Title

Measuring the social responsibility of European companies: a goal programming approach

Abstract

Corporate social responsibility can be measured by a number of different criteria, some of which are similar to each other, while others can be manifestly contrary to the general tendency. This means that some companies can obtain a good valuation in some criteria but a bad valuation in others, which makes it difficult to assess the company's overall corporate social responsibility valuation. It is not easy to find a single measure that covers all aspects of corporate social performance. This paper aims to estimate multicriteria corporate social responsibility performance through different models of goal programming and by taking into account all the dimensions that make up corporate social responsibility. An illustrative example shows the result of applying these models to a database composed of 212 European companies, which enabled us to identify the most socially responsible group, regardless of the approach considered in the construction of the multicriteria performance. The results show that environmental and corporate governance dimensions are the most important elements in measuring this performance.

Keywords

Social behavior; EIRIS; Goal programming; Dimensionality reduction

1. Introduction

The financial crisis of 2008 highlighted the concern and growing interest of society about issues related to Corporate Social Responsibility (CSR). This has led researchers to focus on the analysis of corporate social behavior, and as a consequence a significant number of papers on this subject have recently been published (Aguinis and Glavas, 2012; Eccles et al., 2014; Malik, 2015; Bilbao-Terol et al., 2012; Bilbao-Terol et al., 2013; Gasser et al., 2017).

Igalens and Gond (2005) point out that the diversity of the data sources used to measure social behavior combined with the multitude of theoretical approaches has helped to create confusion on how to properly measure it. The authors confirm that although an attempt has been made to find the best measurement system available for a given definition of the theoretical construct, most studies have been found to include data in a non-systematic way, which means relatively distant approximations to the concept of CSR have been used.

The review of empirical measurements found in the literature raises serious doubts about the accuracy with which they reflect the concept of social performance. This has led several authors to suggest a combination of different measurement systems (Rowley and Berman, 2000). The lack of relevant and accurate data measuring corporate social performance is another limitation of numerous empirical studies, and many of the data and measurement systems used have not been adequately tested.

Wood (2010) maintains that in order to review the methods for the measurement of any variable it is first necessary to take into account the nature of what one wants to measure. This author lists the main topics to be measured by CSR: environmental assessment, stakeholder management, clients and consumers, employees, suppliers, criminal conduct, among others. However, Rowley and Berman (2000) argue that social performance measures composed of several aggregate dimensions are often misused. Those who use them do not usually propose a theoretical model that previously correlates these dimensions with each other. According to the authors, the measurement model can be examined through statistical techniques such as factor analysis, which reduces the dimension of the problem. Instead of using all the possible variables reported by different CSR databases, we should be able to extract the most important and representative of corporate performance.

This paper aims to provide an objective, general and unifying method of measuring CSR by using Goal Programming (GP), a well-established multicriteria technique. This methodology makes it possible to construct models that satisfy conflicting criteria, which in the scope of this study translates into models that allow simultaneous consideration of the different dimensions that make up social responsibility.

A number of studies incorporate social responsibility criteria into the decision-making area, and in some cases GP models are proposed to both design the objective function and the constraints of the decisional problem. Tsai and Hsu (2008) developed a model for operationalizing social responsibility programs for air transport management within the context of constrained physical resources. The authors combine two classical multicriteria techniques: the Analytic Hierarchy Process (AHP) and GP. In a similar way, Tsai et al. (2010) propose an integrated approach to help the hospitality industry to solve the problem of selection decisions and cost evaluation of CSR initiatives. Tsai et al. (2009) propose a novel model which is applied to the case study of a small enterprise. The model

combines the decision making trial and evaluation laboratory method (DEMATEL), Analytic Network Process (ANP) and zero-one Goal Programming (ZOGP) in evaluating socially responsible investment selection procedures. DEMATEL helps companies to identify the most important criterion or the one that affects other criteria the most. ANP helps to determine the priority weights among the alternative stocks, while the ZOGP model helps organizations to use resources without exceeding their constraints

Zhang (2016) considers the economic, environmental and social implications of the tourist industry. A combination of the Analytic Network Process (ANP) and GP is used to determine the relevant variables for the development of tourism in Tibet, simultaneously considering economic, environmental and social goals.

Trenado et al. (2014) formulated a GP model in a portfolio selection scenario in which social responsibility is defined through the introduction of a battery of sustainability indicators. The approach is illustrated by a case study related to the selection of securities in international markets.

Bilbao-Terol et al. (2012) present a Socially Responsible Investment (SRI) model for selecting portfolios when an ethical dimension on financial products is considered. The authors introduce an index called ‘‘SRI-Attractiveness’’ that summarizes the ‘‘social, environmental and ethical performance’’ of each SRI-fund for a particular investor. This index relies on an aggregation process and uses Fuzzy Multi-Criteria Decision-Making techniques. GP is used to handle multiple criteria with flexible targets and constraints. Bilbao-Terol et al. (2013) present the Hedonic Price Method (HPM), which is applied to obtain an evaluation of SRI criteria that is integrated into a multi-objective mathematical programming model. The model works with two financial criteria (expected value of the final wealth and a measure of risk—variance or CVaR) and a new criterion for measuring the social responsibility of the portfolio.

Gasser et al. (2017) revisit Markowitz' portfolio selection theory and propose a model modification that allows a social responsibility measure to be incorporated into the investment decision making process, and not only return and risk expectations. The model enables investors to custom–tailor their asset allocations and incorporate all personal preferences regarding return, risk and social responsibility.

The use of GP in problems related to social responsibility can in some cases be combined with other methodologies. This is the approach followed in the present study, which combines GP with the factor analysis statistical technique to reduce the dimensionality of the data. The proposed models were applied to a database composed of 212 European companies, considering 11 variables to measure social responsibility, after reducing the initial database of 44 CSR variables.

The rest of the paper is organized as follows: Section 2 introduces the most popular databases that report information on social responsibility performance. Section 3 introduces the GP methodology used for the computation of the single measure of social responsibility. Section 4 deals with the EIRIS database, which was used in this work, and details the dimensions of social responsibility considered. Section 5 discusses the results obtained when applying the GP methodology to the data described in Section 4. Finally, the main conclusions reached are given.

