:
Corporate social responsibility
Social sustainability
Weight
Public procurement
Data envelopment analysis
Benefit of doubt approach

ABSTRACT

There is an urgent need to improve the assessment of construction companies' Corporate Social Responsibility (CSR) in public-works procurement. Current procurement procedures assign a high level of subjectivity to CSR assessment and lack transparency. Existing research basically highlights the need to define weighting systems in which the importance of each social criterion is objective and based on the social weaknesses in the context of a project. In order to fulfill this gap, this research proposes a composite indicator for assessing CSR in public construction procurement. A Data Envelopment Analysis based on the Benefit of Doubt Approach (DEA-BOD) was chosen to define the weighting system based on the main social weaknesses that exist in the country where the contract is procured. The research employs simulation to assess the validity of this indicator. The results highlight that the use of national indices as a proxy for CSR indicators can be helpful in determining the level of importance of CSR in public procurement. The simulation showed that the proposed approach allows the objective comparison of CSR performance of construction companies, regardless of their size. This research assists decision-makers in properly integrating social sustainability in procurement procedures.

1. Introduction

Social sustainability is aimed at guaranteeing a state of welfare for the people by securing social, economic, and political justice and creating healthy and livable communities through equity, human morality, diversity, connectivity, and democracy (Goodland, 1995; Illankoon et al., 2017). From a business perspective, social sustainability refers to the impact corporations have on people and society, giving rise to corporate social responsibility (CSR from now on) (Hutchins et al., 2019). The term CSR has evolved over the last decades representing the implementation of the triple bottom line of sustainability (environmental, social, and economic dimensions) at the corporate level. However, the social dimension has been overshadowed by the other two dimensions. Given this, this study focuses on the social dimension of CSR.

During the last decades, numerous authors have claimed the importance of implementing CSR practices to achieve economic benefits and societal well-being (Hutchins et al., 2019; Xia et al., 2018). However, the implementation of CSR in the construction industry is still scarce (Loosemore et al., 2021; Xia et al., 2018; Zhang et al., 2022a), and the need of construction firms to adopt CSR has already been claimed (Pham et al., 2021).

Although the assessment of CSR has gathered some strength globally, additional work is needed to boost the incorporation of social sustainability in the daily activities of construction companies (Xia et al., 2018; Zhang et al., 2020; Zhao et al., 2012). Zhao et al. (2012) found that the lack of engagement in CSR may be because the construction industry has not yet realized its obligations to society. Furthermore, Pham et al. (2021) stated that construction firms must act socially responsible under the pressure of government guidelines and regulations. Public procurement has been claimed as an essential element in fostering behavioral change in construction companies (Montalbán-Domingo et al., 2021; Ruparathna and Hewage, 2015; Xia et al., 2018). However, objective CSR evaluation frameworks are needed to facilitate the

* Corresponding author.
E-mail addresses: laumondo@upv.es (L. Montalbán-Domingo), tagarse@upv.es (T. García-Segura), asanz@upv.es (A. Sanz-Benlloch), pellicer@upv.es (E. Pellicer), cristina.torresmachi@colorado.edu (C. Torres-Machi), keith.molenaar@colorado.edu (K. Molenaar).

https://doi.org/10.1016/j.eiar.2022.106844
Received 28 July 2021; Received in revised form 22 June 2022; Accepted 29 June 2022
Available online 9 July 2022

inclusion of the CSR assessment in public procurement (Montalbán-Domingo et al., 2021; Pham et al., 2021). International standards lack specific CSR aspects related to the construction industry (Lu et al., 2016). Therefore, more efforts are demanded to establish quantitative CSR indicators and transparent weighting schemes suitable for quantifying social well-being benefits offered by CSR practices in construction (Liao et al., 2016; Zhao et al., 2012). This is the gap that this research aims to fulfill. Consequently, the goal of this research is to define a composite indicator for assessing the CSR of construction companies in public procurement and develop a weighting method that aligns the level of importance of each CSR indicator with the social needs of each country's industry.

The paper is structured as follows. The following section analyzes the current literature on public procurement and composite indicators related to CSR assessment. Section 3 presents the proposed method, including the overall approach and a description of defining the composite indicator. Then, Section 4 gathers the implementation of the proposed method in the European Union countries. Section 5 shows a simulation with eight Spanish companies. Next, Section 6 contains the discussion. Finally, Section 7 summarizes the contributions, recommendations, limitations, and further research.

2. Literature review

2.1. CSR assessment through public procurement

The evaluation criteria currently used to characterize companies in public procurement is mainly focused on their economic and financial standing as well as their technical and professional ability to perform the work or services covered by the contract (European Commission, 2018; Scott et al., 2006). However, governments need to include social criteria in public procurement qualifications to promote socially sustainable development (Kaddouri and Saussier, 2021; Montalbán-Domingo et al., 2021). Therefore, several authors have claimed the need to assess the CSR of construction companies during the award process (Knebel and Seele, 2021; Montalbán-Domingo et al., 2021; Xia et al., 2018).

In public procurement procedures, the selection of the contractor must guarantee fair and objective competition (Park et al., 2015; Schöttle and Arroyo, 2017). All potential suppliers should be treated equally through a rigorous and transparent selection procedure (Falagario et al., 2012). International standards such as Global Reporting Initiative, Occupational Health and Safety Assessment Series 18001 (OHSAS 18001), and Social Accountability 8000 (SA8000), among others, do not include specific CSR aspects regarding the construction industry. Additionally, very few CSR evaluation frameworks have been developed for the construction industry (Montalbán-Domingo et al., 2021; Pham et al., 2021). In line with this, Pham et al. (2021) claimed that the construction industry still lacks CSR assessment frameworks and tools by which firms can report CSR practices. Zhang et al. (2022a), Pham et al. (2021), and Xia et al. (2018) emphasized that governments need to define CSR indicators for the construction industry and a transparent weighting scheme to evaluate CSR performance. To address this gap, this study proposes a composite indicator for assessing the CSR of construction companies in public procurement.

2.2. Composite indicator for CSR assessment of construction companies

A composite indicator is the mathematical combination of individual indicators, representing different dimensions of a concept whose description is the objective of the analysis, and weights, which represent the level of importance of each indicator (Nardo et al., 2005; Tokos et al., 2012). The correct definition of the indicators is essential to assess and monitor performance, identify trends, benchmark, and set policy priorities (Tokos et al., 2012). Using a composite indicator during the award process entails the definition of quantitative indicators to ensure transparent, objective, and equitable bid-selection processes (Park et al., 2015; Popovic et al., 2018).

According to Pham et al. (2021), indicators applied for assessing and improving CSR performance are still in infancy and require more consideration. The indicators defined by disclosure standards, such as Global Reporting Initiative, International Integrated Reporting Council, Sustainability Accounting Standard Board, etc., are not valid for assessing the CSR performance of construction companies (Olanipekun et al., 2020; Pham et al., 2021), mainly because they barely include CSR aspects regarding this industry (Lu et al., 2016). Based on this, several works have focused on developing CSR indicators for the construction industry. Zhao et al. (2012) developed a comprehensive set of quantitative and qualitative indicators for the assessment of CSR in construction companies. These authors defined CSR indicators at the organizational level in eight categories: 'occupational health and safety of employees', 'legal working hours and rest time', 'wages and welfare', 'staff employment', 'education and training', 'freedom of association and bargaining', 'harmonious labor/management relationship', and 'human rights measures'. Wu et al. (2015) defined 26 qualitative indicators for assessing CSR of international contractors and group them in the following categories: 'labor practice', 'fair operating practices', 'community involvement and development', 'human rights', 'shareholders' rights', and 'organizational governance'. Dolla and Laishram (2020) developed a bid-selection model to assess the sustainability of construction companies, but most of the indicators were qualitative and barely included CSR indicators. Montalbán-Domingo et al. (2021) developed an integrated method for assessing social sustainability in public-works procurement; the CSR assessment was defined at the organizational level through 20 quantitative indicators grouped in nine categories: 'employment creation', 'job stability', 'social benefits and social security', 'occupational health and safety performance', 'social value', 'nondiscrimination and equal opportunities', 'fair wages and fair income distributions', 'technical training' and 'sustainability training'.

Regarding the weights, these have a significant impact on the results of the composite indicator (Joint Research Centre-European Commission, 2008). In this regard, Mohebali et al. (2020) and Abdella et al. (2021) highlighted that the most critical step in defining a composite indicator is determining the weights by which individual indicators contribute to the aggregated impact. Currently, in public procurement, the awarding committee has to assign a weight to each award criterion in advance (Falagario et al., 2012). Generally, these weights are set based on subjective judgments (European Commission, 2019; Ruparathna and Hewage, 2015), being affected by internal consistency and validity problems (Falagario et al., 2012). Less frequently, the awarding committee establishes each indicator's level of importance based on expert judgment, public opinion, or assigning equal weights (Zhou et al., 2007). At the research level, setting equal weight or using expert judgments are the most widely applied methods in CSR assessment (Montalbán-Domingo et al., 2021; Rahdari and Rostamy, 2015; Zhao et al., 2012). However, these techniques are not generally accepted because the CSR performances are significantly different in each company and country (Montalbán-Domingo et al., 2020; Pham et al., 2021; Zhao et al., 2012), and the weighting of CSR indicators must reflect contextual differences related to regional economic development and cultural background (Popovic et al., 2018; UNEP, 2009; Zhao et al., 2012).

Weights can also be defined using statistical weighting methods, such as factor analysis, data envelopment analysis, or unobserved component models (Abdella et al., 2021; Freudenberg, 2003; Joint Research Centre-European Commission, 2008). Factor analysis is the most commonly applied method (Abdella et al., 2021). This method relies on the correlation among the indicators to create factors that capture as much as possible of the common information (Hair et al., 2014). This technique estimates the weights of the original indicators; however, these weights are the same for each participant unit in the analyzed sample regardless of their individual performance (Hair et al., 2014).

Data envelopment analysis (DEA), on the other hand, is a well-established non-parametric technique that allows capturing the different performances of the units under analysis (Abdella et al., 2021). Through a mathematical programming model, DEA defines an efficiency frontier and uses this frontier as a benchmark to measure the performance of a given set of participating units (such as countries, companies, projects, etc.) (Nardo et al., 2005; Joint Research Centre-European Commission, 2008). Then, a set of weights is assigned to each participating unit, comparing it with the benchmark and looking for its maximum or minimum efficiency (Zhou et al., 2007). Thus, the weights assigned to each entity are different from the other entities in case their performances are different (Cherchye et al., 2008).

Finally, in unobserved component models, individual indicators are assumed to depend on an unobserved variable plus an error term. The aim is to estimate the unknown component and set the weights to minimize the error in the composite (Joint Research Centre-European Commission, 2008). This is a complex method characterized by high computational cost. Authors such as Singh et al. (2007) claimed this is not a robust method because the weights are a decreasing function of the variance indicators.

2.3. Research gap and theoretical approach

According to the literature review, defining a composite indicator for assessing the social dimension of CSR in public procurement would enable a quick and efficient assessment and benchmark within the industry (Krajnc and Glavič, 2005a; Pham et al., 2021; Xia et al., 2018). Moreover, it would assist government agencies in supervising the social responsibility of construction companies and shaping the CSR policies. Although researchers such as Dolla and Laishram (2020) and Montalbán-Domingo et al. (2021) have developed indicators for assessing CSR in procurement procedures in the construction industry, more efforts are demanded to define a weighting that varies across objectives, over countries, and through time (Cook et al., 2017). This weighting method would be a perfect tool for supporting socially sustainable development policies conducted at the country level.

Based on the aforementioned gap, this research aims to define a composite indicator for assessing the CSR of construction companies in public procurement. This research has several innovative elements. First, the novelty of the composite indicator lies in defining a weighting method to align the level of importance of each CSR indicator with the context of the construction industry in each country. The objective is to reduce the social weaknesses that exist in the country's construction industry where the project will be developed, assigning the maximum weights to the worst social performance indicators.

Second, the weighting method is defined for the European countries. This method uses the country as the unit of measure to determine the weights, and it is based on defining a benchmark within a selected sample of countries to identify the social weaknesses of each one of these countries. The social performance of each country can vary significantly depending on aspects such as the country's size, its level of development, culture, etc. (Joint Research Centre-European Commission, 2008). Thus, the selection of the countries to be included in the sample significantly impacts the results, being highly relevant for the method's reliability (Cherchye et al., 2007). Based on these facts, this research has decided to delimit the scope to countries in the European Union since the European Commission establishes common sustainability policies and programs

Third, authors such as Antolín-López et al. (2016), Flynn (2018), Zhang et al. (2022a), and the European Commission (2010) have highlighted the importance of properly defining social criteria in public procurement to reduce the barriers of Small and Medium-sized Enterprises (SME) to participate in public contract competition. Thus, this research performs a simulation analysis to assess whether the composite indicator is feasible and applicable not only for the assessment of one individual company but also for the assessment and comparison of two or more companies, similar to a procurement procedure; the simulation is applied to Spain and CSR performances of Spanish construction companies are gathered from GRI reports.

