Revista Catarinense da CIÊNCIA CONTÁBIL

ISSN 2237-7662, Florianópolis, SC, v. 21, 1-23, e3246, 2022

DOI: 10.16930/2237-7662202232462
Available at http://revista.crcsc.org.br

INFORMATION ENTROPY AND RANKING OF IBOVESPA COMPANIES: THE RELEVANCE OF ENVIRONMENTAL INNOVATION

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ABSTRACT

This study analyzes the weights of multidimensional performance indicators to determine *the ranking* of the companies listed in Bovespa index. This is a quantitative research using the multicriteria data entropy method, in which the indicators of the environmental, social, governance, economic-financial and market dimensions were obtained through the Refinitiv Eikon database. Thus, it was possible to establish the indicators weights for each year in order to determine the *rankings* of the companies at sector and general level. The environmental innovation variable was responsible for the greater information relevance, while the indicators such as return on net worth and financial leverage obtained the lowest weights. As for *the ranking*, Renner occupied the first place, which makes it possible to infer that this company has been standing out in the indicators portrayed with higher weight. In addition, the communication and public utility sectors presented the highest mean scores, while the health and energy segments had the lowest mean performances. These results indicate the relevance of providing corporate information to reach investors, increasingly concerned with good management practices and socio-environmental indicators. Moreover, the findings suggest that innovating on environmental issues does not consist of a priority for the companies in the sample, raising the question whether these organizations visualize the legitimacy or returns of successful innovations as rewards of the investments made. Research contributes by pointing out that companies with best environmental practices can obtain more benefits, as well as the society, before the quality of life and environmental preservation.

Keywords: Indicators. Performance. Entropy. *Ranking*. Ibovespa.

Edited in Portuguese and English. Original Release in Portuguese.

Presented at the 11th UFSC Congress on Controllership and Finance, in Florianópolis, Santa Catarina, in November 2021.

Received on 01/12/2022. **Revised** on 05/12/2022. **Accepted on** 06/07/2022 by Professor PhD Rogério Joao Lunkes (Editor-in-Chief). **Published on** 06/24/2022.

1 INTRODUCTION

The performance evaluation in organizations has become part of the strategic approach to integrating business policies and business planning activities (Maghsoodi, Abouhamzeh, Khalilzadeh, & Zavadskas, 2018). This evaluation can be considered as a social phenomenon that quantitatively highlights accounting information, which can cover other dimensions besides the economic, financial and market dimensions (Bititci, Garengo, Dörfler, & Nudurupati, 2012; Degenhart, Vogt, Hein, Rosa, & Brizolla, 2019)

The use of accounting-financial indicators is a viable alternative, since it allows the determination of the critical, positive and negative points of an organization (Macedo, Corrar, & Siqueira, 2012). However, the existence of multiple criteria in the decision-making procedure makes it challenging to define a performance evaluation method (Maghsoodi et al., 2018). In view of the above, the legitimacy theory has contributed to the understanding of the reasons that encourage the voluntary disclosure practice by companies (Eliwa, Aboud, & Saleh, 2021).

Brito and Brito (2012) argued that using only financial performance indicators, such as profitability and rate of return, is not sufficient to highlight the existence of competitive advantage, as these capture only a part of the value created. In addition, previous studies usually have multidimensional constructs with limited efficacy of performance quantification practices (Hein, Vogt, Degenhart, Haussmann, & Kroenke, 2020; Jacintho & Kroenke, 2021; Marcos, Nascimento, De Nez, & Kroenke, 2018). This suggests the need for research that recognizes environmental, social and governance (ESG) aspects (Jacintho & Kroenke, 2021).

The integration of ESG practices into business management and investment decision-making has become an international passport for companies to practice sustainable development (Li, Wang, Sueyoshi, & Wang, 2021). In this context, Miralles-Quirós, Miralles-Quirós and Valente-Goncalves (2018) indicated that the Brazilian stock market valued positively the companies with higher *ESG performance* , which reveals the implementation of corporate social responsibility policies that lead to higher performance in sustainability as a strategic advantage for value generation.

The difficulties related to the holistic measurement of the companies' performance justify the interest in the search for new techniques and indicators that help both managers in decision making and shareholders in investment management. The use of multiple indicators also makes it possible to allocate resources for more important variables and compare results with other organizations (Deng, 2015). In this scenario, information entropy, a method of multicriteria support to decision, may be a tool capable of diagnosing which indicators have the greatest weight of information, that is, greater relevance (Almeida-Santos, Rocha, & Hein, 2014; Beuren, Cunha, Theiss, & Cordeiro, 2013).

Studies have demonstrated the efficacy of the entropy method to classify environmental impact evidence (Degenhart et al., 2019), as well as measuring the development of the organizations sustainability (Deng, 2015) and calculating the weight of environmental information (Vogt, Degenhart, Hein, & Rosa, 2018). On the other hand, the differential of this research in relation to the above studies (Degenhart et al., 2019; Jacintho & Kroenke, 2021) consists of considering the sustainable dimensions in the *rankings* classification in a Brazilian context; therefore, the research aims to answer the following question: What is the weight of the multidimensional performance indicators to determine *the ranking* of Ibovespa companies?

Thus, the objective of this study aims at analyzing the weights of multidimensional performance indicators to determine *the ranking* of the companies listed in Bovespa index. To this end, 64 non-financial companies were analyzed between 2016 and 2020, through descriptive statistics and information entropy, generating consolidated and sectoral rankings. *Refinitiv Eikon* data were used, encompassing the environmental, social, governance, economic-financial and market dimensions.