2. Measuring CSR

CSR is measured by different specialized organizations that rate the social behavior of firms by considering public information, questionnaires, expert judgments, etc. This section is devoted to introduce some of these rating agencies and the CSR dimensions they measure.

The KLD independent rating service (Kinder, Lydenberg, Domini & Co) is one of the leaders in this field and performs a multidimensional evaluation of social responsibility using different variables related to stakeholders. KLD monitors the behavior of these variables, grouped into different social and environmental dimensions. Its scope of action is broad, although it focuses mainly on the US companies listed in indices such as the Domini 400 Social Index.

One of the main criticisms received by this rating agency is based on the equal weight they give to the different attributes that make up social performance, as it seems logical that not all dimensions should have the same importance (Itkonen, 2003).

The ASSET4 database is a compilation of more than 5,000 companies from publicly available information, including sustainability/CSR reports, firm websites, annual reports, non-governmental organizations, and news of all major providers. The ASSET4 database has a pyramid structure: 400 sub-indicators that are grouped into 10 categories, and these in turn into four pillars: environmental, social, governance and economic performance. ASSET4 provides an overall score composed of the equally weighted pillars.

Vigeo is a specialized CSR rating agency which provides information on the social responsibility of European companies on a scale of 0 to 100. Vigeo has developed the Equitics database, a model based on internationally recognized standards to assess the degree to which companies under review take into account their social responsibility objectives in the definition and deployment of their strategy (Petrillo et al., 2016). This database summarizes social responsibility in 6 dimensions: human rights, human resources, environment, business behavior, corporate governance and community involvement. These 6 global criteria are divided into 17 more specific subcriteria.

EIRIS is a British CSR rating agency of listed companies that provides information for the development of the Financial Times' ethical index, aka FTSE 4 Good. For their analysis, they design a comprehensive questionnaire that is sent to companies and later receives external verification. The database is completed with information made public by the companies themselves in annual reports. On January 2016, EIRIS and Vigeo announced a merger in order to create a single European agency with a global reach. The variables involved in the database will be described below in greater detail, since this database was used in the present work.

As mentioned above, all these databases use different variables to describe CSR (Table 1). Many of these variables are independent of each other, but some variables are closely related to others in the same dimension, and even to other variables in a different dimension. When defining CSR, we may want an overall measure that summarizes the behavior not only in a single dimension but in the whole of its activity. Some databases simply average the total variables to define CSR, which means assuming that all dimensions have the same importance. However, it is clear that this assumption is not supported by any empirical evidence. Other databases give different weights to each dimension based on the judgements made by a panel of experts, and this weighting scheme remains constant regardless of the country, the sector or the year analyzed. However, it is reasonable to think that the weight of the different dimensions may vary

from one country to another, or depend on the sector to which the company belongs, or may even change over time. For example, the importance given by KLD in 1997 to relations with South Africa is no longer relevant. The inclusion of human rights variables could also be questioned, because for many experts this can be a redundant variable, according to the country or region being analyzed. It is for this reason that the relative importance given by a panel of experts may have to be revised, according to the country, the sector, or the time of the research.

[Here Table 1]

The purpose of this paper is thus to form a single overall measure of social responsibility by objectively weighting the different dimensions of which it is composed through a goal programming model. This makes it impossible for a group of experts to subjectively weight each dimension and facilitates the updating of the weights when analyzing a different sector, or when the variables that make up a company's social responsibility change with time.

3. A goal programming approach to summarizing CSR performance in a single measure

Ignizio and Romero (2003) define GP as a multicriteria technique that builds mathematical programming models consisting of linear and/or nonlinear functions, explicitly considering both continuous and discrete variables in which all functions have been transformed into goals.

In this sense, GP can be considered an example of what Simon (Simon, 1979) called 'satisficing': construct satisficing models that provide good enough decisions with a sensible computation cost. Decision makers can satisfice either by finding optimum solutions for a simplified world, or by finding satisfactory solutions for a more realistic world. GP is a realistic alternative to those mathematical models based on a single-objective function, where some constraints are relaxed in order to construct a simplified model and achieve an optimal solution. In general terms, GP can be expressed as an optimization model that minimizes the deviation between the achievement of goals and their aspiration levels. Its basic formulation can be expressed as (1)-(2):

$$Min \quad \sum_{i=1}^{n} |f_i(X) - g_i| \tag{1}$$

$$s.t.$$

$$X \in F \qquad (F \; is \; a \; feasible \; set) \tag{2}$$

where $f_i(X)$ is usually a linear function of the i-th goal and g_i is its aspiration level. Some recent practical applications of GP can be found in Gagnon et al. (2012), Mezghani et al. (2012), García et al. (2013), and Munoz et al. (2016).

Linares and Romero (2002) propose a GP-based methodology that allows the aggregation of individual preferences provided by several social groups towards different criteria in a cardinal manner.

Following this methodology, García et al. (2000a) propose several GP models for constructing firm rankings. These rankings are constructed on several economic and financial variables (performance measures). The aggregation of these variables is accomplished through the GP methodology, which establishes the most appropriate weight for each variable. Instead of ranking the firms by a single criterion, GP enables simultaneously incorporating all the criteria. Since some single-criterion performance measures are usually in conflict, they propose two opposed alternatives for determining multiple-criterion performance: the first is to calculate a consensus performance that reflects the majority trend of the single-criterion measures, and the other is to calculate a performance that is biased towards the measures that show the most discrepancy with the rest. As a compromise solution between the two alternatives, García et al. (2000a) also propose a parametric version to widen the range of possibilities open to the decision maker in such a way that the two previous approaches become particular cases of this compromise model.

Similarly, García et al. (2000b) compare the aforementioned GP models to CRITIC and a modified version of TOPSIS by applying the methodology to two databases of companies proposed by Diakoulaki et al. (1995) and Deng et al. (2000). By using the sum of absolute deviations and the maximum absolute deviation between the multicriteria performance and the single-criterion performances, they conclude that GP solutions dominate the ones obtained by CRITIC and TOPSIS.