3. Proposed method

3.1. Overall approach

As stated previously, the research goal is to define a composite indicator for assessing the social dimension of CSR performance of construction companies in the award stage of public procurement. This section proposes a method for defining this composite indicator. Fig. 1 shows the four main steps for building the CSR composite indicator. First, the social indicators are selected from previous contributions (Step 1). These indicators have to be defined at the organizational level in order to guarantee the assessment of the company's attitude regarding CSR performance in their daily activities (Dočekalová and Kocmanová, 2016; Pham et al., 2021). These indicators have to satisfy quality criteria to guarantee their use within the procurement procedure (Montalbán-Domingo et al., 2021).

The following steps (2 through 4) define the weights according to the social weaknesses that exist in the country where the contract is procured. To this end, national indices related to the CSR indicators are selected from databases to assess the social performance of each country (Step 2). These national indices allow defining the level of importance (i.e., the weights) in the composite indicator. Subsequently, the weights are calculated using a weighting method based on the DEA-BoD approach (Step 3); the choice of the DEA-BoD approach is justified later in sub-Section 3.4.

Finally, the composite indicator for CSR assessment is built (Step 4). This last step entails clustering and normalizing the CSR indicators according to the national indices and associating these indicators with the calculated weights. The following sub-sections describe each of these four steps in-depth.

3.2. CSR indicators

The role of the CSR indicators is to represent the key categories for assessing the social dimension of CSR performance of construction companies. According to Krajnc and Glavič (2005a) and Dočekalová and Kocmanová (2016), the assessment must focus on the entire company in order to analyze its daily activities. Additionally, the CSR indicators must ensure fair and objective competition (Park et al., 2015; Schöttle and Arroyo, 2017); therefore, the indicators must be defined to ensure internal and external verification. All these constraints are satisfied by the CSR indicators proposed by Montalbán-Domingo et al. (2021). These authors identified nine social categories as the most important to analyze CSR at the organizational level. They defined 20 quantitative indicators for assessing the CSR of construction companies in public-works procurement; these indicators are displayed in Table 1. The indicators were selected by experts from a pool of 141 indicators according to quality criteria, such as comparability, relevance, understandability, reliability, and verifiability, in order to guarantee their use within the procurement process. These indicators were found relevant for assessing the social dimension of CSR of construction companies in a previous study by Montalbán-Domingo et al. (2021) and are, therefore, considered as the point of departure of this study.

3.3. National indices

National indices were selected from databases to define the weights based on the social flaws that exist in a country. A top-down approach was defined to evaluate and choose national indices. First, a 'theoretical' assessment was undertaken in which national indices were evaluated based on a set of quality criteria. Second, a 'practical' assessment was performed by a focus group of experts; the focus group chose the national indices to be used as proxy indicators of CSR indicators. Third, a

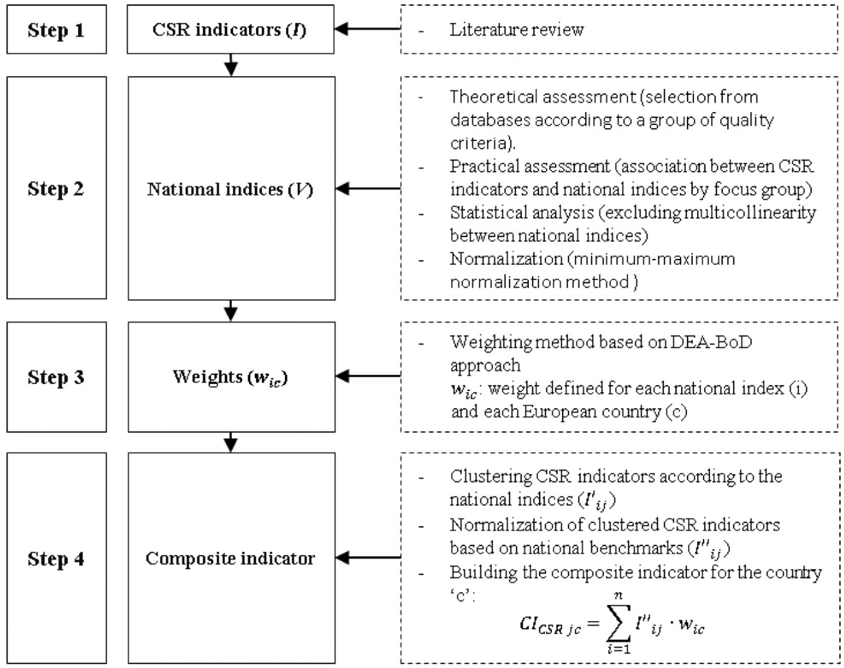

Fig. 1. Proposed method.

'statistical analysis' was performed to avoid possible multicollinearity between national indices. These three sub-steps are explained next.

3.3.1. *Theoretical assessment*

Organizations such as Eurostat, the Organization for Economic Cooperation and Development, the Sustainable Governance Indicators, the International Labor Organization, or the United Nations Conference on Sustainable Development, among others, have a wide sample of national indices in different fields. The quality of the method to determine the social weaknesses depend mainly on the appropriateness of the national indices used; therefore, data sources possessing a quality assurance framework were preferred wherever practicable (Cook et al., 2017; Montalbán-Domingo et al., 2020).

National indices were evaluated according to the following set of quality criteria (Montalbán-Domingo et al., 2020):

(1) relevance, to select the indices related to some of the CSR indicators;
(2) utility, to judge whether the indices are easily understandable;
(3) measurable, to assess whether the indices are defined at the national scale;
(4) geographical coverage, to guarantee that the indices are available for the 28 European countries;
(5) time coverage, to screen indices with data over the years; and,
(6) soundness, to select indices with metadata available.

The first step focused on selecting, from the databases of Eurostat (2017), ILO (2017), OECD (2017), SDG (2017), UNCSD (2017), and the World Bank (2017), the national indices that fulfilled the (1,2) criteria. Secondly, national indices were assessed according to the criteria (3, 4, 5, 6). Subsequently, redundant indices were rejected.

3.3.2. *Practical assessment*

The practical assessment aims to associate each CSR indicator with one or several national indices. The purpose is that the national indices work as proxy indicators of the CSR indicators. A proxy indicator is generally used to stand in for variables that cannot be directly measured (Benini and Sala, 2016). The use of proxy indicators in the definition of composite indicators has been proposed in numerous studies with good results (Nardo et al., 2005; UNEP, 2009; Cook et al., 2017).

An expert panel approach was used to link national indices with CSR indicators, following the recommendations of Cook et al. (2017) and the Joint Research Centre-European Commission (2008). This kind of approach, based on experts, was essential to ensure transparency in this decision-making procedure (Nikolaou et al., 2019; UNEP, 2009), the concept of social sustainability encompasses complex terms (Landorf, 2011; Nikolaou et al., 2019) and entails an analysis from different perspectives (UNEP, 2009). The focus group was the selected technique. This technique aims to encourage interactive discussions and knowledge sharing between a group of experts to generate new ideas and knowledge, defining a consistent and holistic viewpoint (Xenarios and Tziritis, 2007; Yu et al., 2017); it can help acquire a large amount of information within a relatively short period of time (Yu et al., 2017). To collect the focus group, three profiles of experts were identified depending on the following areas of knowledge (Bhandari and Hallowell, 2021): (Profile 1) public procurement procedures and project delivery methods; (Profile 2) construction of civil engineering projects; and, (Profile 3) social sustainability in the construction industry. These three profiles aimed to guarantee the heterogeneity among the members, encouraging a wide range of experiences, perceptions, and opinions (Brüggen and Willems, 2009). Twelve experts were selected and characterized according to six criteria (Hallowell and Gambatese, 2010), as indicated in Table 2. As can be seen, every member has broad expertise in one of the established profiles and holds at least a civil engineering degree.

The 'practical assessment' entailed that: first, each expert individually selected the national indices for each CSR indicator; and, second, the results of this first task were shared and discussed in the focus group. Finally, a proposal of national indices was defined by consensus.

3.3.3. *Statistical analysis*

The statistical analysis of the national indices focused on correlation analysis. The aim was to identify the national indices with multicollinearity and delete redundant indices (Joint Research Centre-European Commission, 2008). Multicollinearity is identified through the correlation matrix. The multicollinearity corresponds to those indicators most highly correlated (coefficient correlation above 0.80). According to Hair et al. (2014), the correlation matrix can be calculated using three possible correlation coefficients: Pearson's correlation

Table 1
CSR indicators for construction companies (Montalbán-Domingo et al., 2021).

Indicator	Metric
I_1: New staff hiring	Total number of new staff hired in the company divided by the maximum number of workers
I_2: Temporary contracts	Total number of temporary workers divided by the maximum number of workers
I_3: Employee turnover	Maximum number of leaving workers divided by the maximum number of workers
I_4: Investment in the health of employees	Annual investment in the health of employees divided by revenue
I_5: Parental leave	The number of employees who returned to work after parental leave ended, who were still employed 12 months after their return to work, concerning the number of employees that were entitled to parental leave over the last two years
I_6: Training on health and safety	Total number of hours of staff time used for giving or receiving formal training on health and safety aspects of construction concerning the total number of worked hours
I_7: Certificates in health and safety	1 If the company is currently certificated by OHSAS 18001, ISO45001:2018 or equivalent; otherwise, 0
I_8: Fatalities	Number of fatalities over last year divided by the total number of worked hours
I_9: Accidents	The number of accidents involving sick leave divided by the total number of worked hours * 1000,000,000
I_{10}: Occupational disease	The number of occupational diseases concerning the total number of workers * 200,000
I_{11}:Working days lost	The number of working days lost due to sick leave accidents registered concerning the total number of worked hours * 1000
I_{12}: Social value	Total number of hours that employees spent on social programs and voluntary activities during working hours
I_{13}: Female labor force participation	Total number of female employees divided by the maximum number of workers
I_{14}: Wage gap	Difference between basic salary and remuneration of male and female employees.
I_{15}: Women in executive management positions	Percentage of women in executive management positions
I_{16}: Disabled people	Total number of workers registered as disabled concerning the maximum number of workers
I_{17}: Salary distribution	Annual total compensation of the highest-paid individual divided by the median annual total compensation for all employees except the highest-paid individual
I_{18}: Technical training	Annual investment in workers' technical training per the maximum number of workers
I_{19}: Social ethics, social awareness, and human rights	Total hours of staff time used for giving or receiving formal training on code of ethics, social awareness, human rights, and social aspects of construction divided by the maximum number of workers
I_{20}: Research and Development	Annual investment in research and innovation projects divided by the revenue

Table 2
Percentage of experts that satisfies the criteria per profile.

Criteria	Profile 1	Profile 2	Profile 3
At least ten years of professional experience in the construction industry	100%	100%	100%
Advanced degree	100%	100%	100%
Primary or secondary author of at least three peer-reviewed journal articles	25%	75%	75%
Manager in a private company	50%	100%	0%
Faculty member at an accredited institution of higher learning	50%	50%	75%
Doctoral degree	50%	50%	75%

coefficient, when the sample fulfills statistical normality; Spearman's correlation coefficient, when the data do not present a normal distribution; and, Kendall's tau, which is recommended rather than Spearman's coefficient when the data set is small, offering, in small samples, a better estimate of the correlation. These tests assume as a null hypothesis that the correlation coefficient between variables is not significantly different from zero. This condition is satisfied when the *p*-value is less than 0.05 (Hair et al., 2014). Additionally, these correlation coefficients (r) represent the standardized covariance. The coefficients go from −1 to +1. A coefficient of +1 indicates that the two variables are perfectly positively correlated; a coefficient of −1 indicates a perfect negative relationship, and a coefficient of zero indicates no linear relationship. To measure the size of an effect, values of ±0.1 represent a small effect, ±0.3 a medium effect, and ± 0.5 a large effect (Hair et al., 2014). Thus, first, the normality of the sample was analyzed through the Shapiro-Will test, as the sample includes 28 countries (less than 50) (Hair et al., 2014). The results showed that indicators were normally distributed (p-value$>$0.05). Therefore, the correlation matrix was calculated using IBM SPSS Statistics 23.0, through Kendall's tau test and the indices with multicollinearity ($r > 0.80$) were deleted.

