MANUFACTURING COMPANIES' SUSTAINABILITY PROFILE: IDENTIFICATION BASED ON MULTIPLE CORRESPONDENCE ANALYSIS

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Abstract: *Addressing manufacturing companies sustainability issue can be seen as a fine balance between environmental resilience, humans and financial net benefits. In the literature, the issue of organizational sustainability is analyzed extensively, but still unclear and debatable. Hence, it's very difficult to evaluate organizational sustainability, given the lack of consensus on addressing this issue. The paper purpose is to improve the manufacturing company's sustainability evaluation process. Using multiple correspondence analysis on a final sample of 30 large companies (listed on Bucharest Stock Exchange) from Romania, the research results consist in identifying a manufacturing company sustainable profile.*
Key words: *manufacturing companies sustainability approach, sustainability profile, Multiple Correspondence Analysis, statistical analysis, methodology.*

1. INTRODUCTION

Companies' sustainability can be characterized as participative issue of all organizational parties [1], that consider environmental performance, human resource and net benefits to be synergic correlated [2].

In literature, companies' sustainability issue is analyzed extensively but still debatable and even confusing. Hence, it's very difficult to evaluate organizational sustainability, given the lack of consensus on addressing this issue [2-4].

The companies' sustainability concept has recently gained a great momentum in the literature and many efforts in defining its meaning have been made. However, there is no generally accepted definition for organizational sustainability; as a result, several terms were suggested such as: corporate sustainability, CSR, organizational stakeholding, corporate citizenship, and so on [5,6].

Van Marrewijk consider relatively similar the corporate sustainability and corporate social responsibility concepts base on triple-bottom-line approach. Also, the financial or non-financial organizational component approach represents another important issue associated to sustainability debate. Hence, certain researches have focused on different case studies associated with organizational sustainability, where environmental and social efforts represent a way of improving the company's financial performance [6-8].

The multitude of organizational sustainability assessment methodologies, presented in the literature, is mainly due to the varia definitions associated with sustainable development (for e.g.: environmental sustainability, corporate citizenship, ecological efficiency, triple-bottom-line, and so on), because they have been transferred from the sustainability general concept (Brundtland reports - the UN Conference on "Environment and Development", and respectively from other milestones associated with sustainability) [6].

Hence, in the case of manufacturing companies' sustainability, the evaluation approach, must be based on indicators set [9] that can allow an easy monitoring and analysis [10] of a variational business reality. The evaluation process, as stated by Phillis and Kouikoglou [11], must define the border between sustainability and non-sustainability, associated with a wide range of

indicators that are difficult (e.g., collinearity) to aggregate.

The paper purpose is to improve the manufacturing company's sustainability evaluation process. Using multiple correspondence analysis on a final sample of 30 large companies (listed on Bucharest Stock Exchange) from Romania, the research results consist in identifying a manufacturing company sustainable profile.

2. SUSTAINABILITY THEORETHICAL FRAMEWORK

2.1 Sustainability concept

A new paradigm was established in 1987 when the "Brundtland report" (WCED, 1987) introduced the concept of "sustainable development". Sustainable development address current development but without compromising the future generation's ability to meet their own needs.

This approach / definition is based on: (i) "needs" - associated to human population, and (ii) limitations idea - environment ability to meet present and future necessities, taking into account the technological and social context [12]. In table 1, an evolution associated with the sustainability concept definition can be observed with references mentioned in 3rd column.

Transition to sustainable production and consumption is recognized as one of the great challenges associated with sustainability and thus specific methodologies are necessary to (i) diagnostic the current situation; (ii) operate scenarios; (iii) identify solutions. Increasing demand various resources has led to depletion, environmental negative impact and climate change [12].

2.2 Companies sustainability dimensions

Literature presents three major dimensions associated to companies'/ organizations sustainability, namely: economic, social and environmental – which are presented synthetically in table 2 [2,4].

Table 1

The concept of sustainability – associated definitions [13].