In this context, we propose the use of a GP model for measuring CSR performance. The objective is to obtain a single measure of CSR performance (multicriteria CSR), as an aggregation of the different variables that measure each of the dimensions of social responsibility (uni-criterion CSR). As can be seen in Eq. (3), the social responsibility of the i-th company, CSR_i, is obtained as a linear function of the different d dimensions considered as inputs by the model:

$$CSR_i = \sum_{j=1}^{d} w_j csr_{ij} \tag{3}$$

where input csr_{ij} stands for the normalized value of the j-th social responsibility dimension of the i-th company, and w_j stands for the weight of the j-th social responsibility dimension. Our purpose is to objectively determine the w_j weights.

The first GP model (4)-(9) calculates the single multicriteria measure of social responsibility by maximizing the similarity between this unifying measure and the other measures considered as inputs to the model. This model is known as the weighted goal programming model (WGP).

$$Min \quad \sum_{i=1}^{n} \sum_{j=1}^{d} \left(\alpha_j n_{ij} + \beta_j p_{ij}\right) \tag{4}$$

$$s.t.$$

$$\sum_{j=1}^{d} \left(w_j csr_{ij}\right) + n_{ij} - p_{ij} = csr_{ij} \qquad i = 1..n,\ j = 1..d \tag{5}$$

$$\sum_{j=1}^{d} w_j = 1 \tag{6}$$

$$\sum_{j=1}^{d} w_j csr_{ij} = CSR_i \qquad i = 1..n \tag{7}$$

$$\sum_{i=1}^{n}(n_{ij} + p_{ij}) = D_j \qquad j = 1..d \tag{8}$$

$$\sum_{j=1}^{d} D_j = Z \tag{9}$$

where all variables are assumed to be positive and:

$\alpha_j = 1$ if n_{ij} is unwanted, otherwise $\alpha_j = 0$.

$\beta_j = 1$ if p_{ij} is unwanted, otherwise $\beta_j = 0$.

w_j = weight calculated for the j-th criterion.

$n_{ij}(p_{ij})$= negative (positive) deviation variable. It quantifies the difference by excess (deficiency) between the observed CSR performance of the i-th company in the j-th criterion and the estimated multicriteria CSR performance for the j-th criterion. We must bear in mind that some CSR attributes are of the type "the more, the better", implying that only the negative deviation variable must be minimized (Romero, 2004). On the other hand, other attributes are of the type "the less, the better", and in this case the positive deviation variables must be minimized. Both situations are considered through the coefficients α_j and β_j. Only when under as well as over-achievements are unwanted for the dimension analyzed both deviation variables should be included in the achievement equation.

D_j = accounts for the disagreement between the j-th CSR performance and the multicriteria CSR performance. In other words, D_j quantifies the difference between firms in the j-th criterion with respect to the estimated multicriteria CSR.

Z= sum of the overall disagreement.

Eq. (5) is divided into a total of $n \times d$ equations. For each company i, so many equations are created as criteria have been considered to measure social responsibility; that is, d equations. In each of these equations, the company's estimated multicriteria CSR performance is compared to its CSR performance in the j-th criterion. The estimated multicriteria CSR performance is computed as the weighted uni-criterion measures $\sum_{j=1}^{d}(w_j csr_{ij})$, and is summarized as CSR_i in Eq. (7). This value is unique for the company, obtained from the estimated weights w_j. The difference between this value and each of the different d values of the uni-criterion CSR performance, csr_{ij}, is computed by the deviation variables: $n_{ij} - p_{ij}$. That is, $n_{ij} - p_{ij} = csr_{ij} - \sum_{j=1}^{d} w_j csr_{ij} = csr_{ij} - CSR_i$.

Eq. (6) determines that the sum of the weights must be one.

Eqs. (7)-(9) are accounting constraints. Eq. (8) computes D_j for each CSR variable, as the sum of the differences between the estimated multicriteria CSR performance and the uni-criterion CSR performance. A high value in D_j indicates that there is a high degree of disagreement between the j-th CSR criterion and the estimated multicriteria CSR performance. On the other hand, small values indicate that companies' behaviour in that CSR criterion is very close to the global multicriteria CSR performance. Eq. (9) calculates the sum of all disagreements and coincides with the value of the objective function. In this way, a model with a low value of Z indicates that the multicriteria CSR performance is in line with all CSR uni-criterion measures, and a high value means that there are large

differences between the two values. The last situation will occur when uni-criterion measures are very dissimilar to each other.

Our objective is to achieve a unique measure of CSR performance that is in line with the different CSR dimensions used in the analysis, although this will be more complicated when the dimensions are in conflict with each other, so that a high value in one dimension can suppose a low value in another. However, if companies can improve one CSR dimension without worsening the rest, it can be assumed that the multicriteria estimate is aligned with the set of CSR considered dimensions.

Finally, notice that the weights w_j are calculated objectively, with no need for the participation of a group of experts with subjective and (in many cases) discordant opinions about the relevance of each CSR dimension. Note also that in the objective function, all deviation variables have been equally weighted, which should not be understood as meaning that all the variables are equally important, as is verified in the case study.

In (10)-(16) we show another variant of goal programming that allows an alternative approach in the calculation of multicriteria CSR performance.This model is known as the MINMAX or Chebyshev GP model (Romero, 2001), since it precisely minimizes the maximum difference between the multicriteria performance and the uni-criterion performances.

$$Min \quad \mathrm{D} \tag{10}$$

$$s.t.$$

$$\sum_{j=1}^{d}\left(w_j csr_{ij}\right) + n_{ij} - p_{ij} = csr_{ij} \qquad i = 1..n,\ j = 1..d \tag{11}$$

$$\sum_{i=1}^{n}\left(\alpha_j n_{ij} + \beta_j p_{ij}\right) \leq D \qquad j = 1..d \tag{12}$$

$$\sum_{j=1}^{d} w_j = 1 \tag{13}$$

$$\sum_{j=1}^{d} w_j csr_{ij} = CSR_i \qquad i = 1..n \tag{14}$$

$$\sum_{i=1}^{n}\left(n_{ij} + p_{ij}\right) = D_j \qquad j = 1..d \tag{15}$$

$$\sum_{j=1}^{d} D_j = Z \tag{16}$$

where all variables have been previously defined except D:

D = represents the maximum deviation between the multicriteria CSR performance and the uni-criterion CSR performances.