3.3.4. Normalization

National indices are expressed in different measurement units and, therefore, were normalized. The normalization technique was the minimum-maximum normalization method within an interval scale of 1.00 (the worst performance) and 2.00 (the best performance). Each national index with a positive impact was transformed into a normalized form by Eq. (1), and the indices with a negative impact were normalized by Eq. (2) (Zhou et al., 2012):

$$V^{+}_{Ni,c} = 1 + \frac{V^{+}_{i,c} - V^{MIN}_{Ni}}{V^{MAX}_{Ni} - V^{MIN}_{Ni}} \tag{1}$$

$$V^{-}_{Ni,c} = 2 - \frac{V^{-}_{i,c} - V^{MIN}_{Ni}}{V^{MAX}_{Ni} - V^{MIN}_{Ni}} \tag{2}$$

- $V^{+}_{i,\ c}$ and $V^{-}_{i,\ c}$: Values for the national index i from the country c, with positive and negative impact on social aspects, respectively.
- $V^{+}_{Ni,\ c}$ and $V^{-}_{Ni,\ c}$: Normalized indicators, respectively.
- V^{MAX}_{Ni}: The highest value for the indicador i in the sample.
- V^{MIN}_{Ni}: The lowest value for the indicator i in the sample.

3.4. Weights

After an intensive analysis of previous contributions, the DEA was deemed the most appropriate method to measure the efficiency of each participating unit and determine objective weights by reference to the observational data (Charnes et al., 1978). DEA is extensively used at macroeconomic levels for supporting sustainable development policies (Bianchi et al., 2020). Over the years, different DEA models have been developed for various applications, including sustainability research. In terms of building a composite indicator, DEA has been widely accepted (Zhou et al., 2018). There are two different approaches to DEA. One approach is the traditional DEA, where the model identifies a set of performance measures that are termed as inputs and outputs. Then, it constructs an efficient frontier formed by a set of participating units that represent the best performances. Finally, it assigns the weights to each participating unit to achieve the efficiency level according to their distances to the efficient frontier (Zhou et al., 2018).

A more innovative approach does not take inputs and only takes outputs (or performance measures) that transform into benefit or cost type variables. This approach defines an objective aggregated indicator for each assessed participating unit. The weights are determined endogenously through an optimization method. This method is named DEA-BoD (Benefit-of-Doubt) approach; it allows varying weights of each participating unit according to an optimal solution to look for the maximum or minimum benefit for each participating unit under analysis (Cherchye et al., 2007). Numerous authors have widely used the DEA-BoD to develop composite indicators to measure social inclusion in European Countries (Giambona and Vassallo, 2014), to assess the progress of the European Union towards Europe's targets (Verbunt and Rogge, 2018; Wüst and Rogge, 2021), to assess the sustainable performance of different industries (Aparicio et al., 2020; Aparicio and Kapelko, 2019; Fukuyama et al., 2020; Oliveira et al., 2020), among others.

The DEA-BoD approach is designed to increase the discriminating powers of the DEA method, improving the comparisons among different entities (Zhou, 2008). There are two versions of the DEA-BoD approach: the optimistic and pessimistic versions (Rogge, 2018). The goal of the pessimistic version is to minimize the efficiency, assigning the maximum weights to the worst performance indicators in a country (Zhou et al., 2007). The pessimistic version represents the methodological approach of this research and the basis for the development of the weighting method. This optimization problem aims to minimize the efficiency, assigning the maximum weights in the composite indicator to the worst performance indicators in a country. This approach has been widely defined by authors such as Zhou et al. (2007), Cherchye et al. (2008), Zhou (2008), and Rogge (2018). The basic idea of the DEA-BoD approach is to put the data of the country indices in a relative perspective by comparing them to a benchmark (Rogge, 2018).

The following model of equations defines the weighting method. Eq. (3) seeks to define the weights (w_{ic}) in the country 'c' for each National index (V_i) to achieve the minimum value of SI_C. Additionally, three conditions have to be satisfied: (1) a normalization constraint to guarantee that, when the weights defined for country 'c' are applied to any other country in the sample, none of these countries can obtain a value in the weighted sum lower than one (Eq. (4), 2) the weights cannot be negative (Eq. (5)); and, (3) the sum of these weights has to be equal to 1.00 (Eq. (6)). This way, the weighting problem is performed for each country independently, and the benchmark of each country will be taken from the observed sample itself. Therefore, the country 'c' benchmark will be the country 'j' that, having applied the weights of the country 'c', obtains the maximum value of the composite indicator SI_C (Rogge, 2018; Verbunt and Rogge, 2018). Additionally, 'proportional share restrictions' were included (see Eqs. (7) and (8)). According to Zhou et al. (2007), Zhou (2008), Cherchye et al. (2008), and Rogge (2018), 'proportional shared restrictions' are needed to guarantee that every indicator is considered and to ensure that a proper weighting scheme is established.

$$SI_c = \frac{min}{w_{ic}}\left(\sum_{i=1}^{m} w_{ic} \bullet V_{ic}\right) \tag{3}$$

Subject to:

$$\sum_{i=1}^{n} w_{ic} \bullet V_{ij} \geq 1 \tag{4}$$

$$w_{ic} \geq 0 \tag{5}$$

$$\sum_{i=1}^{n} w_{ic} = 1 \tag{6}$$

$$\alpha_j \leq \frac{V_{ij\bullet} w_{ij}}{\sum_{i=1}^{n} V_{ij\bullet} w_{ij}} \leq \beta_j \tag{7}$$

$$0 \leq \alpha_j < \beta_j \leq 1 \tag{8}$$

with:

- SI_c: Result of the composite indicator. It shows the social performance of the country 'c'.
- w_{ic}: Weight assigned to the indicator' i' in the country 'c'.
- V_{ic}: Value for country 'c' on the proxy indicator 'i' ($i = 1, \ldots, n$; n is the number of indicators in the model).
- V_{ij}: Value for the country 'j' on the proxy indicator 'i' ($j = 1, \ldots, m$; m is the number of countries in the sample).
- α_j and β_j: Lower and upper limits in the 'proportional share restrictions'.

Based on these equations, the authors performed the following process to define the optimal weights for each country. First, analyze the weighting method without the 'proportional share restrictions' to verify its proper performance. Second, add the 'proportional share restrictions' to study the influence of α_j and β_j in the model; and, third, calculate the weights based on a specific scenario of α_j and β_j taking into account that the aim is to define the weights of each indicator based on the social weaknesses that exist in a country but being able to adapt to the needs of each procurer, agency, or government.

3.5. Composite indicator

The definition of a composite indicator (CI) entails three stages. First, the CSR indicators must be normalized to be integrated into a CI. According to Tokos et al. (2012) and Zhou et al. (2012), normalization using benchmarks ensures that all indicators are transformed transparently and comparably. The external benchmark can be defined based on the values of measurements and standards in the construction industry, local legal regulations, GRI reports for the construction industry, and other relevant documents (Zhou et al., 2012). In this regard, this study recommended using GRI reports to define the benchmark because the GRI guideline is the world's most widely used standardized sustainability reporting framework (Roca and Searcy, 2012; Tokos et al., 2012). Following the recommendations of Tokos et al. (2012) and Zhou et al. (2012), the CSR indicators with a positive effect (maximization) were normalized using Eq. (9), and indicators with a negative effect (minimization) were normalized using Eq. (10); where, I denotes the value of a CSR indicator, I' is the normalized CSR indicator, and λ is the benchmark of each indicator.

$$I' = \frac{I}{\lambda} \tag{9}$$

$$I' = 1 - \frac{I}{\lambda} \tag{10}$$

Second, the CSR indicators are clustered according to the national indices, since these indices act as proxy of the CSR indicators and the weights have been defined according to them. Finally, the composite indicator is built (see Eq. (11)). $CI_{CSR\ jc}$ represents the result of the composite indicator for the construction company 'j' in the country 'c' where the project is procured; I''_{ij} is the value of the company indicator I''_i for the construction company 'j'; and, w_{ic} is the weight assigned to the indicator I''_i for the country 'c'. The weights must be between 0 and 1 ($0 \leq w_i \leq 1$), and the sum of the weights must be equal to 1 ($\sum_{i=1}^{n} w_i = 1$).

$$CI_{CSR\ jc} = \sum_{i=1}^{n} I''_{ij} \bullet w_{ic} \tag{11}$$

4. Implementation

This section illustrates the proposed method for building composite indicators for CSR assessment in public procurement. Once the authors set the CSR indicators to include in the CI, the proposed method is implemented for the 28 European countries. First, the national indices are selected by experts and associated with the CSR indicators. Second, the weights are calculated through the DEA-BoD method. Finally, the CI is built. The following sub-sections gather each of these steps in-depth.

4.1. National indices

The selection of national indices was based on a top-down approach. First, the 'theoretical assessment' resulted in the selection of 37 national indices. Second, the focus group performed the 'practical assessment' and chose 24 national indices to be used as proxy indicators of the CSR indicators. Table 3 shows the result of the focus group. To bring stability to the method, the experts proposed that the values considered for each national index should be the average of the three last years. In our study, the authors took the data from 2017, 2018, and 2019. The focus group, trying not to duplicate information, selected all those national indices related to each CSR indicator's general concept. Seven national indices were proposed as proxy indicators of new staff hiring (I_1). The focus group tried not to limit excessively the number of national indices in this stage. The reason was based on allowing the correlation analysis to reject the national indices with multicollinearity. Regarding the CSR indicators investment in the health of employees (I_4) and parental leave (I_5), the focus group decided to cover them with the same proxy indicator: public health expenditure. They considered that these CSR indicators depend on the law of each country and the national policies concerning the investment of governments in public health (CIRIA, 2001; United Nations, 2008a; GRI, 2018). Finally, the focus group decided that the national indices 'death rate due to chronic diseases', 'fatal accidents at work', and 'non-fatal accidents at work' may be proxy indicators of the CSR indicators I_6 (training on health and safety), I_7 (certificates health and safety), I_8 (fatalities), I_9 (accidents) and I_{10} (occupational disease). The reason was that occupational health and safety performance reflects the health and safety management and training systems that exist in an organization (GRI, 2018).

The *statistical analysis* identified the national indices with multicollinearity (Kendall's correlations >0.8) (see Table 4). The index 'unemployment total' was highly correlated with 'long-term unemployment rate', 'unemployment female', 'youth unemployment rate', 'unemployment rate by foreign-born', 'unemployment with advanced education', 'unemployment with intermediate education', and 'unemployment with basic education'. Similarly, the national index 'patent application' was highly correlated to 'research and development expenditure'. Consequently, only the national indices 'unemployment total' and 'research and development expenditure' were considered.

Table 5 gathers the normalized national indices. The minimum and maximum values are in bold.

Table 3
National indices assigned by the focus group to each CSR indicator.

CSR Indicator	National indices	Source
I_1: New staff hiring	Unemployment with advanced education	ILOSTAT
	Unemployment with basic education	ILOSTAT
	Unemployment with intermediate education	ILOSTAT
	Unemployment rate	ILOSTAT
	Long-term unemployment rate	Eurostat
	Youth unemployment rate	ILOSTAT
	Unemployment rate by foreign-born	Eurostat
I_2: Temporary contracts	Temporary employment	Eurostat
I_3: Employee turnover	Job tenure	ILOSTAT
I_4: Investment in the health of employees	Public health expenditure	Eurostat
I_5: Parental leave	Public health expenditure	Eurostat
I_6: Training on health and safety	Death rate due to chronic diseases	Eurostat
	Fatal accidents at work	Eurostat
	Non-fatal accidents at work	Eurostat
I_7: Certificates in health and safety	Death rate due to chronic diseases	Eurostat
	Fatal accidents at work	Eurostat
	Non-fatal accidents at work	Eurostat
I_8: Fatalities	Fatal accidents at work	Eurostat
I_9: Accidents	Non-fatal accidents at work	
I_{10}: Occupational disease	Death rate due to chronic diseases	Eurostat
I_{11}:Working days lost	Non-fatal accidents at work	Eurostat
I_{12}: Social value	Human Development Index	Eurostat
I_{13}: Female labor force participation	Ratio of female to male labor force participation	ILOSTAT
	Unemployment, female	ILOSTAT
I_{14}: Wage gap	Ratio of female to male salary	Eurostat
I_{15}: Women in executive management positions	Employed women being in managerial positions	Eurostat
I_{16}: Disabled people	Unemployment rate of disabled people	
I_{17}: Salary distribution	Employed persons at-risk-of-poverty rate	Eurostat
I_{18}: Technical training	Employed persons participating in job-related non-formal education and training in the past 12 months	Eurostat
I_{19}: Social ethics, social awareness, and human rights	Corruption perception index	Eurostat
I_{20}: Research and Development	Patent applications	Eurostat
	Research and development expenditure	Eurostat

4.2. Weights

The first step to defining the optimal weights for each country was analyzing the weighting method without the 'proportional share restrictions'. The reason was to verify the proper performance of the method. Without 'proportional share restrictions', the weighting method must assign the maximum weights to the worst performance indicators for each country, and the rest of the indicators must get weights equal to zero.