Terminology	Definition	Reference
Sustaincentrism	Sustainable development components: *1.* inclusiveness; *2.* connectivity; *3.* equity; *4.* prudence; and *5.* security.	[14]
Ecological sustainability	Associated mechanisms: *1.* total environmental quality management; *2.* sustainable and competitive ecological strategies; *3.* technological swaps for nature; *4.* corporate control of the impact on the population.	[15]
Sustainable development	Brundtland definition could be characterized as a slogan; sustainable development implies ethnocentric - managerial efficiency.	[16]
Sustainable corporate development	Based on three principles: *1.* economic prosperity; *2.* social equity; and *3.* environmental integrity	[17]
Sustainability	Building a society in which economic, social and environmental objectives are balanced. For organizations, this involves economic development, shareholder value, reputation, good relationships with customers and quality.	[18]
Sustainable development	One of the three key strategic capabilities in the natural resource-based vision (along with pollution prevention and product management); evolved into two distinct areas: clean technology as the basis of pyramid schemes	[19]
Sustainable organization	Organization whose characteristics and actions are designed to drive a "desired future" for all stakeholders	[20]
Sustainable enterprise	Sustainable development is the process of achieving human development in an inclusive, connected, equitable, prudent and secure manner	[21]
Sustainability	Firms must integrate six perspectives: *1.* compliance with regulations; *2.* incremental mitigation; *3.* value alignment; *4.* designing the entire system; *5.* business model innovation and *6.* mission transformation	[22]
Sustainability	Firms must focus on human and physical resources	[23]

Sustainability	Based on the GRI [Global Reporting Initiative] framework, sustainability not only encompasses aspects such as philanthropy and pollution, but also a wide range of social, environmental and governance indicators	[24]

Table 2

Dimensions associated with companies/ organizational sustainability [2,4].

No.	Dimension	Subdimension
1	Economic	Financial net benefits Efficiency Government relations Suppliers' management Marketing management Innovation management Ethics Risk management Employee motivation
2	Social	Human resource programs Health and safety Human rights Philanthropy Voluntary work programs Quality management Local engagement Sustainable consumption Product liability Consumer management
3	Environ-mental	Energy consumption reduction Row materials management Water management Climate change Waste management Pollution Biodiversity Product management EMS Transport and distribution Green suppliers Environmental reporting Environmental regulation compliance Environmental risk

2.3 Sustainability measurement initiatives

Over time many initiatives have been proposed to measure sustainability. Considering (i) the approach of sustainability dimensions, (ii) a spectrum as wide as possible, and (iii) the relative balance of the initiative or orientation, the following are considered to be representative [25]: (i) Sustainable indicators – developed by the Commission for Sustainable Development; United Nations in 1995; the main objective was to make these specific indicators accessible to decision makers;

(ii) Sustainability Scoreboard – developed in 1998 by the Advisory Group for Sustainable Development Indicators;

(iii) Sustainability Barometer – developed by the World Conservation Institute; the barometer measures sustainability at a local, regional or national level through a scale of human and environmental well-being performance;

(iv) Sustainability Rating System – indicators set developed with the purpose to measure process industries sustainable performance (triple-bottom-line);

(v) Global Reporting Initiative (GRI) – is a reporting voluntary scheme associated to sustainability performance issue;

(vi) Triple Bottom Line Index (TBL) – represents an aggregate index that evaluates organizations sustainability performance; sustainability is considered to be the balance between financial growth, ecological and ethical improvement associated to capital;

(vii) Dow Jones Sustainability Index (DJSI) – established in '99 to evaluate corporate sustainability performance associated to top 10% firms in Dow Jones Global Index;

(viii) ETHOS Corporate Social Responsibility Indicators – presents indicators set launched in 2002 with the aim of helping Brazilian companies "learn and evaluate the organization management in terms of social responsibility practices, business strategy and overall performance monitoring associated to the company ".

Regardless dimensions and aspects number associated to organizational sustainability evaluation process, two types of methodological approaches can be identified [4,6]:

(I) approaches that consider certain basic indicators. Related to this type, the following limitations can be listed: (i) measuring an organization or a specific sector; (ii) measuring various definitions associated to organizational sustainability and each aspect of sustainability; (iii) lack of well-defined indicators; (iv) undefine standardization techniques; (v) measuring small output indicators (outcomes) with process (operational) indicators; (vi)

absence of representative indicators and even the lack of specific indicators associated to organizational sustainability;

(II) approaches that consider composite indices associated with organizational sustainability. Related to this type, the following limitations can be listed: (i) composite indices can be subjective because they use unsystematic and unclear ways to include or exclude certain indicators; (ii) measurement complexity and aggregation problem; a better overall score of an index associated with organizational sustainability will generate an induced effect on one of sustainability dimensions performance; (iii) the fuzzy techniques used to transform the results into normalized and common units, may have a certain subjectivity degree; (iv) assigning the importance degree associated to the factors necessary to integrate the indicators in the final composite index. Likewise, additional disadvantage associated with composite indices is the free substitutability between organizational sustainability dimensions.

2.4 Companies sustainability assessment approach

Analyzing the literature, it can be observed that the different constructs for measuring organizational sustainability have a non-homogeneous and relatively particular character.