The model (10)-(16) presents only two differences with respect to the previous model. The first is the objective function, in which the maximum deviation D between the multicriteria CSR performance and the different uni-criterion CSR performance is minimized. The second difference is the new constraint (12), which calculates the value of D as the supremum of the sum of deviations for each criterion j. The rest of the constraints remain the same as in the WGP model.

The solutions from both models represent extreme cases in which two contrasting strategies are set against one another, giving an advantage to the general consensus

between uni-criterion CSR performances (WGP) or to the conflicting CSR performance measures (MINMAX GP).

There is an alternative if one is seeking to find a compromise between the WGP model and the MINMAX model: the so-called extended goal programming model (EGP, Romero, 2001) in (17)-(23). The λ parameter enables more balanced solutions between WGP and MINMAX models. This parameter widens the range of alternatives, giving compromise solutions between the extreme cases represented by the WGP and the MINMAX models. Note that $\lambda = 1$ gives the same solution as the WGP model, while $\lambda = 0$ gives the solution of the MINMAX model. Therefore, it can be concluded that the first two models are special cases of the EGP model. The EGP model is defined in Eqs. (17)-(23).

$$Min \;\; \lambda \sum_{i=1}^{n} \sum_{j=1}^{d} \left(\alpha_j n_{ij} + \beta_j p_{ij}\right) + (1-\lambda) D \tag{17}$$

$$s.t.$$

$$\sum_{j=1}^{d} \left(w_j csr_{ij}\right) + n_{ij} - p_{ij} = csr_{ij} \qquad i = 1..n,\ j = 1..d \tag{18}$$

$$\sum_{i=1}^{n} \left(\alpha_j n_{ij} + \beta_j p_{ij}\right) \leq D \qquad j = 1..d \tag{19}$$

$$\sum_{j=1}^{d} w_j = 1 \tag{20}$$

$$\sum_{j=1}^{d} w_j csr_{ij} = CSR_i \qquad i = 1..n \tag{21}$$

$$\sum_{i=1}^{n} \left(n_{ij} + p_{ij}\right) = D_j \qquad j = 1..d \tag{22}$$

$$\sum_{j=1}^{d} D_j = Z \tag{23}$$

An important issue to consider in all the models mentioned above is the need to normalize the variables. It should be taken into account that some CSR variables are binary (yes/no questions), others are expressed on a Likert scale, while others may be integer values between 0 and 100. In a model in which deviations n_{ij} and p_{ij} are considered, this fact would give greater importance to those variables that were expressed on a larger scale. It is precisely to avoid this situation that the variables are normalized so that their value is between 0 and 1, following Eq. (24):

$$csr_{ij}^{*} = \left(csr_j^{max} - csr_{ij}\right) / \left(csr_j^{max} - csr_j^{min}\right) \tag{24}$$

where csr_{ij}^{*} is the normalized value of the j-th CSR criterion in the i-th company; csr_j^{max} is the maximum value of the j-th CSR criterion; and csr_j^{min} is the minimum value of the j-th CSR criterion. This type of normalization is also known as *zero-one normalization* (Tamiz et al., 1998, p. 573)

4. Data base and dimensionality reduction

The EIRIS database, which is based on a methodology certified according to external quality standards was used in the present study. EIRIS offers consistent and comparable data from around 80 different areas related with Environment, Social and Government,

and including management practices, environmental management, bribery and corruption, impacts on climate change, human rights in the production chain, etc. The core of the EIRIS research process begins with the data that companies make public. Segmented questionnaires are then sent to companies in areas where the data published by these companies are not entirely clear. Therefore, a considerable process of dialogue is carried out with a multitude of companies, which are asked to clarify those issues that raise doubts, and to recommend that they improve certain aspects of their process for publishing sustainability information. Each research team has specialists from each of the sectors who review the analysis carried out by their colleagues before publishing. Regarding sources and methods, EIRIS uses other information than that published by the company, to complement and verify this information, such as NGO reports, news reports in the media, as well as information issued by regulatory agencies.

Some of the questions have a dichotomous response (Yes / No), other issues are defined on a whole numerical scale, and others have a Likert-type response of between 3 and 5 possible levels. In addition, there are a number of issues addressed only to UK companies, together with sector-specific issues. Of all the issues, almost 50% are questions in which companies are previously classified according to the EIRIS criteria, depending on their degree of risk or potential impact. The level of response is thus relatively low, although the number of companies is very high.

Our study is limited to European companies in 2011. The number of variables considered is limited, leaving only those with a response rate equal to or greater than 80%. This excludes issues that may be relevant in a specific region or sector, but which hinder the overall analysis of the results. Companies with no response in any of the variables have also been excluded, since the methodology used requires that all cases be complete.

Summarizing all these issues, the database finally employed is composed of 212 European companies and 44 variables. The issues analyzed are classified into different thematic areas: Environment (15 questions), Governance (12 questions), Human rights (3 questions), Stakeholder management (4 questions), Stakeholder employees (7 questions), Stakeholder customers and suppliers (2 questions), Stakeholder community (1 question). Thus, the most represented CSR dimension is Environment, followed by Stakeholders (14 questions in total) and Governance.