The second step entailed the analysis of the influence of the lower (α_j) and upper (β_j) limits of the 'proportional share restrictions'. To characterize the influence of α_j and β_j on the model, these were analyzed independently. First, β_j was set at 1.00, representing that upper restriction does not exist in the model. Consequently, only the influence of the lower restriction was analyzed for different scenarios of α_j (0.01, 0.02, 0.03, 0.04, 0.05, and 0.06). The maximum value of α_j was 0.06 because the model has 16 indicators; thus, the maximum weight that can be assigned to each indicator is 0.062. Although the restrictions were defined based on proportion constraints and these are not direct restrictions on weights, it was considered that a higher value of α_j could unduly limit the flexibility of the model (Rogge, 2018). The analysis of

Table 4
Kendall's correlations of national indices characterized by multicollinearity.

Correlated indicators		Unemployment, total	Research and development expenditure
Long-term unemployment rate	Correlation coefficient	0.802	
	p-value	0.000	
Unemployment, female	Correlation coefficient	0.886	
	p-value	0.000	
Youth unemployment rate	Correlation coefficient	0.821	
	p-value	0.000	
Unemployment rate by Foreign-born	Correlation coefficient	0.802	
	p-value	0.000	
Unemployment with advanced education	Correlation coefficient	0.837	
	p-value	0.000	
Unemployment with intermediate education	Correlation coefficient	0.820	
	Sig. (2-tailed)	0.000	
Unemployment with basic education	Correlation coefficient	0.857	
	p-value	0.001	
Patent applications	Correlation coefficient		0.813
	p-value		0.000

Table 5
Normalized national indices.

Country	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	V_{12}	V_{13}	V_{14}	V_{15}	V_{16}
Austria	1.92	1.70	1.42	1.66	1.84	1.78	1.53	1.77	1.74	1.25	1.47	1.94	1.72	1.75	1.70	1.85
Belgium	1.81	1.68	1.67	1.57	1.87	1.67	1.50	1.78	1.67	1.94	1.54	1.72	1.92	1.84	1.72	1.65
Bulgaria	1.83	1.88	1.68	1.25	1.30	1.22	2.00	**1.00**	1.64	1.56	1.72	1.50	1.62	1.15	**1.00**	1.10
Croatia	1.52	1.23	1.50	1.48	1.43	1.58	1.86	1.27	1.58	1.84	1.38	1.39	1.85	1.37	1.17	1.11
Cyprus	1.54	1.41	1.08	**1.00**	1.97	1.43	1.89	1.49	1.84	1.59	1.22	1.72	1.69	1.30	1.33	1.01
Czech Republic	**2.00**	1.66	1.68	1.55	1.64	1.52	1.89	1.64	1.47	1.21	1.31	1.42	1.98	1.95	1.46	1.51
Denmark	1.89	1.60	**1.00**	1.69	1.83	1.93	1.43	2.00	1.91	1.53	1.35	1.68	1.89	1.63	**2.00**	1.89
Estonia	1.87	1.92	1.34	1.45	1.56	1.53	1.79	1.56	1.64	**1.00**	1.61	1.28	1.55	1.87	1.60	1.47
Finland	1.76	1.44	1.27	1.36	1.88	1.89	1.40	1.74	1.95	1.42	1.55	1.78	**2.00**	**2.00**	1.97	**2.00**
France	1.70	1.41	1.58	1.61	1.87	1.47	1.13	1.78	1.77	1.53	1.53	1.60	1.72	1.69	1.58	1.62
Germany	2.00	1.55	1.53	1.89	1.81	1.84	1.30	**2.00**	1.73	1.22	1.41	1.61	1.60	1.71	1.82	1.84
Greece	**1.00**	1.61	1.69	1.18	1.78	1.62	1.94	1.60	1.44	1.66	1.33	1.48	1.35	**1.00**	1.09	1.11
Hungary	1.94	1.67	1.43	1.19	**1.00**	1.47	1.97	1.34	1.42	1.57	1.79	1.22	1.68	1.36	1.13	1.31
Ireland	1.81	1.72	1.45	1.44	1.88	1.57	1.84	1.99	1.56	1.60	1.63	1.30	1.90	1.91	1.67	1.41
Italy	1.61	1.49	1.68	1.46	1.96	1.59	1.69	1.67	1.16	1.98	1.35	1.83	1.49	1.47	1.18	1.29
Latvia	1.72	1.92	1.42	1.17	1.18	1.74	1.98	1.28	1.68	1.45	**2.00**	1.33	1.68	1.55	1.31	1.08
Lithuania	1.79	1.98	1.22	1.40	1.16	1.03	1.96	1.42	1.78	1.59	1.76	**1.00**	1.65	1.54	1.36	1.18
Luxembourg	1.89	1.69	1.55	1.46	1.95	1.82	1.16	1.79	1.71	1.99	**1.00**	**2.00**	1.48	1.87	1.66	1.31
Malta	1.96	1.78	1.63	1.61	1.88	1.28	1.48	1.45	**1.00**	1.75	1.39	2.00	1.86	1.64	1.30	1.14
Netherlands	1.91	1.24	1.51	**2.00**	1.90	**2.00**	1.68	1.99	1.75	1.50	1.30	1.80	1.88	1.90	1.70	1.56
Poland	1.89	**1.00**	1.64	1.23	1.54	1.71	1.94	1.44	1.44	1.90	1.84	1.65	1.53	1.58	1.50	1.17
Portugal	1.64	1.20	1.44	1.35	1.81	1.00	**1.00**	1.36	1.76	1.46	1.60	1.49	1.53	1.37	1.44	1.33
Romania	1.90	**2.00**	**2.00**	1.40	1.14	**1.00**	**2.00**	1.07	1.26	**2.00**	1.51	1.83	**1.00**	1.22	1.36	**1.00**
Slovak Republic	1.70	1.66	1.55	1.33	1.35	1.76	1.98	1.41	1.78	1.34	1.55	1.25	1.83	1.83	1.19	1.14
Slovenia	1.80	1.37	1.58	1.56	1.72	1.32	1.65	1.72	1.52	1.89	1.80	1.73	1.81	1.74	1.40	1.74
Spain	1.21	1.05	1.18	1.52	1.91	1.48	1.15	1.70	1.68	1.57	1.47	1.02	1.40	1.50	1.33	1.28
Sweden	1.84	1.40	1.13	1.86	**2.00**	1.96	1.84	1.92	**2.00**	1.60	1.78	1.75	1.74	1.79	1.90	1.97
United Kingdom	1.96	1.82	1.39	1.67	1.82	1.95	1.85	1.90	1.75	1.27	1.65	1.70	1.68	1.90	1.81	1.44

Note: V_1: unemployment rate; V_2: temporary employment; V_3: job tenure; V_4: public health expenditure; V_5: death rate due to chronic diseases; V_6: fatal accidents at work; V_7: non-fatal accidents at work; V_8: human development index; V_9: ratio of female to male labor force participation rate; V_{10}: ratio of female to male salary; V_{11}: employed women being in managerial positions; V_{12}: unemployment rate of disabled people; V_{13}: employed persons at-risk-of-poverty rate; V_{14}: employed persons participating in job-related non-formal education and training in the past 12 months; V_{15}: corruption perception index; V_{16}: research and development expenditure

Table 6
Minimum and maximum weights in the sample for each scenario of α_j.

Scenarios	Weights in α_j scenarios	
$\alpha_j = 0.00$	Min w_i	0.00
	Max w_i	0.59
$\alpha_j = 0.01$	Min w_i	0.01
	Max w_i	0.49
$\alpha_j = 0.02$	Min w_i	0.01
	Max w_i	0.46
$\alpha_j = 0.03$	Min w_i	0.02
	Max w_i	0.36
$\alpha_j = 0.04$	Min w_i	0.02
	Max w_i	0.29
$\alpha_j = 0.05$	Min w_i	0.03
	Max w_i	0.19
$\alpha_j = 0.06$	Min w_i	0.04
	Max w_i	0.10

Table 7
Minimum and maximum weights in the sample for each scenario of $\beta_{j.}$

Scenarios	Weights in β_j scenarios	
$\beta_j = 1$	Min w_i	0.01
	Max w_i	0.91
$\beta_j = 0.8$	Min w_i	0.01
	Max w_i	0.87
$\beta_j = 0.6$	Min w_i	0.01
	Max w_i	0.69
$\beta_j = 0.4$	Min w_i	0.01
	Max w_i	0.49
$\beta_j = 0.2$	Min w_i	0.01
	Max w_i	0.27
$\beta_j = 0.1$	Min w_i	0.01
	Max w_i	0.15

these scenarios of α_j highlighted that α_j controls the minimum weight assigned to each indicator. Table 6 shows the minimum and maximum weights considering all countries and indices for every scenario. As can be seen, the more α_j increases, the more the minimum value of the weights grows.

After characterizing α_j, the second step was analyzing the role of β_j in the weighting method. α_j was set at 0.01 and scenarios varying β_j (1.0, 0.8, 0.6, 0.4, 0.2, 0.1) were analyzed. The results of these scenarios are summarized in Table 7 and highlights that the maximum weights decrease with β_j to satisfy the restriction; however, the minimum weights in the different scenarios are not affected by β_j. The role of β_j in the model manages the number of indicators that should be emphasized for each country.

Therefore, the lower (α_j) and upper (β_j) limits of the 'proportional share restrictions' are parameters to adapt the weighting method to the requirements of a procurer, agency or government. Based on this, a hypothetical scenario was defined and α_j and β_j were set to guarantee a minimum weight of 0.03 (3%) for each indicator, and at least four indicators with weights over 0.10 (10%). Under these premises, the third step was performed and the optimal weights for each European country were defined considering α_j equal to 0.05, and β_j equal to 0.10. The optimal weights defined in this scenario are gathered in Table 8. In this table, the cells highlighted in grey and bold font represent the worst indicators for each country. As can be seen, these cells received the maximum weights of each country. On the other hand, the cells highlighted in grey and italics font are the worst following indicators for each country. These indicators received weights over 0.10, guaranteeing a minimum of four indicators with weights over 0.10 for each country.

Results show that Greece and Romania are the countries with the worst social performance (SI = 1.29); and Belgium is the country with the best social performance (SI = 1.68) followed by Sweden (SI = 1.67), the United Kingdom (SI = 1.63), and the Netherlands (SI = 1.62). Regarding the weights, Romania needs to focus its efforts on boosting fatal accidents at work (I''_6), social value (I''_8), salary distribution (I''_{13}),

Table 8
Weights with αj equal to 0.05, and βj equal to 0.1 and SI results.