This research contributes to the literature about multidimensional indicators when analyzing performance, taking into account ESG dimensions, with emphasis on environmental innovation as the variable responsible for the greatest informational relevance, while the return on equity obtained the lowest weights in all the analyzed years. In addition, the dimensions with the greatest information load were environment, market, economic-financial, social, governance, and finally, ESG. Based on these results, the usefulness of accounting information is increased by means of the multidimensional indicators for their distinct users, especially the investor, who usually needs to make decisions that involve evaluating companies from different sectors, according to different criteria and weights.

As a practical contribution, the results offer subsidies to emphasize the importance of ESG practices, especially environmental practices, in a national context, showing that these organizations can obtain more benefits, as well as the society, before quality of life and the environment preservation. In addition, the entropy multicriteria approach is capable of reducing such subjectivity by offering weights capable of indicating the importance of each information.

This Article encourages the use of entropy as a decision support tool, based on the selection of weights for the variables analyzed. This calculation allows the knowledge of the multi-dimensional performance indicators that are more relevant. The weight of innovation capacity as a mechanism for differentiating Ibovespa companies in the market was highlighted. In this sense, the research emphasizes knowledge about the efficiency, planning and quality of the management of these public traded companies through *rankings*, in order to strengthen the initiative to integrate ESG aspects into investment decision making.

2 THEORETICAL FRAMEWORK

2.1 Increasing performance through environmental, social and governance practices

The role of finance has changed over time, moving from an exclusive focus on maximizing shareholder profits and wealth to growing attention to ESG issues (Atan, Alam, Said, & Zamri, 2018; Ryszawska, 2016). Investors are concerned about ESG practices of a company to know where the company invests its resources and how it conducts its business (Atan et al., 2018). This trend remains as sustainability issues remain relevant (Hartmann & Uhlenbruck, 2015), as the organization is said to be legitimate insofar as its means and purposes comply with social standards, values and expectations (Eliwa et al., 2021).

In view of the growing interest in environmental aspects, Bachmann, Carneiro and Espejo (2013) emphasize attributes for the composition of an indicator capable of evaluating the quality of environmental evidence, which presented greater weight for the environmental impacts of products and processes, and for information on waste. Another example refers to the *Refinitiv* database (2020), in which the environmental score evaluates companies' performance in avoiding environmental risks through the following categories: emissions, resource use and innovation scores. In addition, Jakimowicz e Rzeczkowski (2019) they stated that eco-innovations are based on external sources of knowledge greater than other types of innovation, because they are strongly determined by socioeconomic and institutional factors.

However, the focus on environmental dimensions is not expressive in the companies belonging to the IBrX-100 index (Degenhart et al., 2019). This index is made up of the most representative and negotiable assets of *Bolsa, Brasil, Balcão (B3)*, Brazilian Stock Exchange (Vogt et al., 2018). For Douek and Angelo (2021), if the growing interest in ESG aspects is a reality, it is also true that the incorporation of these elements in the context of the Brazilian capital market is still an evolving process. Thus, there are indications that managers consider ESG factors as an investment and not as an expense, applying efforts and resources in lasting ESG initiatives that

seek the company's legitimacy in the foreign market (Duque-Grisales & Aguilera-Caracuel, 2021).

Regarding the social dimension, Atan et al. (2018) presented among the most relevant factors for stakeholders the rights to equality and diversity in the workplace, as well as the company's contribution to society. As a result, companies with high social performance are easier to attract eligible employees and, as investors are more concerned about the company's sustainable activities, this is understood to have a greater competitive advantage (Velte, 2017). In addition, organizations with higher levels of social responsibility are likely to increase the care of the information disclosed, denoting higher quality of accounting information (Freire & Albuquerque Filho, 2022).

As a third explicit dimension, in this section, corporate governance is defined as the organization's code of conduct to ensure that the actions of the counselors and CEOs are compatible with the stakeholders' preferences (Esteban-Sanchez, La Cuesta-Gonzalez, & Paredes-Gazquez, 2017). Tarmuji, Tarmuji and Maelah (2016) pointed out that the corporate governance practices of Malaysian companies significantly influenced economic performance, corporate transparency and disclosure relating them to corporate performance. On the other hand, the weak corporate governance and the main managers' negligence in business operations can undermine the company's profitability and create volatility in stock prices (Cannella, Park, & Lee, 2008).

In short, ESG best practices signal the company's commitment to institutionalized rules of responsible behavior, with corresponding positive impacts on society, the natural environment and the socially sanctioned interests expressed by shareholders and other stakeholders (Del Bosco & Misani, 2016). In addition, the increasing attention given to ESG issues has led to an increase in credit institutions' awareness of the credit institutions' reputation risk imposed by borrowing companies (Eliwa et al., 2021). However, these concerns occur unevenly among countries. From *a benchmarking* of sustainable performance, Deng (2015) showed that the United States of America had the best result, regardless of the criteria weighting methods used.

In a Brazilian context, when analyzing the level of *disclosure* in the sustainability reports in accordance with the *Global Reporting Initiative*, in a sample of 93 companies listed in Ibovespa , Di Domenico, Tormem and Mazzioni (2017) found that most companies showed, in a lower way, composite items in the sustainability reports. On the other hand, these authors presented the existence of companies that voluntarily and with quality evidenced the indicators in the reports. Another national study, analyzing the companies of the electric sector listed in the Corporate Sustainability Index, found innovation as a strategy that can be understood as a way of legitimizing Corporate Social Responsibility actions, being more focused on obligations imposed by the regulatory bodies (Furtado, Antonovz, Correa, Silva, & Panhoca, 2019).