In many cases only one dimension/ structural component of sustainability is evaluated; e.g. [6]: Delmas and Blass [26] consider the environmental dimension and focus on environmental factors, using associated indicators. Hutchins and Sutherland [27] and Wood [28] consider the social dimension by measuring ethical and social aspects of organizational sustainability such as equity, health, education and human rights. Schaltegger and his collaborator's [8] consider the economic dimension and consequently focus on organizations seeking to develop/ maximize assets through social and environmental strategies.

Other scholars [2,29,30] measure two or more dimensions associated with organizational sustainability by developing instrumental models, indicators and statistical correlations. Nikolaou and his collaborators [6] specify the fact that regardless of the number of dimensions

and aspects of organizational sustainability evaluated, two types of methodological approaches can be identified, namely:
(i) approaches that consider certain basic indicators;
(ii) approaches that consider composite indices associated with organizational sustainability.

3. RESEARCH METHODOLOGY

The methodological approach is a statistical one [31]. Hence the first phase is considered the studied population and analyzed sample definition, then variables are identified and the analysis models and methods are chosen, and subsequent the used data are collected for the analysis and statistical processing [2,31,32].

3.1 Analyzed Population and Sample

The analyzed population are manufacturing Romanian organizations, listed on a regulated capital market (Bucharest Stock Exchange – BSE), and the final sample proposed for analysis includes 30 large national companies – interval 2010-1019.

3.2 Analyzed variables and data source

Variables/ indicators considered as being representative, according to the literature, related to dimensions/components of organizational sustainability are presented in Table 3 [2,4,33].

Table 3

Variables / indicators associated with manufacturing organizational sustainability [2,4,33].

No.	Dimension	Variables / indicators considered as representative
1	Economic	Stock exchange rate / Earnings per share Financial profitability Economic profitability Profitability of sales Return on investment Gross sales margin Sales growth index
2	Social	Water consumption Toxic metals Solid suspensions Greenhouse gases Volatile organic compounds Sulfur dioxide and oxides of nitrogen Waste Hazardous Material

		Eco-design
		Recycling rate
3	Environmental	Work shift
		The wage
		Sex ratio
		Vocational training
		Safety training
		Work accidents
		Local suppliers
		Local employees
		Sustainable suppliers

Data sources: Global Reporting Initiative (GRI), Environmental Protection Agency (EPA), Stock Exchange, DataStream Advance, profile sites, surveys.

In the paper to obtain the estimated results, the data analysis was performed using IBM SPSS 22.0.

3.3. Multiple correspondence analysis

Identifying a sustainability profile associate to a manufacturing company can be done using Multiple Correspondence Analysis (MCA).

MCA is developed by Benzrcri (1969) and could be considered a generalized variant associated to correspondences factor analysis; likewise, is a multivariate analysis method, used to study the associations between three or more nominal variables (categorical) [31,34].

This statistical method summarizes the initial information by studying the associations between variables highlighted by a scatter diagram developed on a factorial axes system, ranked descending associated to their importance in explaining the total variance of cloud points [34].

The aim of this research is to obtain a sustainability profile from a certain group, considering records of the values associated to a series of m variables for a sample consisting of n entities, after studying the associations between the analyzed variables.

4. RESULTS AND DISCUSSION

This scientific approach is based on presented conceptual framework and on a statistical approach (MCA method) fit it to the proposed research purpose.

In MCA were introduced the variables related to the three dimensions of sustainability as well as the one related to the sustainability score

("Score_Sus"). The analyzed variables are categorical obtained starting from the previously estimated scores (on each component separately) [4], considering the benchmarks: minimum, Q1, Q3, and maximum:

- for the values between the minimum and Q1, the Low category was considered;
- for the values between Q1 and Q3, the Medium category was considered;
- for values between Q3 and maximum, the High category was considered.

Based on the analysis of these data in MCA, the following presented results were obtained (Table 4; Fig. 1.).

Table 4

Statistics for MCA – identifying a sustainability profile (for obtaining categorical variables)

		Dim_Fin	Dim_Env	Dim_Soc	Score_Sus
N	Valid	300	300	300	300
	Missing	0	0	0	0
Mean		.000	.000	.000	.000
Minimum		-1.896	-1.551	-.785	-1.012
Maximum		4.598	2.0436	2.678	2.459
Percentiles	25	-.530	-.473	-.475	-.545
	50	-.008	-.298	-.382	-.396
	75	.262	.162	-.283	-.056