Country	W_1	W_2	W_3	W_4	W_5	W_6	W_7	W_8	W_9	W_{10}	W_{11}	W_{12}	W_{13}	W_{14}	W_{15}	W_{16}	SI
Austria	0.04	0.05	*0.11*	0.05	0.04	0.05	*0.11*	0.05	0.05	**0.13**	*0.11*	0.04	0.05	0.05	0.05	0.04	1.61
Belgium	0.05	0.05	0.05	*0.11*	0.05	0.05	**0.11**	0.05	0.05	0.04	*0.11*	0.05	0.04	0.05	0.05	*0.10*	1.68
Bulgaria	0.04	0.03	0.04	0.05	0.05	0.05	0.03	**0.13**	0.04	0.04	0.04	0.04	0.04	*0.11*	**0.13**	*0.12*	1.31
Croatia	0.05	*0.11*	0.05	0.05	0.05	0.04	0.04	*0.11*	0.04	0.04	0.05	0.05	0.04	0.05	*0.12*	**0.12**	1.38
Cyprus	0.04	0.05	*0.12*	**0.13**	0.03	0.05	0.04	0.04	0.04	0.04	*0.11*	0.04	0.04	0.05	0.05	*0.13*	1.32
Czech Republic	0.04	0.05	0.05	0.05	0.05	0.05	0.04	0.05	0.05	**0.13**	*0.12*	*0.11*	0.04	0.04	*0.10*	0.05	1.53
Denmark	0.04	0.05	**0.16**	0.05	0.04	0.04	*0.11*	0.04	0.04	*0.10*	*0.12*	0.05	0.04	0.05	0.04	0.04	1.56
Estonia	0.04	0.04	*0.11*	*0.10*	0.05	0.05	0.04	0.05	0.04	**0.15**	0.05	*0.11*	0.05	0.04	0.05	0.05	1.46
Finland	0.05	0.06	**0.13**	*0.12*	0.04	0.04	*0.11*	0.05	0.04	*0.11*	0.05	0.04	0.04	0.04	0.04	0.04	1.60
France	0.05	*0.11*	0.05	0.05	0.04	*0.10*	**0.14**	0.04	0.04	*0.10*	0.05	0.05	0.04	0.05	0.05	0.05	1.53
Germany	0.04	0.05	*0.10*	0.04	0.04	0.04	*0.12*	0.04	0.05	**0.13**	*0.11*	0.05	0.05	0.05	0.04	0.04	1.58
Greece	**0.13**	0.04	0.04	0.05	0.04	0.04	0.03	0.04	0.04	0.04	0.05	0.04	0.05	**0.13**	*0.12*	*0.12*	1.29
Hungary	0.03	0.04	0.05	*0.11*	**0.13**	0.05	0.03	0.05	0.05	0.04	0.04	*0.11*	0.04	0.05	*0.12*	0.05	1.35
Ireland	0.04	0.05	*0.11*	*0.11*	0.04	0.05	0.04	0.04	0.05	0.05	0.05	**0.12**	0.04	0.04	0.05	*0.11*	1.59
Italy	0.05	0.05	0.04	0.05	0.04	0.05	0.04	0.04	**0.13**	0.04	*0.11*	0.04	0.05	0.05	*0.12*	*0.11*	1.45
Latvia	0.04	0.04	0.05	*0.12*	*0.12*	0.04	0.04	*0.11*	0.04	0.05	0.04	0.05	0.04	0.05	0.05	**0.13**	1.40
Lithuania	0.04	0.03	0.06	0.05	*0.12*	*0.13*	0.03	0.05	0.04	0.04	0.04	**0.13**	0.04	0.04	0.05	*0.11*	1.34
Luxembourg	0.04	0.04	0.05	*0.10*	0.04	0.04	*0.13*	0.04	0.04	0.04	**0.15**	0.04	0.05	0.04	0.04	*0.11*	1.49
Malta	0.04	0.04	0.04	0.04	0.04	*0.11*	0.05	0.05	**0.14**	0.04	0.05	0.04	0.04	0.04	*0.11*	*0.13*	1.43
Netherlands	0.04	**0.13**	*0.11*	0.04	0.04	0.04	0.05	0.04	0.05	*0.11*	*0.12*	0.04	0.04	0.04	0.05	0.05	1.62
Poland	0.04	**0.14**	0.04	*0.12*	0.05	0.04	0.04	0.05	*0.10*	0.04	0.04	0.04	0.05	0.05	0.05	*0.12*	1.44
Portugal	0.04	*0.11*	0.05	0.05	0.04	0.13	**0.13**	0.05	0.04	0.05	0.04	0.04	0.04	0.05	0.05	*0.10*	1.32
Romania	0.03	0.03	0.03	0.05	0.06	**0.13**	0.03	*0.12*	0.05	0.03	0.04	0.04	**0.13**	0.05	0.05	**0.13**	1.29
Slovak Republic	0.04	0.04	0.05	*0.11*	0.05	0.04	0.04	0.05	0.04	0.05	0.05	*0.12*	0.04	0.04	*0.12*	**0.13**	1.43
Slovenia	0.04	*0.12*	0.05	0.05	0.05	**0.12**	0.05	0.05	*0.10*	0.04	0.04	0.05	0.04	0.05	*0.11*	0.05	1.58
Spain	0.05	*0.12*	*0.11*	0.04	0.03	0.04	*0.11*	0.04	0.04	0.04	0.04	**0.13**	0.05	0.04	0.05	0.05	1.30
Sweden	0.05	*0.12*	**0.15**	0.04	0.04	0.04	0.05	0.04	0.04	*0.10*	0.05	0.05	*0.10*	0.05	0.04	0.04	1.67
United Kingdom	0.04	0.04	*0.12*	0.05	0.04	0.04	0.04	0.04	0.05	**0.13**	*0.10*	0.05	0.05	*0.04*	0.05	*0.11*	1.63

Note: W_1: unemployment rate; W_2: temporary employment; W_3: job tenure; W_4: public health expenditure; W_5: death rate due to chronic diseases; W_6: fatal accidents at work; W_7: non-fatal accidents at work; W_8: human development index; W_9: ratio of female to male labor force participation rate; W_{10}: ratio of female to male salary; W_{11}: employed women being in managerial positions; W_{12}: unemployment rate of disabled people; W_{13}: employed persons at-risk-of poverty rate; W_{14}: employed persons participating in job-related non-formal education and training in the past 12 months; W_{15}: corruption perception index; W_{16}: research and development expenditure; SI: Social performance of each country and research and development ($''_{16}$). On the other hand, Sweden needs to work on temporary contracts (I''_2), employee turnover (I''_3), wage gap (I''_{10}), and salary distribution (I''_{13}).

4.3. Composite indicator

To define the composite indicator, the CSR indicators must first be normalized using benchmarks. Second, the normalized CSR indicators (I'_i) are clustered according to the national indices (see Table 9). The experts proposed that the CSR indicators training on health and safety (I_6), certificates health and safety (I_7), fatalities (I_8), accidents (I_9), occupational disease (I_{10}), and working days lost (I_{11}) may be clustered into three indicators: fatal accidents at work, non-fatal injuries at work, and chronic disease. Table 9 gathers the definition of each company indicator and the allocated national index. Finally, the composite indicator can be applied according to Eq. (11) defined in Section 3.5.

5. Simulation

A simulation analysis was performed to evaluate the capabilities of the CSR composite indicator to compare construction companies. The simulation analyzes whether the composite indicator is feasible and applicable for assessing one individual company and the evaluation and comparison of two or more companies, similar to a procurement procedure. The simulation was applied to Spain. The data of the CSR indicators and benchmarks were extracted from Montalbán-Domingo et al. (2021). These authors gathered CSR performances of Spanish construction companies from GRI reports. Table 10 collects the values for each CSR indicator of each company. As can be seen, not all the information about each indicator in each company was found in the reports (see empty cells in the table). This happened because GRI guidelines are recommendations; therefore, using these indicators is not mandatory and may be excluded or not considered by the company (Tokos et al., 2012). Following the recommendations of Tokos et al. (2012) and Zhou et al. (2012), to determine the normalization parameter (the benchmark), the maximum value for each CSR indicator was selected, except for parental leave (I_5), female labor force participation (I_{13}), wage gap (I_{14}), and women in executive management positions (I_{15}). Regarding parental leave, none of the analyzed reports offers this data. Then, the maximum was fixed at 1, representing that every man and woman entitled to parental leave, take leave, and return to work to the same or a comparable position, securing, thus, their employment, remuneration, and career path (GRI, 2011). Concerning female labor force participation, the maximum value was 0.48. Therefore, considering that the goal of the EU is to achieve equality between women and men workforce, the normalization parameter was fixed at 0.50 (European Comission, 2016). The wage gap in GRI reports was 0.95. Thus, to achieve equality between women and men workforce, the normalization parameter was fixed as 1.00 (European Commision, 2014). Finally, the maximum of women in executive management positions was 0.36; however, to achieve equality between women and men workforce, the normalization parameter was fixed at 0.50 (European Comission, 2016).

Table 9
CSR indicators clustered according to the national indices.

CSR Indicators clustered	Metric	National index
I''_1: New staff hiring	$I''_1 = I'_1$	V_1: Unemployment rate
I''_2: Temporary contracts	$I''_2 = I'_2$	V_2: Temporary employment
I''_3: Employee turnover	$I''_3 = I'_3$	V_3: Job tenure
I''_4: Benefits	$I''_4 = \frac{1}{2}(I'_4 + I'_5)$	V_4: Public health expenditure
I''_5:Chronic disease	$I''_5 = \frac{1}{4}(I'_6 + I'_7 + I'_{10} + I'_{11})$	V_5: Death rate due to chronic diseases
I''_6:Fatal accidents at work	$I''_6 = \frac{1}{3}(I'_6 + I'_7 + I'_8)$	V_6: Fatal accidents at work
I''_7:Non-fatal injuries at work	$I''_7 = \frac{1}{4}(I'_6 + I'_7 + I'_9 + I'_{11})$	V_7: Non-fatal accidents at work
I''_8:Social value	$I''_8 = I'_{12}$	V_8: Human development index
I''_9:Female labor force participation	$I''_9 = I'_{13}$	V_9: Ratio of female to male labor force participation rate
$''_{10}$:Wage gap	$I''_{10} = I'_{14}$	V_{10}: Ratio of female to male salary
I''_{11}:Women in executive management positions	$I''_{11} = I'_{15}$	V_{11}: Employed women being in managerial positions
I''_{12}:Disabled people	$I''_{12} = I'_{16}$	V_{12}: Unemployment rate of disabled people
I''_{13}:Salary distribution	$I''_{13} = I'_{17}$	V_{13}: Employed persons at-risk-of-poverty rate
I''_{14}:Technical training	$I''_{14} = I'_{18}$	V_{14}: Employed persons participating in job-related non-formal education and training in the past 12 months
I''_{15}:Social ethics, social awareness, and human rights	$I''_{15} = I'_{19}$	V_{15}: Corruption perception index
I''_{16}:Research and Development	$I''_{16} = I'_{20}$	V_{16}: Research and development expenditure

Note: I'_i: normalized CSR indicator.

Since a high number of values were lacking, following the process defined by Montalbán-Domingo et al. (2021), three possible values were assigned to each empty cell: 1.00 (represent the best performance), 0.50 (represent medium performance), and 0.00 (represent the worst performance). The authors selected the Taguchi orthogonal array to calculate the company scenarios. This method reduces the number of scenarios without significantly affecting the outcomes (Mia et al., 2018). The Taguchi orthogonal array design is a general fractional factorial design that allows considering a selected subset of combinations of multiple factors at multiple levels. This method focuses on defining balanced scenarios to ensure that all levels of all factors are considered equally (Narayana et al., 2019). This technique has been widely used in many fields such as physics, management and business, medicine, chemistry, environmental science, etc. (Bolboacă and Jäntschi, 2007). The scenarios of each firm were defined using IBM SPSS Statistics 23.0. Implementing the Taguchi Orthogonal Array, the number of combinations for each firm were: 25 scenarios for firm 1; 49 scenarios for firm 2; 81 scenarios for firm 3; 27 scenarios for firm 4; 49 scenarios for firm 5; 81 scenarios for firm 6; 81 scenarios for firm 7; and, 25 scenarios for firm 8 (see Table 11).

The results are displayed in Fig. 2. As can be seen, all the scenarios of firm 1 are ahead of the rest of the firms. This is because firm 1 is a multinational enterprise (MNE) with high social awareness. This figure shows that the method is valid for comparing construction companies' CSR performances. However, more detail is needed to determine whether the methodology is helpful in comparing SMEs with MNE concerning their performances.

The following task aimed to assess the effort the SME (firm 8) should make to obtain better performances than the MNE (firm 1). To that end, different social measures (SMs) were defined:

- SM A: Firm 8 has one disabled worker in the workforce.
- SM B: Firm 8 gets an OHSAS 18001, ISO45001:2018, or equivalent certificate.
- SM C: Options A and B are satisfied.
- SM D: Firm 8 hires a disabled worker.
- SM E: Firm 8 hires a woman disabled worker.
- SM F: Firm 8 hires a woman disabled worker, and the firm is certified by OHSAS 18001, ISO45001:2018, or equivalent.

These six SMs were compared to both original scenarios of firm 1 and firm 8. The results are shown in Fig. 3. Results demonstrate that the method is valid to compare the CSR performance of construction

Table 10
Normalized CSR indicators for each Spanish construction companies.