2.2 Previous studies: ranking and information entropy

The most profitable companies are the ones that disseminate corporate information most, as a result of the publicizing being a means of seeking legitimacy from the management and, therefore, of obtaining approval from interested parties (Madrigal, Guzmán, & Guzmán, 2015). In this context of performance, Silva, Sulzbach, Hein and Kroenke (2015) analyzed the *ranking* of telecommunications companies and revealed that the indicators return on assets, overall liquidity and current liquidity were the main companies' components. On the other hand, the return on assets occupied the last position in the *rankings* of the years surveyed.

Maghsoodi et al. (2018) identified the best criteria based on the literature validity and the real applications practicality for the analysis of an optimal performance evaluation. Through MULTIMOORA approach integrated Shannon's entropy, these authors provided a selection of performance assessment methods applied to a case study at a multinational company in various industries in Iran. In addition, the methods *final rankings* were compared with *Technique for*

Order Preference by Similarity to Ideal Solution (TOPSIS) and integrated Shannon Entropy of TOPSIS by means of correlation coefficients.

Aras and Yıldırım (2021) investigated the sustainability and capital indicators in the integrated report of companies in the banking sector from 2014 to 2017, providing an understanding of their impacts through the information entropy. The authors pointed out that the component with maximum weight is determined by intellectual capital, showing that innovative studies are very effective in the banking sector. Then, the relationship equity capital and human capital occupy the second and third order.

Degenhart, Vogt, Hein and Rosa (2016) analyzed the sectoral *ranking* of the degree of environmental evidence of the Brazilian companies listed in IBrX-100 and revealed that the companies in the public service sector are the ones that highlighted information the most, while energy companies have almost not revealed environmental data. The authors suggest future studies with a sample covering Ibovespa companies and an analysis of the degree of environmental evidence, by another method, to verify if there was any evolution.

As sustainability promotes social inclusion through respect for cultural diversity (Bachmann et al., 2013), Barbosa and Cabral-Cardoso (2010) evaluated the extent to which Portuguese companies incorporated issues related to equality and diversity in their management discourse and demonstrated that native companies with sites intended for a local public tend to completely ignore diversity problems. In this context of evaluation, Theiss Kreuzberg, Beck and Hein (2014) carried out a *ranking* through *the analytical Hierarchy process* and verified that the most innovative activities are classified by the manufacture of food products, followed by the manufacturing activity of machines and equipment.

Zaniboni and Montini (2017) analyzed whether the return on the shares of innovative companies is greater than the market performance in Brazil, since the macroeconomic environment affects innovative companies in Brazil in a less severe way than the market as a whole. This study compares the economy impact on the innovative companies' performance and *on the performance* of other Brazilian companies, since companies with continuous investments in innovation may be more likely to survive a recession. In this research, the classification of innovative companies was based on *rankings* published by business management publications.

3 METHODOLOGICAL PROCEDURES

This research is characterized as documentary , descriptive and with a quantitative approach to data. The population was identified by the companies listed in Ibovespa for the period between 2016 and 2020, according to the theoretical portfolio index collected by *Refinitiv Eikon* (formerly *Thomson Reuters*) in September 2021. The justification for this time frame is given by the absence of disclosure of ESG data prior to the year 2016 for most of the companies analyzed. In addition, the financial sector was taken out of the sample due to the lack of data for the circulating passive and current asset groups, since this information is necessary to calculate the companies' current liquidity. In addition, companies that have not reported ESG data for at least two consecutive years have been excluded. Therefore, the sample composition can be summarized as shown in Table 1.

Table 1
Sample composition

Steps	**Companies**
= Research population (companies listed in Ibovespa)	**88**
(-) Financial companies	14
= Initial sample – Non-financial companies listed in Ibovespa	**74**
(-) Companies that have not reported ESG data for at least two consecutive years	10
= Final Sample	**64**

Source: elaborated by the authors (2022).

The unbalanced sample contains 64 companies distributed in ten sectors, mostly represented by cyclical consumption and public utility, both sectors with 17.19%. As a result, 15.63% of the companies are in the materials sector; 14.06% are non-cyclical consumer companies and 12.5% are industrial goods. On the other hand, the telecommunications and information technology sectors present the lowest representation of the sample of this study, the two with 3.13%, being followed by 4.69% of the real estate sector and 6.25% for each of the health and energy sectors, values similar to those reported by Degenhart et al. (2016).

Table 2 shows the variables collected in the *Refinitiv Eikon* database, according to each dimension, to show the level of the companies' performance listed in Bovespa index.