It is reasonable to assume that some of these variables are strongly correlated to each other, indicating that they report on the same CSR dimension. In this case it is appropriate to reduce the size of the database by excluding variables that may be considered redundant. If these variables are not excluded, the GP model can find multiple optimal solutions simply by dividing the weight given to one dimension among all the variables that represent it. The reduction of the dimension was carried out through applying factor analysis on the correlation matrix with Varimax rotation, from which a total of 11 factors were extracted. This analysis groups variables highly correlated to each other and with a low correlation with the variables in other factors. The factor analysis was carried out on the correlation matrix of the CSR variables. This makes the result free of scale, but in addition all variables had previously been transformed through a zero-one normalization and does not affect the correlation matrix between the variables.

Table 2 shows the factor loadings of each variable in the extracted factors, as well as the linkage of each of the variables with that factor in which it has the highest factor loading.

[Here Table 2]

The numbers in bold correspond to those with the highest factor loading in absolute value of their corresponding row. Therefore, they report the factor in which the variable has a greater factor loading and thus a greater correlation in absolute terms. Each variable is then assigned to the factor with the highest factor loading: i.e. variables from "How good are the Company's management systems for stakeholders overall?" to "Does the Company derive more than 33% of its turnover from energy intensive manufacturing or processing industries?" are assigned to Factor 1; variables from "Does the Company have an audit committee with a majority of independent non-executive directors?" to "How many of the core elements of corporate governance does the Company have?" are assigned to Factor 2; and so on.

The variables in bold are those that have reported a higher factor loading in its corresponding factor and therefore we consider them to be the best representative of its factor. The variable "How good are the Company's management systems for stakeholders overall?" becomes the representative variable of Factor 1, the variable "Does the Company have an audit committee with a majority of independent non-executive directors?" is the representative for Factor 2, and so on.

The factor analysis on the 44 variables originally considered allowed us to reduce the dimension of the database to 11 variables: those selected as representatives of each of the factors or dimensions in which the database is structured. In Table 3 we summarize the 11 variables we considered in the GP models, each of them collecting the different dimensions that can be considered when evaluating CSR. The dimension that receives the highest representation is Environment, with 6 of the 11 variables. The set is completed with variables related to Governance (3 variables), Stakeholder management (1 variable) and Human rights (1 variable). The last column indicates the sign of the CSR variable. A positive sign means that the variable has a positive impact on CSR – "the more, the better" –, whereas a negative sign corresponds to variables with negative impact on CSR – "the less, the better" –.

[Here Table 3]

5. Results and discussion

This section analyzes the results obtained by applying the goal programming models of Section 3 to the database described in the previous section. In particular, the EGP model was applied because it is a generalization of the WGP and MINIMAX models. In this way, different multicriteria measures of the social responsibility performance are obtained according to whether some criteria are more strongly promoted than others, or whether a greater weight is given to those criteria more convergent with the mean behavior.

The EGP model (17)-(23) was solved for λ values between 0 and 1, which allows the weight w_j of each of the CSR measurements to be obtained in the multicriteria global measure. The estimated weighting vector provides information on the multicriteria CSR_i performance for the companies that compose the sample, which in turn makes it possible to rank firms according to their CSR behavior. The results are summarized in Table 4.

[Here Table 4]

The first row of Table 4 includes the values considered for the parameter λ. The following 11 rows collect the weighting vector assigned to the CSR criteria by the corresponding EGP model.

We can observe how the same weighting vector is obtained from $\lambda = 0$ to $\lambda = 0.4$: 0.67 for V7 and 0.33 for V9. The most important variables for the range $\lambda \in [0, 0.4]$ are thus the manufacture or supply of internationally restricted chemicals, and if the Company separate the roles of chairman and chief executive; i.e. the first variable from the Environment area and the second one from the Governance area. For values $\lambda \in [0.5, 0.6]$ we observe that V7 loses part of its weight in favor of another environmental variable, V8 (manufacture or supply of pesticides), whereas the weight of the Governance area is reinforced: V7 (0.23), V8 (0.07), V9 (0.70).

Therefore, for values $\lambda \in [0, 0.6]$ the most important variables are from the Environmental and the Governance dimensions. It follows that these types of variables are the most discordant with the other variables considered in the model. In other words, these variables can have a valuation that is not in line with the other CSR variables, so that we find companies with a good performance in them and yet are poorly valued in other dimensions and vice versa.

For $\lambda \in [0.7, 0.8]$ a similar behavior is observed. V8 gets a higher weight whereas V9 gets a lower weight. The most heterogeneous weight is for $\lambda \in [0.9, 1.0]$. For example, for $\lambda = 1.0$ the variables involved in the multicriteria CSR performance are the existence of an audit committee with independent non-executive directors (V3, from the Governance dimension), manufacture or supply of PVC or phthalates (V4, from the Environment dimension), the number of countries listed in EIRIS Category A where the Company operates (V5, from the Human Rights dimension), the use of HCFCs in its refrigerators (V6, from the Environment dimension), the manufacture or supply of internationally restricted chemicals (V7, from the Environment dimension), the manufacture or supply of pesticides (V8, from the Environment dimension), the separation of the roles of chairman and chief executive (V9, from the Governance dimension), and the manufacture or supply of products containing ozone-depleting substances (V11, from the Environment dimension). Of all the variables considered in the $\lambda = 1$ model, the one with the highest coefficient is V5, with a weight of 0.41 of the total unit weight. It can be seen how in the case of $\lambda = 1$ the value of the most D_j is the same: 96.96. That is, most of the CSR criteria employed in our model are at the same distance from the estimated multicriteria CSR.

When applying the EGP model to this database it can be seen that the most important criteria in the computation of the multicriteria CSR are those associated with the environmental and governance. It is worth noting that most of the variables related to stakeholders (employees, community, customers and suppliers) or human rights are excluded from these models. However, these should not be interpreted as irrelevant variables, but rather should be considered as variables that in some cases are closely related to other variables that do appear in the model, and therefore the information they provide is already considered by those variables. In other cases they may be variables with low variability, and therefore it can be considered that all the companies have a very similar level in achieving this standard of social behavior. For example, in the question

"Does the Company have policies on maintaining good relations with customers and/or suppliers?", for 193 of the 212 companies the answer was “yes”.