CSR indicators (I'_i)	Firm 1 (MNE)	Firm 2 (Large)	Firm 3 (Large)	Firm 4 (Large)	Firm 5 (Large)	Firm 6 (Large)	Firm 7 (Large)	Firm 8 (SME)	Benchmark
I'_1	1.00	0.04	0.28	0.72	0.02	0.15	0.12	0.00	0.35
I'_2	0.75	0.00	0.21	0.67	0.52	0.68	0.64	1.00	0.71
I'_3	0.63	0.54	–	0.00	0.64	0.70	0.80	1.00	0.13
I'_4	–	–	–	–	–	–	–	–	
I_4'	–	1.00	–	0.67	–	–	–	–	0.06
I_5'	–	–	–	–	–	–	–	–	1
I'_5	0.34	–	–	–	–	–	–	0.61	
I_6'	1.54E-03	–	–	4.15E-03	1.7E-03	–	5.30E-04	1.90E-03	4.15E-03
I_7'	1.00	–	–	–	–	–	–	0.00	1.00
I_{10}'	0.04	–	–	–	–	–	–	0.00	0.04
I'_{11}	7.15	2.30	4.03	5.16	–	–	–	0.00	7.15
I'_6	0.79	–	–	–	–	–	–	0.49	
I_6'	1.54E-03	–	–	4.15E-03	1.7E-03	–	5.30E-04	1.90E-03	4.15E-03
I_7'	1.00	–	–	–	–	–	–	0.00	1.00
I'_8	0.00E+00	–	–	1.10E-08	–	1.89E-08	3.65E-08	0.00E+00	3.65E-8
I'_7	0.54	–	–	–	–	–	–	0.61	
I_6'	1.54E-03	–	–	4.15E-03	1.7E-03	–	5.30E-04	1.90E-03	4.15E-03
I_7'	1.00	–	–	–	–	–	–	0.00	1.00
I_9'	3.90	18.56	8.34	20.00	13.50	5.15	2.00	0.00	20.00
I_{11}'	7.15	2.30	4.03	5.16	–	–	–	0.00	7.15
I'_8	–	0.01	–	–	1.00	–	–	–	2.81E-4
I'_9	0.68	0.80	0.26	0.58	0.65	0.95	0.69	0.40	0.50
I'_{10}	0.95	–	–	–	–	–	–	0.91	1.00
I'_{11}	0.61	0.22	0.73	0.58	0.33	–	0.40	0.67	0.50
I'_{12}	1.00	0.85	–	–	0.85	0.85	–	0.00	0.04
I'_{13}	–	–	–	0.00	–	–	–	0.96	28.83
I'_{14}	1.00	0.61	0.28	–	–	–	–	–	840.32
I'_{15}	0.67	1.00	–	–	0.82	–	–	–	4.75E-4
I'_{16}	1.00	0.06	0.13	0.15	0.07	0.11	0.11	0.00	2.70E-2

Note: MNE: multinational enterprise; Large: large enterprise; SME: small and medium-sized enterprise.
CSR indicators: I'_1 : New staff hiring; I'_2 : Temporary contracts; I'_3 : Employee turnover; I'_4 : Benefits; I'_5 :Chronic disease; I'_6 : Fatal accidents at work; I'_7 : Non-fatal injuries at work; I'_8 : Social value; I'_9 : Female labor force participation; I'_{10} : Wage gap; I'_{11} : Women in executive management positions; I'_{12} : Disabled; I'_{13} : Salary distribution; I'_{14} : Technical training; I'_{15} : Social ethics, social awareness and human rights; I'_{16} : Research and Development.
Source: Montalbán-Domingo et al. (2021).

Table 11
Number combinations implementing Taguchi orthogonal array.

	Firm 1	Firm 2	Firm 3	Firm 4	Firm 5	Firm 6	Firm 7	Firm 8
Scenarios	25	49	81	27	49	81	81	25

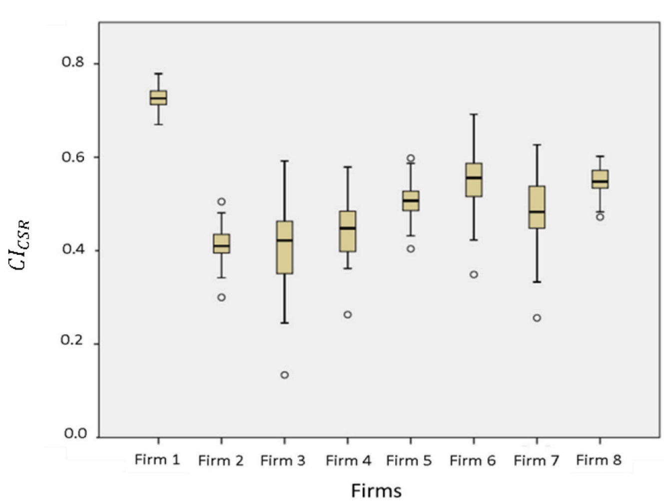

Fig. 2. Corporate social responsibility performance.

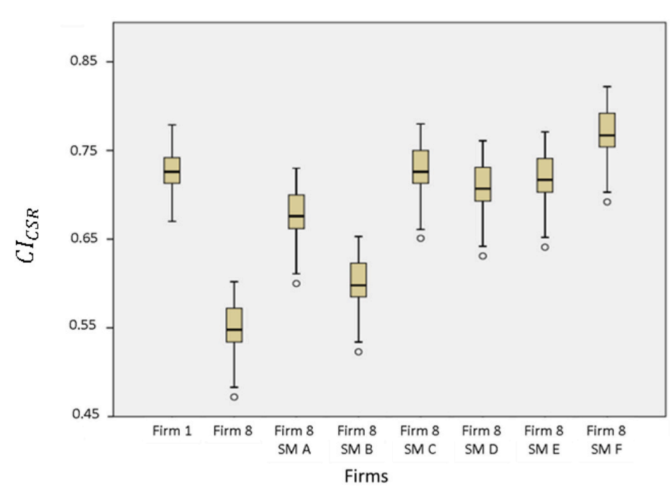

Fig. 3. Social responsibility performance of firm 1 and firm 8 depending on the defined social measures.

companies, regardless of their size, and the social behavior of the construction companies significantly influences their CSR performance results since firm 8 could obtain better results than firm 1, improving its social performance.

6. Discussion

Over time, social considerations have become relevant in public procurement (Sanchez-Graells, 2018). Initially, countries such as the United States of America and Canada defined specific programs based on social goals to promote supplier diversity, involve less-competitive bidders, and create employment opportunities for those workers generally excluded from the labor market. This approach was criticized by the European Union (EU) for years because this type of action created discrimination among economic operators and was, therefore, contrary to full and open competition (Cravero, 2017). However, in 2014, Europe promoted a change concerning the inclusion of social criteria in public procurement. The 2014 directives (Directive 2014/24/EU, Directive 2014/25/EU, and Directive 2014/23/EU) provided an increased scope for contracting authorities to include social considerations in the design and execution of public tenders. Although there has been a switch of direction, if the EU wants to achieve the commitments of the Sustainable Development Goals, more efforts are needed to make public procurement more effective (Eurostat, 2019). Therefore, the current drawbacks have to be overcome since the current public procurement legislation, guidance, and practices in the EU fall short of what is needed to move the different industries towards sustainability (O`Brien et al., 2018).

The construction sector has been criticized for irresponsible practices that harm society and for the need to promote, through public procurement, the curtailment of this harmful behavior and improve the reputation in the area of social responsibility (Olanipekun et al., 2020). CSR reflects the attitude of the company towards its employees, suppliers, contractors, and customers (Krajnc and Glavič, 2005a). Promoting social responsibility for contractors and subcontractors has been claimed to prevent and mitigate negative social impacts in the supply chain and society (CIRIA, 2001; Veleva and Ellenbecker, 2001; Popovic et al., 2018). Thus, implementing CSR practices will add social value to the business (European Commission, 2010). This social value entails enhancing skills and knowledge among the professional community and training and raising community awareness about sustainable development (GRI, 2011; ISI, 2015; Abdel-Raheem and Ramsbottom, 2016). To achieve CSR of construction companies, significant efforts must be addressed to eliminate discrimination (United Nations, 2008a) and promote diversity, equality, and fair wages (GRI, 2016a, 2016b). These actions can directly generate significant benefits for both the workers and organizations (DVFA, 2009; Popovic et al., 2018; United Nations, 2008b) and are essential for guaranteeing stability and prosperity in communities and attracting more skilled, productive, and loyal employees (Popovic et al., 2018). Actions such as promoting the personal development of individual employees can contribute to skills management and to the development of human capital within the organization (GRI, 2016c); and, training of employees reflects in their skills and capabilities, improving their performance and productivity (CIRIA, 2001; Veleva and Ellenbecker, 2001; Popovic et al., 2018).

According to the European Commission (2019), public buyers are responsible for selecting the most appropriate way to include social considerations in a tender. Although public buyers have become aware of the relevance of CSR, they may not know how to include social issues in tendering decisions (Walker et al., 2008). Moreover, contractors perceive social issues in tendering procedures as contractual obstacles due to the high level of subjectivity and uncertainty in the assessment procedure (Murphy and Eadie, 2019). Therefore, defining a composite indicator to assess CSR in public procurement can help public buyers to deal with the complexity of boosting social issues in the construction industry (Montalbán-Domingo et al., 2021). Additionally, it would guide decision-making and new policy guiding instruments to better integrate social issues in the procurement process (Pham et al., 2021). This composite indicator is composed of quantitative indicators since decision-makers need to measure the social progress of companies to know whether they are meeting the goal of social responsibility in the construction industry (Krajnc and Glavič, 2005b; Montalbán-Domingo et al., 2018). These indicators are helpful in assessing the social responsibility of companies, set targets, and help the decision-maker visualize what actions will need to be emphasized in the future (Krajnc and Glavič, 2004).

An important topic for researchers and public buyers is developing tools that help adjust the level of importance of social criteria according to the social shortcomings of each specific context (Iles and Ryall, 2016). The results of this research have demonstrated that each country's social performance can vary significantly (Joint Research Centre-European Commission, 2008); social weaknesses can be identified through the use of national indices and by a cross-country comparison. These results are aligned with previous research Montalbán-Domingo et al. (2020) and Resce and Schiltz (2021), who highlighted the differences in terms of sustainability among European countries.

National indices can be a proxy of indicators defined at the company level; techniques such as DEA-BOD can be helpful in determining the weights of each indicator according to the social needs of each country (Resce and Schiltz, 2021). Through the association between national indices and CSR indicators: (1) public buyers can address the direction of change in the social sustainability of the national industry through public procurement (Cook et al., 2017; Roman, 2017, 2) public buyers can have guidance about the level of importance of each social indicator to maximize the social performance of the country (Montalbán-Domingo et al., 2020); and, (3) the subjectivity within the procurement procedure can be minimized using a transparent decision-making process (Resce and Schiltz, 2021).

In terms of CSR implementation, large construction firms are leading practitioners (Zhang et al., 2022b); however, SMEs tend not to be aware of CSR practices, and do not have the same level of resources to implement it (Tešovičová and Krchová, 2022). SMEs represent most of the population in the construction market (Zhang et al., 2022b), and the European Commission (2010) has claimed that award criteria should not hinder the participation of SMEs in public procurement. In this regard, authors such as Zhang et al. (2022a), Blay Jnr et al. (2022), and Tešovičová and Krchová (2022) highlight that CSR proposals must be defined to guarantee the SME participation. Promoting SMEs in public-works procurement is a need to improve local economies (Walker et al., 2012), and enhancing corporate social awareness and responsibility among SMEs in the construction sector is a crucial aspect of moving the construction sector towards sustainable development (Hossain et al., 2018).

7. Conclusions

This research defines a composite indicator to measure the corporate social responsibility of construction companies in public- procurement. First, quantitative CSR indicators are defined at the company level. Second, national indicators are gathered as proxies of the CSR indicators to determine the weights of the composite indicator depending on the social weaknesses that exist in the country where the contract is procured. The weighting system is based on the DEA-BOD approach; therefore, the level of importance of the social criteria depends on the cross-efficiency of European countries. The results demonstrated that the composite indicator provides a transparent decision-making tool for public buyers to assess and measure social issues objectively. The quantitative indicators will be helpful for companies to evaluate their social performance. Through that knowledge, companies will be able to: (1) identify their social weaknesses and work on them to achieve improved corporate sustainability in both the short and long term; and (2) boost the socio-economic benefits of the construction industry.

Regarding the study limitations, the composite indicator does not include any indicator to assess the social responsibility of subcontractors and suppliers. Subcontractors and supply suppliers can comprise a significant amount of work on specific projects. This information was not included because the quality of this type of data cannot be guaranteed. Future work is needed to establish standard procedures to collect data from subcontractors and suppliers. A second limitation stems from the fact that the national indices have been selected based only on information from European countries. A similar approach could be considered to include other counties in the analysis. It is worth noting that the definition of weights depends on the availability and quality of national indices. Therefore, developing national indices with quality assurance frameworks is essential for measuring countries' social progress. Finally, the simulation has been performed only for Spain and with data from a few construction companies; a broader simulation should be performed previously to implement the method in a real scenario.