Table 2
Specification of the variables that depict the multidimensional performance indicators

Variable		Measurement	Source
	Composite Dimension Environmental, Social and Corporate Governance (ESG)		
ESG score	General score of the company based on the self-reported information in the ESG pillars.	From 0 to 100: the higher the better.	Atan et al. (2018)
	Environmental Dimension		
Environmental Score (PMA)	It measures the company's impact on living and non-living natural systems, including air, land and water, as well as complete ecosystems. This reflects how well a company uses best management practices to avoid environmental risks and capitalize on environmental opportunities.	From 0 to 100: the higher the better.	Ryszawska (2016)
Environmental Innovation (IME)	It reflects a company's ability to reduce environmental costs and charges for its customers and thus create market opportunities through new environmental technologies and processes or eco-design products.	From 0 to 100: the higher the better.	*Refinitiv* (2020)
	Social Dimension		
Pont. Social (PS)	It measures a company's ability to generate trust and loyalty with its employees, customers and society through the use of best management practices. It reflects the company's reputation and the health of its license to operate, which are key factors in determining the ability to generate value for shareholders in the long term.	From 0 to 100: the higher the better.	Atan et al. (2018)
Diversity and equality (DI)	It measures how much the company promotes DI through programs or practices, opportunities in the workforce; promotion of women, minorities, disabled employees; and employment of any age, ethnicity, race, nationality and religion.	From 0 to 100: the higher the better.	Barbosa and Cabral-Cardoso (2010)
	Corporate Governance Dimension		
Pont. Corporative Governance (PGC)	It measures the systems and processes of a company that ensures that directors and executives act in the best interest of its shareholders. It reflects an enterprise's ability to control its rights and duties through the creation of incentives and checks and balances to generate value.	From 0 to 100: the higher the better.	Tarmuji et al. (2016)
Management (PG)	It erasures the commitment and effectiveness to follow the principles of corporate governance best practices.	From 0 to 100: the higher the better.	*Refinitiv* (2020)
	Economic and Financial Dimension		
Return on Assets (ROA)	It shows how profitable a company's assets are in revenue generation.	$\frac{\text{Net Profit}}{Total\ Assets}$	Madrigal et al. (2015)
Profitability (ROE)	It refers to the company's ability to self-add value using its own resources.	$\frac{Net\ Profit}{NetEquity}$	Silva et al. (2015)
Current Liquidity (LC)	It highlights the ability of a company to pay all its debts in the short term.	$\frac{\text{Current Assets}}{Current\ Liabilities}$	Silva et al. (2015)

Financial Leverage (AF)	It refers to the amount of the company's debt for more assets to be purchased.	$\frac{\text{Total Liabilities}}{\text{Total Assets}}$	Silva et al. (2015)
	Market Dimension		
Market-to-book (MTB)	It evaluates a company's current market value relative to its book value.	$\frac{\text{Market Value}}{Accounting\ Value}$	Zaniboni and Montini (2017)
Actions Normal Return (RT)	It refers to the difference in the share price of company *i* at time *t* compared to time *t* – 1 divided by the share price of company *i* at time *t* – 1.	$\frac{P_{i.t} - P_{i.t-1}}{P_{i.t-1}}$	Zaniboni and Montini (2017)

Legend: Pont. - Score; $P_{i.t}$ - Price of the company share *i* in time *t*.
Source : elaborated by the authors based on *Refinitiv* (2022).

As it can be observed, in Table 2, the variables listed for the study are divided into the dimensions (I) ESG, (ii) economic-financial and (iii) market. Also, the composite ESG dimension is subdivided into three: environmental, social and corporate governance. In view of the intention of analyzing companies, based on the premise of maximizing results with minimum spending, all the variables present the meaning that the greater the better, except financial leverage. Thus, this variable was normalized to meet the proposed objective. In addition, it should be noted that *Refinitiv Eikon*'s ESG scores are calculated from data reported by companies and are adapted to objectively assess the multidimensional performance.

Initially, descriptive statistics were adopted for the data analysis by means of central tendency and dispersion measurements. In the sequence, the information entropy was used, a method of decision multicriteria support, making it possible to generate the general and sectoral *rankings*. These steps were supported by the use of spreadsheets. As for the method used, the information entropy needs a reference point, that is, the maximum value for each indicator, and, based on this value, entropy is then calculated (Almeida-Santos et al., 2014, page 90):

> Where the standardized values are $d_i = (d_{i,}^1 d_{i,}^2 \dots d_{i,}^m) : d_i^k = \frac{x_i^k}{x_i^*}$, which characterizes the set D, in terms i-*th* attribute. It is found, therefore $D_{i=} \sum_{k=1}^{m}; d_i^k; i = 1,2, \dots n,$. After that, the intensity contrast entropy measurement is sought for the i-th attribute calculated by: $e(d_i) = -\alpha \sum_{k=1}^{m} \frac{d_i^k}{D_i} Ln(\frac{d_i^k}{D_i})$, where $\alpha = \frac{1}{E_{max}} > 0$ and $E_{max} = Ln(m)$. also checking that $0 \leq d_i^k \leq 1$ and $d_i^k \geq 0$. Being all d_i^k the same for a given i, then $\frac{d_i^k}{D_i} = \frac{1}{n}$ and $e(d_i)$ assumes maximum value, that is $E_{max} = Ln(m)$, . Upon fixing $\alpha = \frac{1}{E_{max}}$, it is determined $0 \leq e(d_i) \leq 1$ for all d_i 's.

The total entropy of *D* is defined by: $E = \sum_{i=1}^{n} e(d_i)$, since the greater the $e(d_i)$, the lower the information transmitted by the *ith* attribute; case $e(d_i) = E_{max} = Ln(m)$, then the i-*th* attribute does not transmit information and can be removed from the decision analysis. Due to the weight $\tilde{\lambda}_i$ being inversely related to $e(d_i)$, it is used $1 - e(d_i)$ instead of $e(d_i)$ and normalizes to ensure $0 \leq \tilde{\lambda}_i \leq 1$ that and $\sum_{i=1}^{n} \tilde{\lambda}_i = 1$. Thus: $\tilde{\lambda}_i = \frac{1}{n - E}[1 - e(d_i)] = \frac{[1 - e(d_i)]}{n - E}$ (Almeida-Santos et al., 2014; Aras & Yıldırım, 2021).

