A Robust Sustainability Assessment for SMEs Based on Multicriteria Decision Aiding

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Abstract. Developing sustainable business standards for small and medium-sized enterprises (SMEs), entailing targets such as the minimization of carbon emissions, the promotion of equality and transparency in business processes, is key to achieve transition towards a greener economy. In light of the challenges in implementing and embedding sustainability practices in small firms, we consider the problem of evaluating the environmental, social, and governance (ESG) performance of listed European SMEs, w.r.t. different sustainability indicators, using a multicriteria decision analysis (MCDA) approach. Due to lack of agreement over the 'true' ESG metrics of firms discussed in the literature, we depart from the practice of constructing a composite indicator based on a sorting of firms, and we assess the stability of the results when the parameters of the preference model are uncertain. Moreover, with the aim of identifying possible sector-specific differences, the sustainability performance is gauged with reference to five economic sectors, based on a unique dataset of SMEs.

Keywords: ESG · Small and medium-sized enterprises (SMEs) · Multiple criteria Decision Analysis · Sustainability

1 Introduction

The sustainability assessment is becoming nowadays the crux of policies aiming at enforcing minimum Environmental, Social, and Governance (ESG) requirements, as sustainability measures may suffer from inconsistency of the data and how they are reported: existing ESG ratings from prominent data providers tend to disagree significantly on the very definition of sustainability drivers [2]. Such difficulties are compounded by the size of small and medium enterprises, which (i) deal with business data in an unstructured and non-standardised way, especially w.r.t. supply chain management [8], or (ii) may have little interest in managing their ESG performance [7], making the operationalization of sustainability practices difficult.

This contribution investigates the problem of sustainability assessment for small and medium enterprises, by using a multicriteria decision analysis (MCDA)

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approach, which allows us to deal flexibly with the multiple, conflicting targets that must be managed when pursuing sustainability. We specifically take care of the size of the involved firms, by selecting twelve indicators ad hoc, which reflect in a parsimonious way many relevant dimensions towards which we expect SMEs should direct their efforts in terms of sustainability goals. In this analysis, rather than constructing a standard composite indicator derived from the aggregation of different dimensions, we evaluate probabilistically the attained rankings, based on rank acceptability and pairwise winning indices, following the stochastic multiacceptability analysis (SMAA) approach [6]. The rank acceptability index gives the probability that, randomly picking a set of parameters, a given firm attains a specific rank, whereas the pairwise winning indices specify the probability that a firm attains a better rank than another. In this way, the outcomes are evaluated in a robust way. The analysis is carried out for five different economic sectors, so as to uncover possible elements where progress on sustainability performance is still uncertain or unstable, with particular attention to best and worst performers within each sector. The rest of the contribution is organized as follows. In Sect. 2 we outline the methodology, then in Sect. 3 we present the data and the empirical application. Section 4 concludes.

2 A Multicriteria Ranking Method for Sustainability Assessment

In what follows, we consider a setting with m alternatives to be assessed w.r.t. n conflicting criteria. The problem is modelled through the MUlticriteria RAnking MEthod (MURAME) approach of [5], which consists in a combination of ELECTRE III and PROMETHEE II outranking methods. We refer to [1] for a detailed discussion of the model, in the context of sustainability assessment. To implement the SMAA, we follow the general framework provided in [6], which is here adapted to the peculiarities of the MURAME approach, in order to construct rank acceptability and pairwise winning indices, allowing to investigate how the ranking of the alternatives varies according to different sets of criteria parameters.

The preferences of a decision maker are integrated in the model by introducing, for any given criterion c_j, with $j = 1, \ldots, n$, an indifference threshold, q_j, a preference threshold p_j and a veto threshold v_j, for which it holds that $q_j \leq p_j \leq v_j$. The main idea of SMAA is to employ Monte Carlo simulation to visit the parameters' spaces, in order to provide the decision makers with values describing the problem, and to perform a parameter stability analysis. Let W and Q, P, V denote the spaces for the feasible weights and the thresholds, respectively, defined as follows:

$$W = \left\{ \mathbf{w} : w_j \geq 0, \sum_{j=1}^{m} w_i = 1 \right\} \qquad Q = \left\{ \mathbf{q} : 0 \leq q_j \leq p_j \right\}$$

$$P = \left\{ \mathbf{p} : q_j \leq p_j \leq v_j \right\} \qquad V = \left\{ \mathbf{v} : p_j \leq v_j \leq 1 \right\}$$