Legend: Dim_Fin = economic (financial) dimension; Dim_Env = environmental dimension; Dim_Soc = social dimension; Score_Sus = sustainability score.
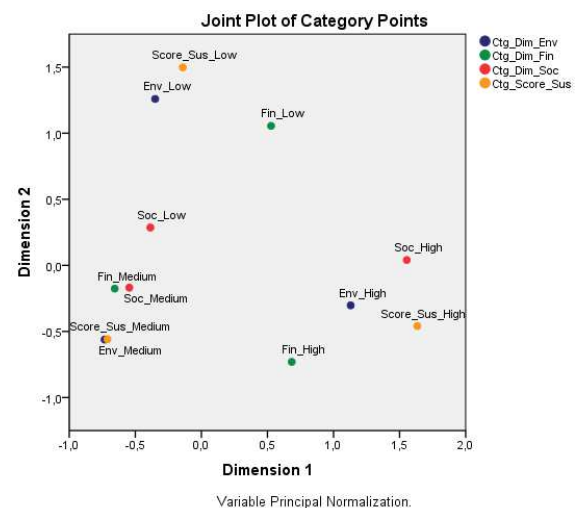

Fig. 1. Sustainability profile of manufacturing companies

The diagram in Figure 1 shows the profile of sustainable performance according to membership

in one of the categories related its dimensions (economic [financial] – "Dim_Fin", environmental – "Dim_Env", social – "Dim_Soc"). Consequently, organizations that have high sustainability score are characterized by a high financial, environmental and social performance.

Likewise, organizations that have average sustainability score can be characterized by average values associated to financial performance, average values of environmental performance and average and low values associated to social performance. Last but not least, a company whose sustainability score is low can be characterized by a low financial, environmental and social performance.

Hence in order to increase manufacturing organizational sustainability score, following can be proposed: (i) for organizations that are characterized by a low-level score associated with the environmental performance to significantly reduce water consumption, and NO_x and SO_2 emissions (process improvements, analysis associated to materials and raw materials used, implementing end-of-pipe control mechanism, technology update); (ii) for organizations that are characterized by a low-level score associated economic (financial) performance, to assess the impact associated to past or present investments; the need for investments in non-polluting technologies is noted; (iii) for organizations that are characterized by low-level score associated to social performance, to increase the awareness level associated to the importance of developing human resource skills through different training programs (diversification and high offer), real training in the safety field, and maintaining at least at a reasonable level the employment from local community.

5. CONCLUSION

World Commission on Environment and Development (WCED), since 1987, in addressing the transition to a more sustainable world, mention the fact that various critical and unpopular measures must be taken.

From an organizational point of view, the question arises as to how decision-makers make

certain decisions/ identify the optimal alternative in an informed way, taking into account the knowledge and priorities of different aspects of sustainability.

Models and profiles are necessary for manufacturing organization managers, and not only, because based on it, simulations can be operated that lead to alternative solutions and to an efficient and effective resources' allocation.

The outcome of a sustainable decision can be evaluated based on how well it met the decision makers' priorities and goals and how well it compares to other possible outcomes.

Taking into account the fact that often the results set of an improvement associated to a considered dimension, corresponds to doing worse in at least one other dimension – it is necessary to identify the non-dominant results, which nevertheless allow different perspectives [35]. Hence the main result of this research comes to clarify and present (in the considered sample) a sustainability profile that can explain/ influence in a positive way the decision-making process of organizational managers.

Through the conducted research, it was proposed and developed an interdisciplinary approach that integrates economic statistics and organizational sustainability associated to various manufacturing companies.

Hence in this paper (i) various clarifications were made of the main approaches used in the organizational sustainability evaluation, (ii) certain representative indicators have been identified by which organizational sustainability can be evaluated, and most important (iii) a company sustainability profile was identified.

Future research directions can be mentioned: (i) determining the probability diagram associated to the organizational sustainability score [+ / -] using fuzzy logic in a computational environment, (ii) testing the results robustness using neural networks.

6. ACKNOWLEDGEMENTS

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PROFILUL DE SUSTENABILITATE AL UNITĂȚILOR DE PRODUCȚIE: IDENTIFICARE PE BAZĂ ANALIZEI CORESPONDENȚELOR MULTIPLE

Abordarea problemei sustenabilității unităților de producție poate fi considerată ca un echilibru fin dintre, reziliența mediului, resurse umane şi beneficii nete. În literatura de specialitate, problema sustenabilității organizaţionale este analizată pe larg, dar neclara si încă in dezbatere. Prin urmare, este foarte dificil de evaluat sustenabilitatea organizaţională, având în vedere lipsa de consens cu privire la abordarea acestei probleme. Scopul articolului este de a îmbunătăţi procesul de evaluare a sustenabilității unităților de producţie. Folosind analiza corespondenţelor multiple pe un eşantion final de 30 de companii mari (cotate la Bursa de Valori Bucureşti) din România, rezultatele cercetării constau în identificarea unui profil de sustenabilitate a unităților de producţie.

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