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AN INTEGRATED MODEL FOR SUPPORTING AWARE DECISIONS OF COMPANIES IN A CIRCULAR AND SUSTAINABLE ECONOMY TRANSITION*

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Abstract

The world of business is rapidly changing, not only thanks to digitization and technological transformation, but also to address challenges related to the environment and climate change, and to reduce its impact in terms of waste, emissions, and raw materials. The COVID-19 crisis and the European Green New Deal have also accelerated this transformation process. In this context, companies must be able to evaluate their commitment and contribution to sustainable development, and to adopt lower impact business models. To achieve this aim, companies need easy and accessible measurement tools. The tools currently available are based on quantitative or statistical approaches and require the process of large amounts of data. This approach is easily accessible to large companies, while small companies or craft businesses may be scared off, as they may lack the structures and expertise. This study fills this gap by presenting an innovative and easy-to-access methodology for assessing sustainability in companies. Through a qualitative assessment of interdependence among nine categories grouping multiple environmental, social, and governance indicators, companies can evaluate their impact on the 17 SDGs and on the 3 ESG dimensions. The result can be used by the companies to design strategies for their businesses and plan future actions to improve circular models, thanks to the awareness and benefits gained from the analysis. The methodology has been applied to the case study of Ohoskin.

Keywords: sustainability, decision support systems, circular economy, ESG, SDG

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1. Introduction

Nowadays companies operate in a changing and challenging world. While on the one hand there is the need to pursue a lasting profit and ensure satisfactory economic survival, on the other hand companies cannot ignore the necessity to protect our planet and the economic system requires to be changed accordingly (Lacy and Rutqvist, 2016). In this metamorphosis, sustainability, digitalization, and intelligent technological transformation are the three main trending drivers. Finally, the market environment is also changing in terms of what consumers are looking for. Indeed, it is clear that they seek sustainable products and services, and they are sensitive to the sustainable behavior of companies on environmental, social and governance issues (Buerke et al., 2016). Therefore, sustainability is now an essential factor for any company offering products or services.

Since the third industrial revolution, the linear economic model, based on the logic of "take, make and dispose", has led to growth and prosperity, improving the living conditions of millions of people; however, some critical issues are currently present. The unsustainability of this economic model has been widely reported, as it conflicts with nature's prosperity and jeopardizes human survival and quality of life (Andrews, 2015; Jørgensen and Pedersen, 2018; Sariatli, 2017). Additionally, the COVID-19 pandemic has highlighted the necessity to change the economic paradigm. Never as in the last year we have been able to "*reflect and understand how necessary is to rethink the economy, in an attitude of greater proximity to the resources that the territories can give, aimed at reducing waste, to manage energy and materials more efficiently, to recover what can be recovered, to develop synergies and symbiosis between supply chains, industries and businesses*" (Bompan and Brambilla, 2021).

In the ongoing transformation, we are rethinking our economy, shifting from the linear to the circular economic model. Circular economy is based on the idea of restoration and regeneration, that is economic activities should strengthen rather than break down social and environmental resources (McDonough and Braungart, 2010). In the circular model, products and services are designed considering their relationships with resources and environment, so that their life cycle will make them returning matter and energy. In this way it is possible to reactivate a new life cycle without using new resources or expending energy for disposal. In the circular economy model the concept of waste disappears since they become new resources (secondary raw materials), closing the supply chain loop (Jawahir and Bradley, 2016; Jørgensen and Pedersen, 2018). Moreover, from the point of view of the companies, the circular economy model can contrast resource depletion, reduce pollution, and represents a source of cost reductions, new revenue streams and better risk management (Jørgensen and Pedersen, 2018).

In this framework, companies should be able to evaluate their commitment and contribution to sustainable development and adopt lower impact business models. Suitable measurement tools represent a helpful and useful way to reach this aim. Currently, the available tools, such as Life Cycle Assessment (LCA), SDG Action Manager and Cradle to Cradle (C2C), involve quantitative or statistical approaches and are usually accessible to large companies, as they require the processing of large amounts of data (Hauschild et al., 2018; McDonough and Braungart, 2010). Therefore, small companies or craft businesses may be scared off, as they may lack money, structure, and expertise to afford such measurement tools.