Moreover, let f_w, f_q, f_p and f_v be the probability distributions over these spaces, ranging in the feasible spaces W, Q, P and V. The choice of the distributions depends on whether the decision maker can express definite information about the shape of the distribution of such parameters or not. For simplicity, in our application we assume uniform distributions for each criterion weights and thresholds. To construct a ranking function, which maps the alternative i to a rank h, according to a set of simulated parameters, we perform a Monte Carlo simulation.

We aim to construct the ranking acceptability and the pairwise winning indices that handle possible robustness concerns w.r.t. the stability of the results, so as to give a probabilistic interpretation of the results. We proceed as follows. First, a function $K(i, w, q, p, v) = h$, providing the rank h of a firm i, for a given simulation of parameters, is considered. To derive the two indices, the ranking functions $m_h^i(i, w, q, p, v)$ and $p_h^i(i, k, w, q, p, v)$, taking either value 1 or 0, are constructed:

$$m_h^i(i, w, q, p, v) = \begin{cases} 1, & \text{if} \quad K(i, w, q, p, v) = h \\ 0, & \quad \text{otherwise} \end{cases}$$

$$p_h^i(i, k, w, q, p, v) = \begin{cases} 1, & \text{if} \quad K(i, w, q, p, v) < K(k, w, q, p, v) \\ 0, & \quad \text{otherwise} \end{cases}$$

Essentially, the ranking function $m_h^i(i, w, q, p, v)$ is equal to 1 if the firm i is assigned to a specific rank h; moreover, $p^i(i, k, w, q, p, v)$ is equal to 1 if firm i has a better (lower) rank compared to k. Finally, the rank acceptability index $C_h^i \in [0, 1]$ and the pairwise winning index $P^i \in [0, 1]$ provide a probabilistic classification of alternatives over possible rankings, i.e. respectively the probability that a rank h is assigned to alternative i and the probability that the alternative i is better than alternative k. Mathematically, both are multidimensional integrals over the parameter spaces, which can be estimated numerically via Monte Carlo simulation (see e.g. the formulation in [4]).

3 Application and Discussion of Results

For the empirical analysis, we consider a unique hand-collected dataset of 78 firms for the year 2021, based on a screening we perform to obtain a set of listed SMEs, adequately reporting on sustainability topics. The analysis is performed for firms belonging to Consumer Discretionary (CD), Health Care (HC), Financials (F), Industrials (I) and Information Technology (IT) classes, on a sector-by-sector basis[1]. Other sectors are not included due to lack of data. Furthermore, the selected criteria are aligned to Global Reporting Initiative Standards and include carbon intensity, waste generation intensity, non-renewable electricity

[1] 10 firms belong to CD, 12 to F, 13 to HC, 16 to IT and 27 to I. For a detailed analysis of the dataset, along with information for its replication, we refer the reader to [1].

consumption, water consumption intensity, average training hours, job creation, management diversity by gender, gender pay gap, board diversity by gender, economic value generation and distribution, board independence and the CEO pay ratio. Moreover, assuming that underreporting implies unwillingness or inability to report information, missing data are replaced with the worst value of the sector. Finally, the acceptability and the pairwise winning indices are obtained by performing $n = 100,000$ simulations over the feasible regions specified in Sect. 2.

Table 1. Category acceptability indices by sector.

	Best			
	ESG	E	S	G
CD	0.7224	0.7281	1	0.7283
F	0.7014	1	1	0.9089
HC	0.4739	0.6145	0.6157	0.9997
I	0.9998	1	0.7463	0.9264
IT	0.8708	1	0.5108	0.7853

(a) Probabilities that the best-classified firm of a sector for a combination of ESG or E, S, G criteria does not change its rank.

	Worst			
	ESG	E	S	G
CD	1	1	0.9999	1
F	0.9986	1	1	0.9959
HC	0.9998	1	1	0.9997
I	0.9992	0.9760	1	0.9614
IT	1	0.9312	0.7746	0.5898

(b) Probabilities that the worst-classified firm of a sector for a combination of ESG or E, S, G criteria does not change its rank.