To sum up, if a multicriteria measure of consensus is sought to measure CSR performance, environmental criteria are the most important. This is due in part to the fact that the variables related to this dimension are in the majority in the study. However, if we give greater importance to discordant criteria, those that report on aspects of CSR that are independent of the rest, then criteria related to governance, as well as environmental criteria, come into play.

Figure 1 summarizes the importance of each dimension in the formation of the multicriteria CSR performance for each of the λ values considered. This importance was obtained by means of an OLS regression, where the multicriteria CSR performance was considered the dependent variable, while the uni-criterion measures were used as independent variables. In this way, the relative importance of each dimension was calculated as the percentage of variance explained (adjusted R^2) in each regression. We can observe how the Environmental and Governance dimensions are the most important for $\lambda \in [0, 0.8]$. However, its relative importance slightly decreases when considering models with higher values in λ; i.e. when the models construct the multicriteria CSR by overweighting the most discordant dimensions.

[Here Figure 1]

Taking into account all the above, it is reasonable to assume that the CSR rating obtained by the companies will differ according to the λ value considered in the EGP model. But we can also see whether there are companies that obtain a good CSR performance regardless of this parameter λ. We can therefore define the CSR persistence of companies as that property that makes them obtain a good (or bad) CSR rating regardless of the GP model employed.

Table 5 contains the best and worst companies according to their multicriteria CSR performance. The companies that appear in the best group are those that managed to be among the 20% of companies best positioned in the multicriteria measure of the CSR for every λ value considered. The companies in the worst-qualified group are those that systematically appeared within the group formed by 20% of the companies with the lowest CSR consideration for each of the λ values considered.

[Here Table 5]

5. Conclusions

CSR has been given a major role in recent times by both customers of products or services, suppliers, managers, shareholders, etc. and has made many companies voluntarily publish sustainability reports, or contract external audits to validate their social behavior. Having to report on different dimensions of CSR, it is common to find situations in which a company can be outstanding in the behavior of a certain CSR dimension but deficient in another. This makes it difficult to identify the most socially responsible companies. This work proposes a multicriteria approach to estimate a single overall measure of CSR

performance through goal programming, a methodology which approaches the problem from a novel perspective.

The different models proposed make it possible: 1) to favor those CSR dimensions that are aligned with the central tendency of the other dimensions that define CSR behavior (the weighted goal programming model), 2) to favor those different and singular dimensions (MINMAX or Chebyshev goal programming model), or 3) to reach a compromise solution between the two previous extremes (extended goal programming model). The first two models are special cases of the extended goal programming model.

In this study we used an extended goal programming model to estimate the multicriteria CSR performance of European companies by means of information from the EIRIS database, with a total of 212 companies and 44 indicators on social responsibility. Since many of these indicators were strongly correlated to each other, the dimensions were reduced in number through a factor analysis, in which the initial set of variables were reduced to 11.

From a practical perspective, the work could be used by companies to identify their relative position with respect to others in the field of CSR. It could also indicate the dimensions that could be improved, and how improving some dimensions can influence the simultaneous improvement of others.

Among the limitations of the work, it should be noted that the positioning of companies depends on the parameter used in the multicriteria model. Certainly, some companies have a slightly variable position regarding the choice of this parameter, but others may present a position strongly dependent on this choice. It would also be interesting to be able to apply this model to data other than the EIRIS data. If we had available data from other sources, the model could have been completed with new indicators, so that a sensitivity analysis could have been done. In the same way we must remember that the results were obtained from a single year's analysis. A longitudinal study might have yielded new conclusions.

A future line of research will relate the multicriteria CSR positioning of companies with their financial performance, an issue that has been widely debated in the literature without achieving conclusive results.

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Table 1. How some rating services measure CSR

Rating service	Profile	Main criteria	Subcriteria and indicators	Website
KLD (MSCI)	KLD offers data for 15 years for more than 3,000 US companies. MSCI KLD 400 Social Index is a capitalization weighted index of 400 US securities that provides exposure to companies with outstanding Environmental, Social and Governance ratings, and excludes companies whose products have negative social or environmental impacts.	(9) Community, Corporate governance, Diversity, Employee relations, Environment, Human rights, Product, Quality & safety, Controversial business issues	(112) subcriteria	http://www.msci.com/products/esg/
ASSET4 (Thomson Reuters)	Asset4 provides environmental, social and governance information based on 400 key performance indicators. The database covers more than 5,000 public companies for 15 years.	(4) Environmental, Social, Corporate Governance, Economic	(10) subcriteria and (400) indicators	http://financial.thomsonreuters.com/en/products/data-analytics/company-data/esg-research-data.html
Vigeo-Eiris	The Equitics database regroups the analysis and opinions on listed companies and fixed income issuers (unlisted companies, local authorities, public institutions) in 6 fields of evaluation	(6) Human rights, Human resources, Environment, Business behavior, Corporate governance, Community	(80) subriteria and (330) indicators	http://www.vigeo.com/csr-rating-agency/en/3-1-investisseurs-et-gestionnaires-d-actifs