In this paper we present an innovative and easy-access methodology to evaluate sustainability in companies. Through a qualitative assessment of interdependence among nine categories grouping multiple environmental, social, and governance indicators, companies can assess their impact on the 17 Sustainable Development Goals (SDGs) and on the three Environmental, Social and Governance (ESG) dimensions. Our approach is grounded on a model-based decision support system (DSS) (Fabbri et al., 2011; Fei et al., 2009), for business management strategic initiatives and (Casini et al., 2009; Casini et al., 2015; Viaroli et al., 2012), for management of environmental ecosystems) having the SDGs framework, the Global Reporting Initiative (GRI) standard and indicators from the United Nations and the World Health Organization as knowledge base. More specifically, we use the Sparse Analytical Hierarchy Process (SAHP) method, which represents a novel and flexible instrument for the decision taking task, when only partial information on the problem is available.

2. Materials and methods

The assessment on sustainability reported in this paper is carried out through a methodology based on system thinking approach which helps us to analyze the complexity and delicate balance of the socio-political and natural ecosystems in which our businesses operate (Raworth, 2020). The method is based on the view of economic systems as complex systems (Arthur, 1999, 2015); more specifically, a company is viewed as a combination of human, technical resources, production processes and relationships working together to carry out a specific activity.

Standing in contrast to positivist and reductionist thinking, system thinking analyzes the linkages and the interactions between the elements that comprise the whole of the system. The approach is based on the belief that each single element of the complex system will act differently when isolated from the system's environment or other parts of the system (Senge, 2006; Stalter et al., 2016).

The evaluation process directly involves the managers of the companies and is based on an in-depth interview. The objective of the interview is to analyze the whole company by focusing on three macro areas: Corporate, Processes and Products, Relations. Approaching this process with a proper system thinking method allows us to find a list of identity labels for each macro area.

The next sections report the entire structure of the process.

2.1. Structure of the evaluation process

Moebeus (https://www.moebeus.com), an innovative start-up and benefit corporation which promotes circular economy models, has developed a dedicated web application to support the evaluator throughout the entire assessment process. Fig. 1 reports the functional diagram describing the software implementation.

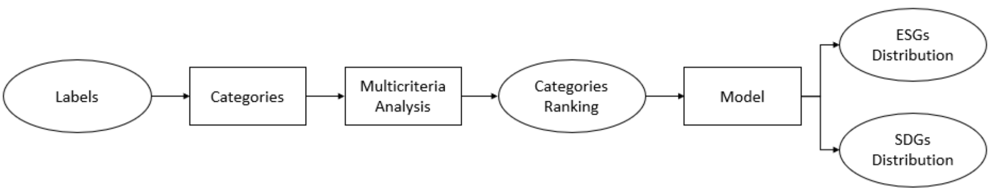

Fig. 1. Software functional diagram

As a first step, the labels identified through the analysis of the Company's corporate context are used as the business' knowledge base and distributed on a set of nine categories (see paragraph 2.1.1) representing themes and issues investigated by SDGs and GRI. This phase deeply involves interviewees, so that they are empowered in the evaluation of the current and potential value of the company's sustainability. In the next stage of the evaluation process, a self-assessment questionnaire is administered: the interviewees are asked to give a qualitative assessment by comparing selected pairs of categories. Then, multicriteria analysis is applied to rank the categories based on their utility/importance. The output of this phase is used as input for the model that will give the final distribution of companies' sustainable impact on SDGs and ESGs.

2.1.1. Categories

The first block of the evaluation process represents the set of categories used for the analysis. GRI standards and a set of indicators from the United Nations and the World Health Organization reported in SDG Compass (https://sdgcompass.org) have been analyzed and divided into nine clusters with respect to sustainability, ethics, and business issues they deal with. The resulting clusters were associated with 9 categories defined according to the literature (Ivanova et al., 2020), namely: Energy, Emissions, Waste, Infrastructures, Product, Social Ethics, Education, Governance, Environment.

By definition of the problem and from the structure of the data reported in SDG Compass (https://sdgcompass.org), it is easy to define a category as:

$$CAT_n = \{BT_{n,1},\ BT_{n,2}, \ldots BT_{n,m_n}\}, \qquad with\ 1 \le n \le N,\ N = 9, \tag{1}$$

where CAT_n is the set of all m_n Business Themes covered by Category *n*. Notice that Business Themes in CAT_n are not covered by any other categories.

Categories are used as alternatives in the multicriteria analysis.

2.1.2. Multicriteria analysis

The final scope of a multicriteria analysis method is the ranking and selection of the available alternatives based on their preference value. Additionally, to the scientific meaning, the multicriteria approach consists with a political exercise of negotiation and trade-off among necessarily subjective values and beliefs, which makes the direct involvement of end-users mandatory to reach meaningful and practical results.