The rank acceptability indices are reported in Tables 1a and 1b, with respect to the ESG performance, along with stand-alone Environmental, Social and Governance components. An important aspect that we observe in the data is that, even when taking into account uncertainty in the evaluation of SME's sustainability performance, the assessments of best and worst firms, i.e. the probabilities that the ranks of the best or the worst firms remain the same across different preferences of a decision maker, such as a policymaker or a credit officer, are robust across all sectors.

When the scores are gauged only w.r.t. specific E, S or G pillars, the outcomes remain stable. Such findings are important when considering the ESG performance of firms, in light of the uncertainty surrounding its measurement, as shown by the lack of agreement between ESG scores from different data providers, with important implications in terms of investor preferences and ultimately, asset prices [3]. Turning to a selection of acceptability and pairwise indices w.r.t. firms in the CD sector, results points to high stability of preferences of good alternatives over poor ones, as shown in Figs. 1 and 2. In the former, we show that little to no variability is observed for most firms, and variation typically occurs within three notches of the ranking. In the latter, the pairwise winning indices are presented. Note that substantial divergence between alternatives emerge in most cases, and in a particular case, a firm is actually preferred over all the alternatives in the dataset. Unreported results[2] for the remaining

[2] Available upon request.

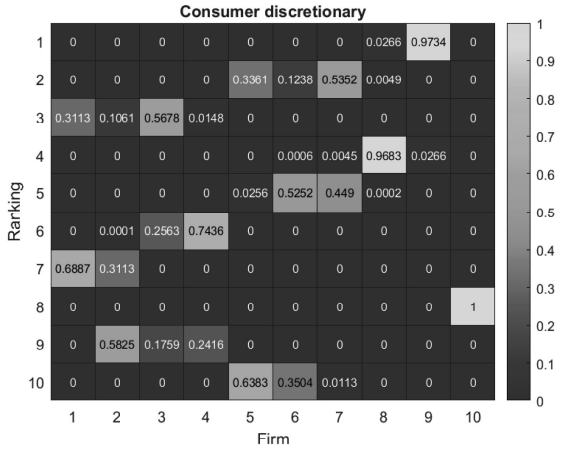

Fig. 1. Category acceptability indices for CD firms. A high percentage implies that the firm is assigned to the corresponding ranking with a high confidence, based on the share of possible parameter values for a given ranking. A low ranking with a high probability should be interpreted as a positive signal about a firm.

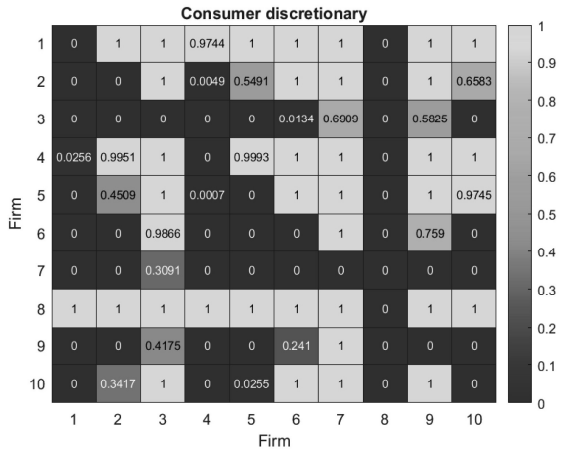

Fig. 2. Pairwise winning indices for CD firms. A high percentage implies that the firm on row i outperforms the firm on column j with a high confidence, based on the share of possible parameter values for a given simulation.

sectors, similarly show that the best firms tend to be picked over poorly performing ones with little uncertainty as well; less accurate assignments for firms with an average performance are observed. Such patterns might suggest that there are no sector-specific ESG reporting practices requiring deeper analysis.

4 Conclusions

In this paper, we have modelled the ESG scoring problem through a combination of an outranking approach and stochastic multiacceptability analysis, to capture the sustainability performance in a probabilistic way. Results confirm the robustness of the methodology, paving the way to more extensive analysis, covering the relationship between ESG performance and financial risk in SMEs.

Disclaimer

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