Future research should gather information about companies' CSR in the construction industry and develop industry-based national indices to assess social performance in the construction industry. Additionally, implementing social sustainability criteria in public-works procurement may confuse practitioners in specific applications. Therefore, studying the strengths and weaknesses of integrating CSR award criteria in different scenarios would be recommended.

Author statement

This paper represents a result of teamwork. All of the authors jointly worked on the conceptualization, methodology, results, and discussion. Laura Montalbán-Domingo, Tatiana García-Segura, Amalia Sanz-Benlloch, and Cristina Torres-Machi jointly drafted the manuscript. Finally, Eugenio Pellicer and Keith Molenaar reviewed and edited the manuscript. All authors have read and agreed to the published version of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors acknowledge the financial support of the Universitat Politècnica de València (PAID-00-17). The authors are grateful to the expert panel for their participation in this research.

References

Abdella, G.M., Kucukvar, M., Ismail, R., Abdelsalam, A.G., Onat, N.C., Dawoud, O., 2021. A mixed model-based Johnson's relative weights for eco-efficiency assessment: the case for global food consumption. Environ. Impact Assess. Rev. 89, 106588. https://doi.org/10.1016/j.eiar.2021.106588.

Abdel-Raheem, M., Ramsbottom, C., 2016. Factors affecting social sustainability in highway projects in Missouri. Procedia Eng. 145, 548–555. https://doi.org/10.1016/j.proeng.2016.04.043.

Antolín-López, R., Delgado-Ceballos, J., Montiel, I., 2016. Deconstructing corporate sustainability: a comparison of different stakeholder metrics. J. Clean. Prod. 136, 5–17. https://doi.org/10.1016/j.jclepro.2016.01.111.

Aparicio, J., Kapelko, M., 2019. Enhancing the measurement of composite indicators of corporate social performance. Soc. Indic. Res. 144, 807–826. https://doi.org/10.1007/s11205-018-02052-1.

Aparicio, J., Kapelko, M., Monge, J.F., 2020. A well-defined composite indicator: an application to corporate social responsibility. J. Optim. Theory Appl. 186, 299–323. https://doi.org/10.1007/s10957-020-01701-1.

Benini, L., Sala, S., 2016. Uncertainty and sensitivity analysis of normalization factors to methodological assumptions. Int. J. Life Cycle Assess. 21, 224–236. https://doi.org/10.1007/s11367-015-1013-5.

Bhandari, S., Hallowell, M.R., 2021. Identifying and controlling biases in expert-opinion research: guidelines for variations of Delphi, nominal group technique, and focus groups. J. Manag. Eng. 37, 04021015 https://doi.org/10.1061/(asce)me.1943-5479.0000909.

Bianchi, M., del Valle, I., Tapia, C., 2020. Measuring eco-efficiency in European regions: evidence from a territorial perspective. J. Clean. Prod. 276, 123246. https://doi.org/10.1016/j.jclepro.2020.123246.

Blay Jnr., A.V.K., Kukah, A.S.K., Opoku, A., Asiedu, R., 2022. Impact of competitive strategies on achieving the sustainable development goals: context of Ghanaian construction firms. Int. J. Constr. Manag. 0, 1–12. https://doi.org/10.1080/15623599.2022.2048343.

Bolboacă, S.D., Jäntschi, L., 2007. Design of experiments: useful orthogonal arrays for number of experiments from 4 to 16. Entropy 9, 198–232. https://doi.org/10.3390/e9040198.

Brüggen, E., Willems, P., 2009. A critical comparison of offline focus groups, online focus groups and e-Delphi. Int. J. Mark. Res. 51, 363–381. https://doi.org/10.2501/S1470785309200608.

Charnes, A., Cooper, W.W., Rhodes, E., 1978. Measuring the efficiency of decision making units. Eur. J. Oper. Res. 2, 429–444. https://doi.org/10.1016/0377-2217(78)90138-8.

Cherchye, L., Moesen, W., Rogge, N., Van Puyenbroeck, T., 2007. An introduction to "benefit of the doubt" composite indicators. Soc. Indic. Res. 82, 111–145. https://doi.org/10.1007/s11205-006-9029-7.

Cherchye, L., Moesen, W., Rogge, N., Van Puyenbroeck, T., 2008. Knowledge Economy Indicators. Workpackage 5 "Benefit of the Doubt" Composite Indicators. Deliverable 5.3.

CIRIA, 2001. Sustainable Construction Company Indicators. Construction Industry Research and Information Association (CIRIA).

Cook, D., Saviolidis, N.M., Davíðsdóttir, B., Jóhannsdóttir, L., Ólafsson, S., 2017. Measuring countries' environmental sustainability performance—the development of a nation-specific indicator set. Ecol. Indic. 74, 463–478. https://doi.org/10.1016/j.ecolind.2016.12.009.

Cravero, C., 2017. Socially responsible public procurement and set-asides: a comparative analysis of the US, Canada and the EU. Arct. Rev. Law Polit. 8, 174–192. https://doi.org/10.23865/arctic.v8.739.

Dočekalová, M.P., Kocmanová, A., 2016. Composite indicator for measuring corporate sustainability. Ecol. Indic. 61, 612–623. https://doi.org/10.1016/j.ecolind.2015.10.012.

Dolla, T., Laishram, B., 2020. Enhancing sustainability in public-private partnership projects through bid selection model. Transp. Res. Procedia 48, 3896–3907. https://doi.org/10.1016/j.trpro.2020.08.031.

DVFA, 2009. Key Performance Indicators for Environmental, Social and Governance Issues. DVFA. Society of Investment Professionals in Germany, Dreieich, Germany.

European Comission, 2016. Strategic Engagement for Gender Equailty 2016-2019. Publications Office of the European Union, Luxembourg. https://doi.org/10.2838/722771.

European Commision, 2014. Recommendation on Strengthening the Principle of Equal Pay between Men and Women through Transparency (2014/124/EU). Official Journal of the European Union.

European Commission, 2010. Buying Social. A Guide to Taking Account of Social Considerations in Public Procurement. Publications Office of the European Union, Luxembourg doi:978-92-79-18738-4.

European Commission, 2018. Public Procurement Guidance for Practitioners. Publications Office of the European Union, Luxembourg. https://doi.org/10.2776/461701.

European Commission, 2019. Buying for social impact. In: Good Practice from Around the EU. https://doi.org/10.2826/8319.

Eurostat, 2017. Eurostat Database [WWW Document]. URL. https://ec.europa.eu/eurostat/data/database (accessed 10.2.17).

Eurostat, 2019. Sustainable Development in the European Union - Monitoring Report on Progress Towards the SDGs in an EU Context. https://doi.org/10.9774/gleaf.3062.2001.wi.00007.

Falagario, M., Sciancalepore, F., Costantino, N., Pietroforte, R., 2012. Using a DEA-cross efficiency approach in public procurement tenders. Eur. J. Oper. Res. 218, 523–529. https://doi.org/10.1016/j.ejor.2011.10.031.

Flynn, A., 2018. Investigating the implementation of SME-friendly policy in public procurement. Policy Stud. 39, 422–443. https://doi.org/10.1080/01442872.2018.1478406.

Freudenberg, M., 2003. Composite Indicators of Country Performance: A Critical Assessment, OECD Science, Technology and Industry Working Papers, 2003/16. OECD Publishing, Paris. https://doi.org/10.1787/405566708255.

Fukuyama, H., Hashimoto, A., Weber, W.L., 2020. Environmental efficiency, energy efficiency and aggregate well-being of Japanese prefectures. J. Clean. Prod. 271 https://doi.org/10.1016/j.jclepro.2020.122810.

Giambona, F., Vassallo, E., 2014. Composite indicator of social inclusion for European countries. Soc. Indic. Res. 116, 269–293. https://doi.org/10.1007/s11205-013-0274-2.

Goodland, R., 1995. The concept of environmental sustainability. Annu. Rev. Ecol. Syst. 26, 1–24. https://doi.org/10.4324/9781315241951-20.

GRI, 2011. Sustainability Reporting Guidelines. Global Reporting Initiative, Amsterdam, the Netherlands.

GRI, 2016a. GRI 401: Employment. Global Reporting Initiative, Amsterdam, the Netherlands.

GRI, 2016b. GRI 405: Diversity and Equal Opportunity, Global Reporting Initiative. Global Reporting Initiative, Amsterdam, the Netherlands.

GRI, 2016c. GRI 404: Training and Education. Global Reporting Initiative, Amsterdam, the Netherlands.

GRI, 2018. GRI 403: Occupational Health and Safety. Global Reporting Initiative, Amsterdam, the Netherlands.

Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E., 2014. Multivariate Data Analysis. Pearson New International Edition Seventh Edition. Pearson, Harlow,UK.
Hallowell, M.R., Gambatese, J.A., 2010. Qualitative research: application of the delphi method to CEM research. J. Constr. Eng. Manag. 136, 99–107.
Hossain, M.U., Poon, C.S., Dong, Y.H., Lo, I.M., Cheng, J.C., 2018. Development of social sustainability assessment method and a comparative case study on assessing recycled construction materials. Int. J. Life Cycle Assess. 23, 1654–1674. https://doi.org/10.1007/s11367-017-1373-0.
Hutchins, M.J., Richter, J.S., Henry, M.L., Sutherland, J.W., 2019. Development of indicators for the social dimension of sustainability in a U.S. business context. J. Clean. Prod. 212, 687–697. https://doi.org/10.1016/j.jclepro.2018.11.199.
Iles, D., Ryall, P., 2016. How can the United Kingdom construction industry implement sustainable procurement strategies?. In: 32nd Annual ARCOM Conference, 5–7 September 2016, pp. 1121–1130. Manchester, UK.
Illankoon, I.M.C.S., Tam, V.W.Y.T., Le, K.N., 2017. Environmental, economic, and social parameters in international green building rating tools. J. Prof. Issues Eng. Educ. Pract. 143, 05016010 https://doi.org/10.1061/(ASCE)EI.1943-5541.0000313.
ILO, 2017. ILO. International Labour Organization Statistics and Datablases [WWW Document]. URL. https://www.ilo.org/global/statistics-and-databases/lang–en/index.htm (accessed 10.2.17).
ISI, 2015. ENVISION Rating System for Sustainable Infrastructure. Institute for Sustainable Infrastructure, Washington.
Joint Research Centre-European Commission, 2008. Handbook on contructing composite indicators: methodology and user guide. Joint Research Centre (JRC) of the European Commission. OECD publishing. https://doi.org/10.1787/9789264043466-en.
Kaddouri, O., Saussier, S., 2021. CSR communication and firms' ability to win public procurement contracts. Eur. J. Manag. Bus. Econ. https://doi.org/10.1108/EJMBE-06-2021-0173.
Knebel, S., Seele, P., 2021. Framing sustainability in public procurement by typologizing sustainability indicators – the case of Switzerland. J. Public Procure. 21, 119–137. https://doi.org/10.1108/JOPP-09-2020-0066.
Krajnc, D., Glavič, P., 2004. Indicators of Sustainable Production. Technological Choices for Sustainability. Springer, Berlin, Heidelberg. https://doi.org/10.1007/s10098-003-0221-z.
Krajnc, D., Glavič, P., 2005a. How to compare companies on relevant dimensions of sustainability. Ecol. Econ. 55, 551–563. https://doi.org/10.1016/j.ecolecon.2004.12.011.
Krajnc, D., Glavič, P., 2005b. A model for integrated assessment of sustainable development. Resour. Conserv. Recycl. 43, 189–208. https://doi.org/10.1016/j.resconrec.2004.06.002.
Landorf, C., 2011. Evaluating social sustainability in historic urban environments. Int. J. Herit. Stud. 17, 463–477. https://doi.org/10.1080/13527258.2011.563788.
Liao, P.C., Tsenguun, G., Liang, L.W., 2016. Development of social responsibility evaluation framework of construction projects: a multi-stakeholders perspective. Procedia Eng. 145, 234–241. https://doi.org/10.1016/j.proeng.2016.04.068.
Loosemore, M., Alkilani, S.Z., Murphy, R., 2021. The institutional drivers of social procurement implementation in Australian construction projects. Int. J. Proj. Manag. 39, 750–761. https://doi.org/10.1016/j.ijproman.2021.07.002.
Lu, W., Ye, M., Flanagan, R., Ye, K., 2016. Corporate social responsibility disclosures in international construction business: trends and prospects. J. Constr. Eng. Manag. 142, 04015053 https://doi.org/10.1061/(asce)co.1943-7862.0001034.
Mia, M., Dey, P.R., Hossain, M.S., Arafat, M.T., Asaduzzaman, M., Ullah, M.S., Zobaer, S.M.T., 2018. Taguchi S/N based optimization of machining parameters for surface roughness, tool wear and material removal rate in hard turning under MQL cutting condition. Measurement 122, 380–391. https://doi.org/10.1016/j.measurement.2018.02.016.
Mohebali, S., Maghsoudy, S., Ardejani, F.D., 2020. Application of data envelopment analysis in environmental impact assessment of a coal washing plant: a new sustainable approach. Environ. Impact Assess. Rev. 83, 106389. https://doi.org/10.1016/j.eiar.2020.106389.
Montalbán-Domingo, L., Aguilar-Morocho, M., García-Segura, T., Pellicer, E., 2020. Study of social and environmental needs for the selection of sustainable criteria in the procurement of public works. Sustainability 12, 7756. https://doi.org/10.3390/SU12187756.
Montalbán-Domingo, L., García-Segura, T., Sanz, M.A., Pellicer, E., 2018. Social sustainability criteria in public-works procurement: an international perspective. J. Clean. Prod. 198, 1355–1371. https://doi.org/10.1016/j.jclepro.2018.07.083.
Montalbán-Domingo, L., Pellicer, E., García-Segura, T., Sanz-Benlloch, A., 2021. An integrated method for the assessment of social sustainability in public-works procurement. Environ. Impact Assess. Rev. 89, 106581. https://doi.org/10.1016/j.eiar.2021.106581.
Murphy, M., Eadie, R., 2019. Socially responsible procurement: a service innovation for generating employment in construction. Built Environ. Proj. Asset Manag. https://doi.org/10.1108/BEPAM-02-2018-0049.
Narayana, S.A., Pati, R.K., Padhi, S.S., 2019. Market dynamics and reverse logistics for sustainability in the Indian pharmaceuticals industry. J. Clean. Prod. 208, 968–987. https://doi.org/10.1016/j.jclepro.2018.10.171.
Nardo, M., Saisana, M., Saltelli, A., Tarantola, S., 2005. Tools for Composite Indicators Building. Institute for the Protection and Security of the Citizen Econometrics and Statistical Support to Antifraud Unit I-21020 Ispra.
Nikolaou, I.E., Tsalis, T.A., Evangelinos, K.I., 2019. A framework to measure corporate sustainability performance: a strong sustainability-based view of firm. Sustain. Prod. Consum. 18, 1–18. https://doi.org/10.1016/j.spc.2018.10.004.
O'Brien, C.M., Martin-Ortega, O., Conlon, E., 2018. Guidance on Socially Responsible Public Procurement Response to Consultation of the European Commision by the International Learning Lab on Procurement and Human Rights, BHRE Research Series, 5. Policy Paper. July 2018.
OECD, 2017. OECD Data. [WWW Document]. Organ. Econ. Coop. Dev.. URL. https://data.oecd.org/ (accessed 10.2.17).
Olanipekun, A.O., Oshodi, O.S., Darko, A., Omotayo, T., 2020. The state of corporate social responsibility practice in the construction sector. Smart Sustain. Built Environ. 9, 91–111. https://doi.org/10.1108/SASBE-11-2018-0056.
Oliveira, R., Zanella, A., Camanho, A.S., 2020. A temporal progressive analysis of the social performance of mining firms based on a Malmquist index estimated with a benefit-of-the-doubt directional model. J. Clean. Prod. 267, 121807. https://doi.org/10.1016/j.jclepro.2020.121807.
Park, J., Ojiako, U., Williams, T., Chipulu, M., Marshall, A., 2015. Practical tool for assessing best value at the procurement stage of public building projects in Korea. J. Manag. Eng. 31, 06014005 https://doi.org/10.1061/(ASCE)ME.1943-5479.0000337.
Pham, H., Pham, T., Dang, C.N., 2021. Barriers to corporate social responsibility practices in construction and roles of education and government support. Eng. Constr. Archit. Manag. https://doi.org/10.1108/ECAM-03-2020-0199.
Popovic, T., Barbosa-Póvoa, A., Kraslawski, A., Carvalho, A., 2018. Quantitative indicators for social sustainability assessment of supply chains. J. Clean. Prod. 180, 748–768. https://doi.org/10.1016/j.jclepro.2018.01.142.
Rahdari, A.H., Rostamy, A.A.A., 2015. Designing a general set of sustainability indicators at the corporate level. J. Clean. Prod. 108, 757–771. https://doi.org/10.1016/j.jclepro.2015.05.108.
Resce, G., Schiltz, F., 2021. Sustainable development in Europe: a multicriteria decision analysis. Rev. Income Wealth 67, 509–529. https://doi.org/10.1111/roiw.12475.
Roca, L.C., Searcy, C., 2012. An analysis of indicators disclosed in corporate sustainability reports. J. Clean. Prod. 20, 103–118. https://doi.org/10.1016/j.jclepro.2011.08.002.
Rogge, N., 2018. Composite indicators as generalized benefit-of-the-doubt weighted averages. Eur. J. Oper. Res. 267, 381–392. https://doi.org/10.1016/j.ejor.2017.11.048.
Roman, A.V., 2017. Institutionalizing sustainability : a structural equation model of sustainable procurement in US public agencies. J. Clean. Prod. 143, 1048–1059. https://doi.org/10.1016/j.jclepro.2016.12.014.
Ruparathna, R., Hewage, K., 2015. Sustainable procurement in the Canadian construction industry : current practices, drivers and opportunities. J. Clean. Prod. 109, 305–314. https://doi.org/10.1016/j.jclepro.2015.07.007.
Sanchez-Graells, A., 2018. Public procurement and 'core' human rights: a sketch of the EU legal framework. In: Public Procurement and Human Rights. Edward Elgar Publishing, Cheltenham, UK.
Schöttle, A., Arroyo, P., 2017. Comparison of weighting-rating-calculating, best value, and choosing by advantages for bidder selection. J. Constr. Eng. Manag. 143, 05017015 https://doi.org/10.1061/(ASCE)CO.1943-7862.0001342.
Scott, S., Molenaar, K.R., Gransberg, D., Smith, N., 2006. Best-value procurement methods for highway construction projects. In: NCHRP Report 561, NCHRP Report 561. Best-Value Procurement Methods for Highway Construction Projects. National Academies of Sciences, Engineering, and Medicine, Washington DC, USA. https://doi.org/10.17226/13982.
SDG, 2017. The sustainable development goals (SDGs) index. [WWW Document]. In: Sustain. Dev. Solut. network. A Glob. Initiat. United Nations. URL. http://sdgindex.org/ (accessed 10.2.17).
Singh, R.K., Murty, H.R., Gupta, S.K., Dikshit, A.K., 2007. Development of composite sustainability performance index for steel industry. Ecol. Indic. 7, 565–588. https://doi.org/10.1016/j.ecolind.2006.06.004.
Tešovičová, Z.J., Krchová, H., 2022. Implementation of corporate social responsibility environmental actions in comparison of small, medium, and large Enterprises in the Slovak Republic. Sustainability 14, 5712. https://doi.org/10.3390/su14095712.
Tokos, H., Pintarič, Z.N., Krajnc, D., 2012. An integrated sustainability performance assessment and benchmarking of breweries. Clean Techn. Environ. Policy 14, 173–193. https://doi.org/10.1007/s10098-011-0390-0.
UNCSD, 2017. United Nations System. Chief Executives Board for Coordination. Statistics [WWW Document]. URL. https://www.unsceb.org/content/statistics (accessed 10.2.17).
UNEP, 2009. Guidelines for Social Life Cycle Assessment of Products. United Nations Environment Programme, Paris, France doi:DTI/1164/PA.
United Nations, 2008a. Guidance on Corporate Responsibility Indicators in Annual Reports. United Nations Conference on Trade and Development. New York, USA.
United Nations, 2008b. Public procurement as a tool for promoting more sustainable consumption and production patterns. Sustain. Dev. Innov. Brief. (5), 1–12.
Veleva, V., Ellenbecker, M., 2001. Indicators of sustainable production: framework and methodology. J. Clean. Prod. 9, 519–549. https://doi.org/10.1016/S0959-6526(01)00010-5.
Verbunt, P., Rogge, N., 2018. Geometric composite indicators with compromise benefit-of-the-doubt weights. Eur. J. Oper. Res. 264, 388–401. https://doi.org/10.1016/j.ejor.2017.06.061.
Walker, H., Di, L., Mcbain, D., 2008. Drivers and Barriers to Environmental Supply Chain Management Practices : Lessons from the Public and Private Sectors, 14, pp. 69–85. https://doi.org/10.1016/j.pursup.2008.01.007.
Walker, H., Miemczyk, J., Johnsen, T., Spencer, R., 2012. Sustainable procurement: past, present and future. J. Purch. Supply Manag. 18, 201–206. https://doi.org/10.1016/j.pursup.2012.11.003.
World Bank, 2017. World Bank Open Data [WWW Document]. URL. https://data.worldbank.org/ (accessed 10.2.17).

Wu, C.L., Fang, D.P., Liao, P.C., Xue, J.W., Li, Y., Wang, T., 2015. Perception of corporate social responsibility: the case of Chinese international contractors. J. Clean. Prod. 107, 185–194. https://doi.org/10.1016/j.jclepro.2015.04.143.

Wüst, C., Rogge, N., 2021. How is the European Union progressing towards its Europe 2020 Targets? A Benefit-of-the-Doubt Window Analysis, Empirica. Springer US. https://doi.org/10.1007/s10663-021-09528-3.

Xenarios, S., Tziritis, I., 2007. Improving pluralism in multi criteria decision aid approach through focus group technique and content analysis. Ecol. Econ. 62, 692–703. https://doi.org/10.1016/j.ecolecon.2006.08.017.

Xia, B., Olanipekun, A., Chen, Q., Xie, L., Liu, Y., 2018. Conceptualising the state of the art of corporate social responsibility (CSR) in the construction industry and its nexus to sustainable development. J. Clean. Prod. 195, 340–353. https://doi.org/10.1016/j.jclepro.2018.05.157.

Yu, T., Shen, G.Q., Shi, Q., Zheng, H.W., Wang, G., Xu, K., 2017. Evaluating social sustainability of urban housing demolition in Shanghai. China. J. Clean. Prod. 153, 26–40. https://doi.org/10.1016/j.jclepro.2017.03.005.

Zhang, Q., Oo, B.L., Lim, B.T.H., 2020. Corporate social responsibility practices by leading construction firms in China: a case study. Int. J. Constr. Manag. 1–12 https://doi.org/10.1080/15623599.2020.1717107.

Zhang, Q., Oo, B.L., Lim, B.T.H., 2022a. Linking corporate social responsibility (CSR) practices and organizational performance in the construction industry: a resource collaboration network. Resour. Conserv. Recycl. 179, 106113. https://doi.org/10.1016/j.resconrec.2021.106113.

Zhang, Q., Oo, B.L., Lim, B.T.H., 2022b. Key practices and impact factors of corporate social responsibility implementation: evidence from construction firms. Eng. Constr. Archit. Manag. https://doi.org/10.1108/ECAM-11-2020-0973.

Zhao, Z.Y., Zhao, X.J., Davidson, K., Zuo, J., 2012. A corporate social responsibility indicator system for construction enterprises. J. Clean. Prod. 29–30, 277–289. https://doi.org/10.1016/j.jclepro.2011.12.036.

Zhou, H., Yang, Y., Chen, Y., Zhu, J., 2018. Data envelopment analysis application in sustainability: the origins, development and future directions. Eur. J. Oper. Res. 264, 1–16. https://doi.org/10.1016/j.ejor.2017.06.023.

Zhou, L., Tokos, H., Krajnc, D., Yang, Y., 2012. Sustainability performance evaluation in industry by composite sustainability index. Clean Techn. Environ. Policy 14, 789–803. https://doi.org/10.1007/s10098-012-0454-9.

Zhou, P., 2008. Composite indicators in energy and environmental modeling. Ph.D. thesis. National University of Singapore, Singapore.

Zhou, P., Ang, B.W., Poh, K.L., 2007. A mathematical programming approach to constructing composite indicators. Ecol. Econ. 62, 291–297. https://doi.org/10.1016/j.ecolecon.2006.12.020.