In a real case, the ranking associated with an alternative might be unknown or difficult to determine directly. Indeed, it is often necessary to infer the intrinsic value of each alternative based on information about the relative importance of pairs of alternatives (i.e., if an alternative A has greater utility than B and B has greater utility than C then A has greater utility than C). The solution to this problem can be achieved by using specific decision-making tools implementing multicriteria analysis methods. Additionally, the number of pairwise comparisons among alternatives can be very high, and the assessment may require several times to be completed, or it can be difficult to measure the relative importance of certain couples of heterogeneous categories.

In the process object of this paper, we use the Sparse Analytic Hierarchy Process (SAHP) (Menci et al., 2018; Oliva et al., 2017; Oliva et al., 2018), a sparse and distributed approach to the centralized decision making AHP introduced by Saaty (1997). In particular, it is applied as an effective tool to make decisions when multiple and conflicting criteria are present. Both qualitative and quantitative aspects of a decision need to be considered and in scenarios characterized by partial information and local/distributed computing and decision-making capabilities (Oliva et al., 2017; Saaty, 1980). Indeed, SAHP extends the standards AHP method by accounting for situation where there is a lack of information, i.e., not all the pairwise comparisons are available due to their high number or to difficulty to compare heterogeneous categories.

Let's consider a set of *n* alternatives, each characterized by an unknown utility or relevance $w_i > 0$. In order to compute the value of such utilities, we start by creating a *pairwise comparison matrix* **S**. The matrix **S** is a $n \times n$ real matrix, where *n* is the number of alternatives considered. Each entry s_{ij} of the matrix **S** represents the importance of the *i*th alternative relative to the *j*th alternative, namely:

$$s_{ij} = \frac{wi}{wj} \qquad (2)$$

If $s_{ij} > 1$, then the *i*th alternative is more important than the *j*th alternative, while if $s_{ij} < 1$, then the *i*th alternative is less important than the *j*th alternative. If two alternatives have the same importance, then the entry s_{ij} is 1. The entries s_{ij} and s_{ji} satisfy the following constraint:

$$s_{ij} \cdot s_{ji} = 1 \qquad (3)$$

Obviously, $s_{ii} = 1$ for all *i*. The relative importance between two alternatives is measured according to a numerical scale from 1 to 9, as shown in Table 1, where it is assumed that the *i*th alternative is equally or more important than the *j*th alternative. The phrases in the “Interpretation” column of Table 1 are only suggestive and may be used to translate the decision maker’s qualitative evaluations of the relative importance between two alternatives into numbers. It is also possible to assign intermediate values which do not correspond to a precise interpretation. According to equation 3, the entries of matrix **S** are by construction pairwise consistent. On the other hand, the ratings are unknown and should be estimated.

Table 1. Table of relative scores used for pairwise comparisons

Value of s_{ij}	***Interpretation***
1	*i* and *j* are equally important
3	*i* is slightly more important than *j*
5	*i* is more important than *j*
7	*i* is decisively more important than *j*
9	*i* is absolutely more important than *j*

The original AHP method consists in a way to compute the weights of the alternatives given the comparison matrix **S**. The problem can be easily solved by computing the dominant eigenvector of the matrix (Saaty, 1977).

Unfortunately, in a real context, as the number of alternatives grows, the data collection procedure may require a nontrivial effort and it becomes harder and harder to obtain complete information (Saaty, 1977; Liang et al., 2008). For this reason, we adopt the SAHP method that is able to deal with sparse information. In other words, instead of knowing the complete information on all pairwise comparison, we know only some decision maker’s qualitative evaluations related to some alternatives, which lead to a sparse matrix **S**. If the comparison between *i* and *j* is not available, then s_{ij} is set equal to 0.

To solve the SAHP problem we use the sparse logarithmic least squares (SLLS) method (Menci et al., 2018; Oliva et al., 2018). With the SLLS algorithm we find a logarithmic least squares approximation $\hat{w}$ of the unknown utility vector w, such that:

$$\hat{w} = arg\ min_{q \in \mathbb{R}_+^n} \left\{ \sum_{i=1}^{n} \sum_{j=1}^{n} s_{ij} \left(ln(s_{ij}) - ln\left(\frac{q_i}{q_j}\right) \right)^2 \right\} \qquad (4)$$

In the case of $s_{ij} = 0$, the value of the corresponding summand $0\ln(0)$ is taken to be zero which is consistent with the limit:

$$\lim_{x \to 0^+} x \ln(x) = 0 \qquad (5)$$

This leads to the final ranking of alternatives.

2.1.3. Model

The evaluated ranking of available categories is then used as input for the model in order to retrieve the weights that the sustainability-oriented actions the company performs have on ESGs and SDGs.