Lower divergence in scores of d_i^k allow for lower variations between $\tilde{\lambda}_i$, making the i-*th* attribute less important, because if the scores of the attributes are equal, then $\tilde{\lambda}_i = 0$ (Aras & Yıldırım, 2021). The weights w_i and $\tilde{\lambda}_i$ are determinant in importance in a parallel way, because if $w_i = 0$ so all $\tilde{\lambda}_i = 1$, which does not justify making the i-*th* important attribute. If $\tilde{\lambda}_i = 0$, then any attribute with $w_i = 1$ becomes irrelevant to the decision-maker. A possible hypothesis to

assign importance side by side can be formulated by $\lambda_i=\tilde{\lambda}_i w_i$, or after normalization: $\lambda_i=\frac{\tilde{\lambda}_i w_i}{\sum_{i=1}^{n}\tilde{\lambda}_i w_i}$.

Thus, the entropy measurement is calculated by $e(d_i)=-\alpha\sum_{k=1}^{m}\frac{d_i^k}{D_i}Ln(\frac{d_i^k}{D_i})$.

From the information entropy , a score per company was obtained for each year and the degree of technical efficiency (performance) was calculated as Appendix A. This score was then used to determine the consolidated and the sectoral *ranking* of the performance of these companies. In addition, companies that reported missing data for any variable in the respective year were removed from the *rankings*. In 2016 and 2017, 12 companies were excluded, totaling 52 companies, while two were excluded in 2018. It is noteworthy that, in the years 2019 and 2020, there was no elimination of companies, totaling 64 companies in ten sectors.

4 PRESENTATION AND ANALYSIS OF RESULTS

4.1 Descriptive statistics and weights of variables

Table 3 presents the descriptive statistics of the variables adopted to capture the environmental, social, governance, economic-financial and market dimensions of the Bovespa index companies. The data collected for ESG and performance indicators are for the period from 2016 to 2020. As pointed out in the methodology, some companies reported missing data for some variables in the early years, which is justified by observations below the quantitative of 320.

Table 3
Variables descriptive statistics

Variables	Mean	Standard Deviation	Median	Minimum	Q1	Q3	Maximum	Notes
ESG	54.74	19.63	57.81	1.31	27.64	69.91	90.05	302
PMA	48.36	27.35	54.04	0	29.1	68.71	94.3	320
IME	23.08	31.11	0	0	0	47.89	99.71	320
PS	53.98	25.45	58.495	0	36.43	74.35	96.65	320
DI	48.42	24.52	58.78	0	55.15	61.76	75.63	320
PGC	51.04	23.89	55.5	0	36.145	69.78	92.57	320
PG	52.93	28.45	56.69	0	33.215	77.21	98.81	320
ROA	0.034	0.07	0.394	-0.686	0.008	0.065	0.223	320
ROE	-0.005	1.61	0.116	-26.26	0.042	0.187	4.2	320
LC	1.71	1.04	1.48	0.312	1.1	2.12	11.8	320
AF	0.663	0.24	0.67	0.004	0.51	0.79	2.12	320
MTB	1.04	0.99	0.74	0.078	0.41	1.23	7.98	312
RT	0.377	0.67	0.24	-0.595	-0.009	0.581	5.11	309

Source: Research data (2022).

It is observed that the variables related to ESG dimensions have greater dispersion, contrary to those related to the economic-financial or market dimensions. Regarding DI, the concentration of data around the median indicates that there is a pattern among the sampled companies, despite the existence of *outliers*. In addition, the interquartile range and the standard deviation of the general score (19.63) indicate lower data variability compared to the other variables related to ESG. It should also be pointed out that more than half of the observations on environmental innovation are of zero value, showing a lack of reports on this variable for the companies and sampling period.

Table 4 then presents the values of entropies of each variable, from 2016 to 2020. Entropy weights are associated with higher amounts of information, because one of the characteristics of the analysis technique is the ability to highlight the most important indicators for decision making (Beuren et al., 2013). In this case, the closer to 1 the entropy value is, the lower the level of

importance of the information, and the farther away from 1, the greater the contribution or weight of this indicator.