Table 2. Reduction of the dimension through factor analysis. Factor loadings

	Factors										
Variables	1	2	3	4	5	6	7	8	9	10	11
How good are the Company's management systems for stakeholders overall?	**0.923**	0.105	-0.036	-0.077	0.040	-0.025	0.028	-0.048	-0.028	0.061	0.056
How good are the Company's policies towards its stakeholders overall?	**0.850**	0.009	0.094	-0.005	0.061	-0.001	0.023	-0.041	0.126	-0.152	-0.135
How good is the Company's quantitative reporting on stakeholder relationships?	**0.843**	0.136	-0.049	-0.017	0.081	-0.055	0.001	-0.060	-0.142	0.074	0.112
What level of engagement with stakeholders is disclosed by the Company?	**0.814**	-0.042	-0.005	-0.034	0.050	-0.067	0.070	-0.067	-0.046	0.070	0.046
How clear is the Company's commitment to community or charitable work?	**0.788**	0.070	0.100	-0.058	0.081	-0.011	-0.005	-0.092	-0.004	-0.101	-0.025
How clear is the evidence of systems and practices to support equal opportunities and diversity?	**0.750**	-0.114	-0.219	0.028	0.064	-0.101	0.091	-0.069	-0.209	-0.021	0.023
How clear is the evidence of systems to support employee training and development?	**0.748**	-0.059	-0.056	-0.026	0.042	0.031	-0.062	0.021	-0.069	-0.135	0.025
Does the Company have policies and procedures on bribery and corruption?	**0.737**	0.048	0.039	-0.090	0.110	0.084	0.099	-0.023	0.053	0.330	0.010
How clear is the evidence of health & safety systems?	**0.717**	0.297	0.131	-0.021	0.027	-0.039	-0.041	-0.040	0.028	0.108	-0.002
How good is the Company's policy on equal opportunity and diversity issues?	**0.706**	-0.073	0.078	0.064	0.113	-0.022	0.028	-0.031	-0.007	-0.097	-0.170
How well do the board and senior management address Company-wide ESG risks and opportunities?	**0.693**	0.207	0.147	0.075	0.052	-0.003	-0.139	0.019	-0.060	0.038	-0.082
How clear is the evidence of systems to maintain good relations with customers and/or suppliers?	**0.692**	0.102	-0.107	0.047	0.068	-0.033	0.091	-0.021	0.157	0.032	0.192
Does the Company have a code of ethics and. if so. how comprehensive is it?	**0.600**	-0.086	0.052	-0.087	0.170	-0.031	0.123	-0.032	0.048	0.457	-0.030
How clear is the evidence of systems to manage employee relations?	**0.592**	0.114	-0.268	-0.141	0.074	0.153	-0.136	0.151	-0.313	0.129	0.065
Does the Company have a system for implementing a code of ethics and. if so. how comprehensive is it?	**0.588**	-0.104	-0.051	0.055	0.273	-0.131	0.011	-0.029	-0.018	0.328	-0.039

How clear is the evidence of systems and practices to advance job creation and security?	**0.569**	-0.208	-0.286	0.072	0.106	-0.068	-0.138	0.137	0.091	-0.284	0.078
How many stakeholder issues have been allocated to board members?	**0.552**	0.073	0.077	0.111	-0.024	-0.034	0.130	-0.102	0.361	-0.233	-0.273
Does the Company develop or use renewable energy?	**-0.464**	-0.075	0.371	-0.026	-0.162	0.025	-0.003	-0.067	0.112	0.059	0.016
What potential impact does the Company have on climate change?	0.110	**0.891**	-0.020	-0.038	0.117	-0.023	-0.025	0.057	-0.095	-0.030	-0.018
What potential impact does the Company have on biodiversity?	0.032	**0.883**	0.005	0.055	0.018	-0.126	-0.080	-0.006	-0.138	0.060	0.055
What potential impact does the Company have on the environment?	0.204	**0.861**	-0.048	-0.023	0.102	-0.087	0.017	0.000	0.032	-0.057	0.019
What is the Company's potential exposure to water risk?	-0.053	**0.767**	-0.052	-0.023	0.061	-0.238	0.020	-0.038	0.038	0.079	-0.096
Does the Company derive more than 33% of turnover from energy intensive manufacturing or processing industries?	-0.002	**-0.645**	0.027	0.279	-0.064	-0.241	0.204	0.060	-0.051	-0.033	0.143
Does the Company have an audit committee with a majority of independent non-executive directors?	-0.026	-0.031	**0.879**	-0.010	-0.039	-0.089	0.056	-0.037	-0.020	-0.022	-0.016
Are more than 33% of the Company board independent non-executives?	0.038	-0.007	**0.852**	-0.006	0.032	0.005	0.022	-0.019	-0.086	-0.067	-0.069
How many of the core elements of corporate governance does the Company have?	-0.012	-0.076	**0.842**	-0.018	-0.034	-0.081	-0.019	0.011	0.391	-0.025	0.094
Does the Company manufacture or supply PVC or phthalates?	-0.001	-0.036	-0.034	**0.958**	0.000	0.150	-0.024	-0.053	0.022	-0.019	-0.028
Does the Company manufacture or supply ozone-depleting substances?	-0.001	-0.036	-0.034	**0.958**	0.000	0.150	-0.024	-0.053	0.022	-0.019	-0.028
Does the Company manufacture or supply chemicals subject to NGO campaigns?	-0.051	-0.136	0.054	**0.701**	-0.003	-0.021	0.225	0.447	-0.101	0.002	0.038
In how many countries listed in EIRIS Category A does the Company have operations?	0.254	0.119	-0.084	0.010	**0.886**	-0.099	0.061	-0.106	0.028	0.105	-0.053
In how many countries listed in EIRIS Category B does the Company have operations?	0.308	0.094	-0.105	-0.001	**0.826**	-0.110	0.060	-0.113	0.060	0.143	-0.127
Does the Company have operations in Burma?	-0.048	-0.038	-0.007	0.004	**-0.734**	-0.064	0.029	-0.049	0.062	0.160	-0.059
Is the Company operating in tropical regions in activities which involve or are likely to involve tropical forest clearance?	-0.091	-0.200	-0.104	0.002	**-0.468**	-0.158	0.002	-0.062	0.341	-0.002	-0.082