Let's define the set of SDGs as $\mathrm{SDG} = \{SDG_1, SDG_2, \dots SDG_Z\}$, where $Z = 17$. From data structure reported in SDG Compass (https://sdgcompass.org), we can associate to each $BT_{n,i}$ a subset $SDG_{n,i} \subset SDG$. Using the definition of category reported in Equation 1 it is possible to build a directed acyclic graph $G = \{V, E\}$, reported in Figure 2, which allows us to map categories into SDGs.

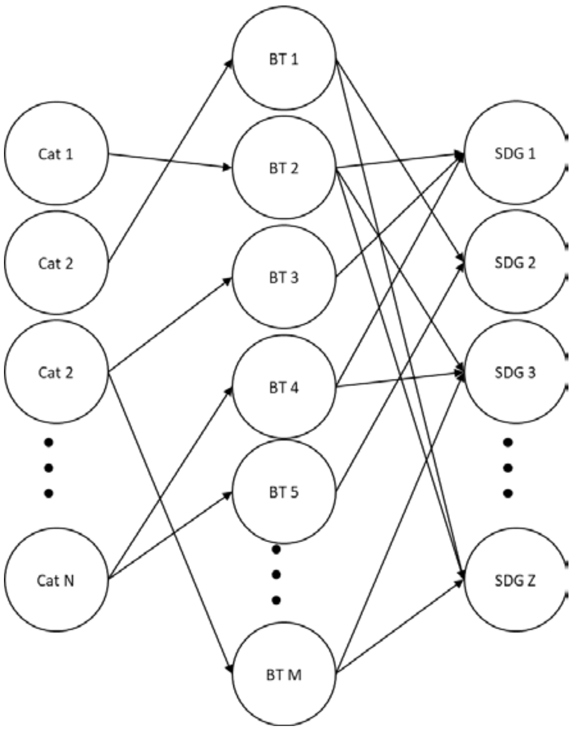

Fig. 2. Structure of the network

Each category CAT_n can be represented by a node of the graph. From the definition of category reported in Equation 1, we introduce m_n outgoing edges from CAT_n to all its elements $BT_{n,i}$, also represented as nodes of the graph. Additionally, from each $BT_{n,i}$ starts a certain number of outgoing edges towards the elements of $SDG_{n,i}$, which are also nodes of the graph. From the graph theory we can easily note that categories are the sources (i.e. the number of in-going links, represented by the in degree $\delta^{in}(CAT_i)$, is equal to zero), Business Themes represent the middle layer and SDGs are the sinks (i.e. the number of out-going links, represented by the out degree $\delta^{out}(SDG_i)$, is equal to zero) of the network defined on the graph. The defined network can be used to propagate the category weights $WCAT = [WCAT_1, WCAT_2 \dots, WCAT_N]$, obtained as output of the multicriteria analysis, to SDGs by defining the weights of the nodes as follows:

$$WBT_{n,i} = WCAT_n, \quad \forall\, i = 1, \dots m_n \tag{6}$$

$$\widehat{WSDG}_j = \sum_{BT_{n,i} \in n^{in}(SDG_j)} WBT_{n,i}, \quad \forall\, j = 1, \dots Z \tag{7}$$

$$WSDG_j = \frac{\widehat{WSDG}_j}{\sum_{z=1}^{Z} \widehat{WSDG}_Z}, \quad \forall\, j = 1, \dots Z, \tag{8}$$

where $N^{in}(SDG_j)$ represents the in-neighbors of node SDG_j (i.e., the set of nodes with outgoing edges toward SDG_j).

This leads to a ranking for SDGs, which represents the distribution of companies' sustainable impact on SDGs. Equation 8 is used to normalize between 0 and 1 all the weights associated to each SDG.

Finally, to obtain the ranking of the ESGs, the map reported in (Berenberg, 2018) has been used, by assuming that the SDGs are associated to the three ESGs factors. Following this association, the weight of each ESG can be easily calculated as the average of the weights included into the SDGs.

3. Case study

Ohoskin (https://www.ohoskin.com) is an Italian startup that has developed and patented a made-in-Italy, cruelty-free, sustainable alternative to quality leather made with oranges and cacti. The vision of the company is to become the new circular-economy landmark for an ethical, sustainable, and guilt-free luxury. Ohoskin works from the design stage to create a sustainable product, protect the environment, and generate a circular economy without waste. Thanks to chemical, system design and agrotechnical skills, Ohoskin is able to transform by-products of the squeezing of oranges and cacti from the food and cosmetic industry into a biopolymer. The leather is then obtained by adding a phthalate-free PVC to the biopolymer to extend the life cycle of the product.