Table 4
Entropy and weight of variables per year and balance

Variable	2016		2017		2018		2019		2020		Balance
	Entropy	Weight	Entropy	Weight	Entropy	Weight	Entropy	Weight	Entropy	Weight	Weight %
ESG	0.983	2.54%	0.982	2.73%	0.979	3.55%	0.982	3.48%	0.984	3.09%	15.39
PMA	0.956	6.63%	0.956	6.72%	0.956	7.52%	0.963	7.32%	0.967	6.24%	34.43
IME	0.773	33.95%	0.769	35.45%	0.788	36.07%	0.795	40.75%	0.804	37.03%	183.2
PS	0.975	3.76%	0.975	3.90%	0.975	4.27%	0.982	3.64%	0.983	3.22%	18.79
DI	0.945	8.16%	0.947	8.16%	0.943	9.76%	0.972	5.58%	0.980	3.75%	35.41
PGC	0.982	2.71%	0.982	2.74%	0.975	4.33%	0.980	4.00%	0.981	3.54%	17.32
PG	0.967	5.01%	0.969	4.78%	0.962	6.44%	0.973	5.44%	0.974	4.83%	26.50
ROA	0.958	6.34%	0.965	5.32%	0.982	3.04%	0.989	2.23%	0.994	1.06%	17.99
ROE	0.989	1.62%	0.999	0.03%	0.994	0.96%	0.996	0.82%	0.996	0.75%	4.18
LC	0.951	7.39%	0.977	3.60%	0.975	4.26%	0.975	4.99%	0.956	8.31%	28.55
AF	0.991	1.38%	0.987	2.06%	0.990	1.77%	0.991	1.81%	0.992	1.43%	8.45
MTB	0.915	12.65%	0.913	13.33%	0.932	11.58%	0.932	13.42%	0.903	18.42%	69.40
RT	0.947	7.85%	0.927	11.19%	0.962	6.44%	0.967	6.52%	0.956	8.31%	40.31

Source: Research data (2022).

The most relevant variable during the whole sample period was environmental innovation with weight showing an increase between 2016 and 2019 and a higher total balance. The DI indicator also calls attention, because in the early years it was 8.16% in weight, falling to 3.54% in 2020, showing interest gains on such issues by the companies studied. In addition, other variables of lesser importance may be highlighted to compose the *ranking* of the sampled companies. For example, ROE obtained weights below 1% every year from 2017, which is in line with the results of Silva et al. (2015). Then, while AF presented values close to 2% during the whole sample period, the CG and the ESG obtained weights between 2% and 4.33%.

According to Jacintho and Kroenke (2021), the presence of weights makes the evaluation "fairer", since the interpretation of "raw" data can be difficult, and the use of weights for indicators of different dimensions can be a strategy to increase the usefulness of accounting data and to evaluate the companies' performance. After obtaining and applying the weights, it is then appropriate to deal with the *ranking* of the companies investigated in Ibovespa, as follows in the next section.

4.2 General *and* Sectoral *ranking*

To build the general *and* sectoral *ranking* based on the partial (annual) classifications, an analysis of the evolution of organizations over the five years was carried out through a consecutive *score* system, which generates a final mean score. Therefore, Table 5 presents the technical efficiency degree of 40 companies among the 64 analyzed, according to the general placement (Cº G.) and sectoral (Cº S.), as well as their general positions (Cº) and scores in the *rankings* of the five years studied. It should also be noted that the 40 companies exposed were segmented between the 20 organizations with the highest means and the 20 companies with the lowest means for the overall score. The other companies, that is, the 24 companies not represented in Table 5, had intermediate scores in the overall *ranking* and can be viewed in Appendix B.