Does the Company still use HCFCs in its refrigeration equipment? (Europe only including UK)	-0.081	-0.126	-0.085	0.133	0.008	**0.883**	0.082	-0.023	-0.026	-0.051	0.069
Does the Company still use CFCs in its refrigeration equipment? (Europe only including UK)	-0.078	-0.189	-0.053	0.166	-0.008	**0.875**	-0.069	0.000	-0.004	-0.014	0.080
Does the Company manufacture or supply internationally restricted chemicals (UNEP 12. OSPAR Priority List)?	-0.043	-0.158	0.034	0.035	0.058	-0.039	**0.873**	0.061	-0.077	-0.030	0.066
Does the Company manufacture or supply chemicals of concern?	-0.071	-0.163	-0.019	0.423	0.039	-0.026	**0.700**	0.482	-0.084	-0.049	0.046
Does the Company have policies on maintaining good relations with customers and/or suppliers?	0.334	0.041	0.086	-0.081	-0.002	0.067	**0.544**	-0.124	0.075	0.015	-0.105
Does the Company disclose the remuneration of its directors?	0.156	-0.187	0.162	0.047	0.061	-0.200	**-0.230**	0.037	-0.119	-0.089	0.200
Does the Company manufacture or supply pesticides?	-0.070	-0.053	-0.058	0.053	-0.009	-0.098	0.082	**0.844**	-0.063	-0.034	0.012
How many of the Company's directors are women?	0.209	-0.153	0.029	0.051	0.124	-0.179	0.098	**-0.514**	-0.286	-0.013	0.168
Does the Company separate the roles of chairman and chief executive?	-0.058	-0.086	0.137	-0.035	-0.053	0.015	-0.053	0.049	**0.858**	0.075	0.154
What is the level of potential exposure to bribery issues?	0.268	0.291	0.001	-0.109	0.269	0.159	-0.115	0.168	0.034	**0.567**	-0.019
Has this Company granted options open to all employees worth over 3% of the company's share value?	-0.181	-0.033	-0.178	0.061	-0.271	-0.188	-0.018	-0.145	0.036	**0.550**	-0.014
Does the Company manufacture or supply products containing ozone depleting substances?	-0.025	-0.082	-0.026	-0.026	-0.036	0.138	0.007	-0.065	0.117	-0.027	**0.863**

Table 3. CSR variables selected for the goal programming models

Factor	CSR question (Variable number)	CSR Area	Wanted (+) / Unwanted (-)
1	How good are the Company's management systems for stakeholders overall? (V1)	Stakeholders Management	+
2	What potential impact does the Company have on climate change? (V2)	Environment	-
3	Does the Company have an audit committee with a majority of independent non-executive directors? (V3)	Governance	+
4	Does the Company manufacture or supply PVC or phthalates? (V4)	Environment	-
5	In how many countries listed in EIRIS Category A does the Company have operations? (V5)	Human Rights	-
6	Does the Company still use HCFCs in its refrigeration equipment? (Europe only including UK) (V6)	Environment	-
7	Does the Company manufacture or supply internationally restricted chemicals (UNEP 12. OSPAR Priority List)? (V7)	Environment	-
8	Does the Company manufacture or supply pesticides? (V8)	Environment	-
9	Does the Company separate the roles of chairman and chief executive? (V9)	Governance	+
10	What is the level of potential exposure to bribery issues? (V10)	Governance	-
11	Does the Company manufacture or supply products containing ozone depleting substances? (V11)	Environment	-

Table 4. Results of the EGP model for the companies in the sample

Lambda		0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Weights	V1	0	0	0	0	0	0	0	0	0	0.15	0
	V2	0	0	0	0	0	0	0	0	0	0.22	0
	V3	0	0	0	0	0	0	0	0	0	0.08	0.10
	V4	0	0	0	0	0	0	0	0	0	0.01	0.05
	V5	0	0	0	0	0	0	0	0	0	0	0.41
	V6	0	0	0	0	0	0	0	0	0	0	0.08
	V7	0.67	0.67	0.67	0.67	0.67	0.23	0.23	0.23	0.23	0.05	0.11
	V8	0	0	0	0	0	0.07	0.07	0.10	0.33	0.03	0.08
	V9	0.33	0.33	0.33	0.33	0.33	0.70	0.70	0.67	0.43	0	0.11
	V10	0	0	0	0	0	0	0	0	0	0.42	0
	V11	0	0	0	0	0	0	0	0	0	0.04	0.06
Deviations	D1	87.67	87.67	87.67	87.67	87.67	89.12	89.12	88.4	85.68	56.45	72.74
	D2	148.67	148.67	148.67	148.67	148.67	147.86	147.86	146.87	142.28	71.71	89.37
	D3	60.33	60.33	60.33	60.33	60.33	61.08	61.08	59.53	62.72	98.12	96.96
	D4	51.67	51.67	51.67	51.67	51.67	53.94	53.94	59.00	56.39	95.93	96.96
	D5	177.40	177.40	177.40	177.40	177.40	176.26	176.26	175.93	173.68	100.07	96.96
	D6	47.00	47.00	47.00	47.00	47.00	48.88	48.88	49.07	50.39	96.66	96.96
	D7	12.33	12.33	12.33	12.33	12.33	28.70	28.70	28.87	30.03	100.07	96.96
	D8	43.67	43.67	43.67	43.67	43.67	42.85	42.85	41.27	40.17	96.44	96.96
	D9	24.67	24.67	24.67	24.67	24.67	11.81	11.81	13.40	24.52	100.07	96.96
	D10	97.33	97.33	97.33	97.33	97.33	95.25	95.25	94.40	89.48	32.74	96.96
	D11	44.33	44.33	44.33	44.33	44.33	41.01	41.01	41.20	42.99	100.07	96.96
Z		795.07	795.07	795.07	795.07	795.07	796.77	796.77	797.93	798.32	948.35	1,034.76
D		177.40	177.40	177.40	177.40	177.40	176.26	176.26	175.93	173.68	100.07	96.96

Note: Values have been rounded to two digits

Table 5. CSR persistence of companies. The best and worst positioned companies in terms of CSR

Best CSR performance	Worst CSR performance
International Ferro Metals	Vp
Allied Gold Mining (UK)	The Imprint Group
Alcatel-Lucent	Bolsas y Mercados Espa0les
Assa Abloy	DCC
AstraZeneca	Domino Printing Sciences
Boskalis Westminster	Galenica
Bourbon	Fuller Smith & Turner
Gemalto	Gecina
International Consolidated Airlines Group (Spain)	Photo-Me International
International Consolidated Airlines Group (UK)	Wilmington Group
Lonmin (UK)	
World Resources	
Saipem	
Schneider Electric	
Sika	
Vestas Wind Systems	

Figure 1. Percent of variance explained for the multicriteria CSR by the CSR dimensions