The goal of Ohoskin is to ensure a sustainable model of production and consumption, which encourages lasting, inclusive, and sustainable economic growth, enhancing the value of typical Sicilian products. This is obtained also thanks to the alliance with other Italian companies operating in chemical, system design, and agrotech industries and through the implementation of a circular business model that gives new life to what would otherwise be destined to waste.

5. Results and discussion

In order to evaluate Ohoskin's positioning on ESGs dimensions and its contribution in achieving SDGs, the entire evaluation process described in Section 2 has been applied. At first, an in-depth interview was conducted: the three macro areas, Corporate, Processes/Products and Relations, were analyzed and discussed with company's managers. This first step of our evaluation process led to the definition of the main identity labels which have been used as a useful knowledge base for the self-assessment questionnaire. The evaluation of interdependence performed through the Moebeus' web application led to the following pairwise comparison matrix (9):

$$S = \begin{pmatrix} 1 & 1/5 & 1/5 & 5 & 1/7 & 0 & 0 & 0 & 1/7 \\ 5 & 1 & 1/3 & 5 & 1/3 & 3 & 1 & 5 & 1/3 \\ 5 & 3 & 1 & 7 & 1/3 & 3 & 1 & 5 & 1 \\ 1/5 & 1/5 & 1/7 & 1 & 1/7 & 0 & 0 & 0 & 1/5 \\ 7 & 3 & 3 & 7 & 1 & 3 & 1 & 5 & 1 \\ 0 & 1/3 & 1/3 & 0 & 1/3 & 1 & 1 & 1/3 & 0 \\ 0 & 1 & 1 & 0 & 1 & 1 & 1 & 3 & 0 \\ 0 & 1/5 & 1/5 & 0 & 1/5 & 3 & 1/3 & 1 & 0 \\ 7 & 3 & 1 & 5 & 1 & 0 & 0 & 0 & 1 \end{pmatrix} \quad (9)$$

Solving the SAHP problem by using the SLLS method reported in Equation 4 led to the following ranking of categories (10):

$$WCAT = \begin{pmatrix} Energy \\ Emissions \\ Waste \\ Infrastructures \\ Product \\ Social\ Ethics \\ Education \\ Governance \\ Environment \end{pmatrix} = \begin{pmatrix} 0.0384 \\ 0.1136 \\ 0.1701 \\ 0.0224 \\ 0.2255 \\ 0.05 \\ 0.1249 \\ 0.0465 \\ 0.2085 \end{pmatrix} \quad (10)$$

This result is used in Equations 6, 7 and 8 to obtain SDGs and ESGs rankings, according to Fig. 3. The results show that Ohoskin is a company which has a more relevant contribution to the environmental dimension than to the social and the governance ones. From our evaluation process, it is clear that the main SDGs impacted by Ohoskin are: 15 - “Life on land”, 6 - “Clean water and sanitation”, 12 - “Responsible consumption and production”, 8 - “Decent work and Economic growth” and 13 - “Climate action”. Figure 2 highlights also all the identity labels impacting the three ESG dimensions and the effects they have on the major SDGs. Moreover, Ohoskin shows a good propensity towards Environmental (39%) and Social issues (36%), and a good, although slightly lower, interest for Governance topics (25%). Overall, the company exhibits a well-balanced distribution on the ESGs, thus certifying its ability to correctly allocate resources on the relevant sectors analyzed in this work.

These results were discussed and validated with company’s managers, who confirmed the validity of the results obtained as they are in line with Ohoskin sustainable objectives. Thanks to our evaluation process, Ohoskin has gained a clearer understanding and awareness of the value of its product and of its contribution to promote sustainable development. Considering this new information, Ohoskin is now able to provide to its customers qualitative insights into the product as well as the ethical and social commitment of the company.

Moreover, identifying the labels that mostly impact on ESGs and SDGs can help Ohoskin to design strategies and to plan future actions to improve its circular business models in terms of both efficiency and eco-design of processes.

Fig. 3. Case study results: identity labels and ESG, SDG ratings

4. Concluding remarks

Moebeus' innovative evaluation method is an important and powerful tool for any company to acquire greater self-awareness regarding the principles of sustainable development and the transition to the circular economy. Through the identification of the distribution on ESGs and the contribution on the SDGs, the company itself acquires a new perspective of development and growth. Moreover, it can identify strategies to be implemented in order to improve its efficiency and effectiveness and to respond more competitively to the current market, while at the same time, ensuring the environmental sustainability. This change of perspective can give back to the company identification of the advantages and opportunities that the circular economy offers.

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