Table 5
Consolidated and sectoral ranking of companies

Cº G.	Institution	2016		2017		2018		2019		2020		Cº S.	Pont.
		Cº	Pont	Cº		Cº	Pont	Cº	Pont	Cº	Pont		
1st	Renner	8th	0.59	1st	0.62	1st	0.83	1st	0.81	2º	0.67	1st	0.70
2nd	Engie Br.	1st	0.69	3rd	0.61	4th	0.69	2nd	0.76	1st	0.67	1st	0.68
3rd	Cent. E. Br.	3rd	0.63	4th	0.59	2nd	0.71	3rd	0.72	3rd	0.64	2nd	0.66
4th	CPFL En.	4th	0.62	2nd	0.61	3rd	0.70	8th	0.66	6º	0.60	3rd	0.64
5th	Klabin	6th	0.59	5th	0.58	6th	0.66	4th	0.68	5th	0.61	1st	0.63
6th	CEMIG	11th	0.56	9th	0.53	7th	0.65	5th	0.68	7th	0.59	4th	0.60
7th	Dexco	7th	0.59	14th	0.46	5th	0.69	7th	0.66	8th	0.59	2nd	0.59
8th	EDP Energ.	2nd	0.64	10th	0.53	8th	0.63	13th	0.59	11th	0.54	5th	0.58
9th	Tim	10th	0.57	8th	0.57	10th	0.60	11th	0.61	12th	0.53	1st	0.576
10th	Multiplan	5th	0.61	7th	0.57	9th	0.60	12th	0.60	15th	0.49	1st	0.575
11th	Minerva	-	-	-	-	12th	0.57	10th	0.63	14th	0.52	1st	0.573
12th	Ambev	9th	0.58	6th	0.58	13th	0.55	15th	0.56	17th	0.46	2nd	0.55
13th	JBS	14th	0.49	13th	0.46	26th	0.43	6th	0.67	9th	0.59	3rd	0.53
14th	WEG	16th	0.43	12th	0.48	15th	0.50	14th	0.58	4th	0.61	16th	0.52
15th	Totvs	35th	0.27	36th	0.29	11th	0.58	9th	0.65	10th	0.55	35th	0.47
16th	SABESP	12th	0.51	11th	0.49	24th	0.44	17th	0.49	25th	0.36	12th	0.457
17th	C. Siderúrg.	13th	0.49	18th	0.42	21st	0.46	21st	0.44	16th	0.47	13th	0.456
18th	Petrob. Dis.	-	-	-	-	17th	0.49	22nd	0.43	23rd	0.38	2nd	0.43
19th	Pet. Petrob.	15th	0.44	20th	0.41	17th	0.49	22nd	0.43	23rd	0.38	1st	0.428
20th	Rumo	25th	0.32	15th	0.45	19th	0.48	18th	0.48	20th	0.39	2nd	0.426
::	::	::	::	::	::	::	::	::	::	::	::	::	::
44th	Americanas	42nd	0.22	39th	0.28	30th	0.39	41st	0.32	43rd	0.27	8th	0.295
45th	CCR	31st	0.28	35th	0.29	43rd	0.32	45th	0.30	49th	0.23	6th	0.286
46th	Hypera	46th	0.19	40th	0.27	46th	0.28	28th	0.37	35th	0.29	3rd	0.284
47th	Cosan	38th	0.25	46th	0.23	51st	0.24	31st	0.36	33rd	0.31	3rd	0.279
48th	USIMINAS	30th	0.29	45th	0.23	53rd	0.22	44th	0.30	37th	0.29	8th	0.270
49th	YDUQS	44th	0.21	27th	0.34	45th	0.29	46th	0.29	59th	0.19	9th	0.263
50th	Qualicorp	41st	0.23	33rd	0.31	49th	0.25	38th	0.33	55th	0.19	4th	0.263
51st	Eneva	45th	0.20	47th	0.23	44th	0.31	50th	0.28	46th	0.26	8th	0.256
52nd	Gol Linhas	49th	0.17	31st	0.31	42nd	0.32	53rd	0.26	56th	0.19	7th	0.253
53rd	Bradespar	40th	0.24	42nd	0.26	48th	0.26	59th	0.20	38th	0.29	9th	0.251
54th	Cyrela Br.	39th	0.24	44th	0.24	47th	0.27	55th	0.24	57th	0.19	10th	0.237
55th	Energisa	-	-	-	-	52nd	0.24	56th	0.24	53rd	0.21	9th	0.230
56th	Gerdau	48th	0.19	51st	0.16	54th	0.22	54th	0.26	48th	0.25	10th	0.219
57th	Petro Rio	47th	0.19	43rd	0.25	55th	0.21	58th	0.21	54th	0.20	4th	0.215
58th	Iguatemi	-	-	-	-	60th	0.17	51st	0.28	58th	0.19	2nd	0.212
59th	Azul	-	-	-	-	56th	0.21	57th	0.23	60th	0.18	8th	0.205
60th	Transm. Al.	50th	0.14	48th	0.17	57th	0.20	61st	0.19	51st	0.22	10th	0.184
61st	BR Malls	51st	0.13	52nd	0.15	59th	0.17	60th	0.19	61st	0.15	3rd	0.159
62nd	CVC Brasil	-	-	50th	0.17	58th	0.17	63rd	0.11	63rd	0.13	11th	0.142
63rd	Equatorial	52nd	0.11	53rd	0.10	61st	0.11	62nd	0.18	62nd	0.13	11th	0.128
64th	Atacadão	-	-	-	-	62nd	0.10	64th	0.09	64th	0.07	9th	0.088

Legend: Cº = Year Position; Cº G. = General Position; Cº S. = Sectorial Position; Pont. = Score.
Source: Research data (2022).

Initially, the number of companies that did not reach a general score of 0.5 was high, with only 14 reaching a *score* higher than this quantity. This indicates that it is necessary for companies to be more concerned with the variables that received the greatest weight according to the method adopted in this article, the information entropy, because society and governments increasingly claim the environmental, social and corporate governance dimensions for greater socio-environmental responsibility, attitude that can generate future benefits.

Regarding the general companies position, Renner was in first position (0.7), followed by Engie Brasil (0.68) and Centrais Elétricas Brasileiras (0.66). These results show that these companies stood out in best practices of environmental innovation compared to the others, suggesting the relevance of providing corporate information to reach investors, increasingly concerned with good management practices and with socio-environmental indicators (Atan et al., 2018; Cannella et al., 2008). Despite the study by Jacintho and Kroenke (2021) classify companies according to economic and financial indicators, the result evidenced in this Article regarding Engie Brazil corroborates the good positions presented by these authors.

Regarding the sectorial *ranking*, the cyclical consumption (discretionary) and public utility sectors stood out among the first positions, respectively, through Renner and Engie Brasil companies. In addition to Lojas Renner occupying the best position in the cyclical consumption sector, they were also in the 1st general positions in the years 2017 to 2019, demonstrating a contrast with the scores of other companies in the same sector. Next, in addition to Klabin showing a steady increase in its scores between 2017 and 2019, it was also responsible for the greater technical efficiency in the materials sector. This result is different from that evidenced by Degenhart et al. (2016), who classified Klabin in 3rd position in its segment.

The Public Service sector has a highlight in the top positions of the general *ranking* (2nd, 3rd, 4th, 6th and 8th positions), which allows to infer that this segment has a greater historical reflection focused on sustainable issues. The first companies in the *ranking* stand out in all the indicators portrayed in the study, corroborating the results of Del Bosco and Misani (2016) that socio-environmental concerns and profit are not dichotomic objectives.

On the other hand, Atacadão, Equatorial Energia and CVC presented the lowest technical efficiencies, which can be justified by zero values for the most relevant indicators of the study. In view of the use of indicators in the elaboration of action plans for organizations, the research points to the realization of actions that foster innovations in the environment. These results also corroborate Liu and Anbumozhi's warning (2009), which greater stakeholder concerns about sustainable issues should be promoted to encourage companies to disseminate more environmental information in their reports.

Of the first ten companies listed in Table 5, only CPFL Energia, CEMIG and Klabin were in the first ten of the *rankings* showing environmental impacts on liquid effluents in Vogt et al. (2018), who considered annual and sustainability reports from 2010 to 2013. A better position of BRF could be expected (36th position in Table B11), positively highlighted by Vogt et al. (2018). However, it is important to consider that there is no standard for the dissemination of environmental information in the reports of Brazilian companies (Vogt et al., 2018).

In the real estate sector, while Multiplan, 10th position, presented the highest technical efficiency in its sector with a mean of 0.575, BR Malls, 61st position, was responsible for the lowest performance with 0.159. These results are consistent with the findings of Degenhart et al. (2016) as to the similarity in positions, as well as those of Douek and Angelo (2021), who stated that "while environmental, social and corporate governance (ESG) is increasingly evident in the business environment, there is still a lot of skepticism from real estate investors about the importance of the theme" (page 1).

As for cyclical consumption, while Petrobras Distribuidora, 18th position, held the second highest technical efficiency in its sector with a mean score of 0.432, the companies Cyrela (54th)

and CVC (62nd) presented the lowest mean scores in the sector, respectively, 0.237 and 0.142. These results are opposed to those of Hein et al. (2020), who highlighted Cyrela in the second position in *rankings* of value creation in the period 2011-2015, although only seven companies in Brazil were considered.

Although Minerva (11th) showed complete information for only three years, this company presented the highest technical efficiency in the non-cyclical consumption sector. This finding is in line with the study by Marcos et al. (2018), who positioned Minerva in the first place in a *ranking* of economic and financial performance from 2010 to 2014, with 25 companies from B3. Then Ambev (12th) held the second highest efficiency, however, the evolution of the *ranking* over the years shows a decline in its scores. JBS (13th) was the third highest performing company, showing high scores in 2019 and 2020.

As for the energy sector, although Petrobras (19th) decreased its technical efficiency with the temporal evolution, this company achieved the best *performance* in this segment. In contrast, Petro Rio (57th) was the company with the lowest technical efficiency in this sector. Petrobras' result is different from that reported in the research by Degenhart et al. (2019), which listed this company in the 9th position through TODA and 10th position through TOPSIS.

WEG (14th) presented the highest technical efficiency among companies in the industrial goods sector, which showed an increase in its scores over the years. Still in this sector, while the company Rumo (20th) occupied the 2nd position, Azul (59th) showed the lowest sectorial *performance* with the 8th position. The result presented for WEG is similar to that reported in the study by Jacintho and Kronke (2021).

Whereas Totvs (15th) occupied the best position with a mean of 0.471 points during the years analyzed, Cielo (42nd position in Table B11) was responsible for a lower efficiency with a mean score of 0.3. Cielo' result is similar from that reported in the research by Degenhart et al. (2016). While Totvs showed an almost constant increase in its performance, Cielo exposes a decrease in the reported values for each year. In relation to the materials sector, Dexco (7th) was the company responsible for the second place, which had a significant oscillation in its values over the period. On the other hand, Bradespar (53rd) and Gerdau (56th) had the lowest mean values of 0.251 and 0.219, respectively. This result can be justified according to the findings of Jacintho and Kronke (2021), which evidenced the material sector with higher weight for the share of profitability, and in this article, this financial dimension did not obtain significant weight.

Equatorial Energia (63rd) had the lowest technical efficiency in the *ranking* public service, a result similar to that reported by Degenhart et al. (2016), which classified this company in the 68th general position. Although Energisa (55th) disclosed data for only three years, this was the company that occupied the 9th sectorial position, maintaining a downward trend in its scores. These evidences can be justified according to the findings of Jacintho and Kronke (2021), which evidenced greater weight in the indicators of activities for the public service sector, and in this article, this dimension was not considered for analysis.

While Table 6 shows the mean scores of each sector, the Communication Services segment is highlighted as the sector with the highest technical efficiency on average (46.86%), according to the multidimensional performance indicators and the methodology adopted in this study.

Table 6
Ranking consolidated by sector

Cº	Sector	Pont. Total	Note	Pont. Mean (%)
1st	Communication Services	4.69	10	46.86%
2nd	Public Service	23.52	53	44.37%
3rd	Non-cyclic consumption	15.08	38	39.69%
4th	Materials	18.68	48	38.92%
5th	Information Technology	3.85	10	38.54%
6th	Industrial Goods	13.3	38	35.01%

7th	Cyclic consumption	17.07	50	34.13%
8th	Real estate	4.3	13	33.15%
9th	Energy	6.16	20	30.79%
10th	Health	4.34	15	28.91%

Legend: Cº = Position; Pont. = Score.
Source: Research data (2022).

The results are in line with the studies by Degenhart et al. (2016) and Di Domenico et al. (2017), which reveal public utility companies as the ones that highlight environmental information the most. In this study, this sector had in the second best position regarding technical efficiency, with a score of 44.37%, allowing to infer that this segment has a higher adjustment in ESG variables. This corroborates the study by Jacintho and Kroenke (2021), which indicated the public service sector as the one that evidences liquidity data the most. However, it differs from the same study when dealing with the industrial goods sector, because it is associated as a sector that points more information from the activity and, in the present result, is in the 2nd position.

Next, the non-cyclical consumption with 39.69%, materials with 38.92% and information technology with 38.54% sectors stand out. The sectors with the lowest technical efficiency were health with 28.91%, energy with 30.79%, real estate with 33.15%, cyclic consumption with 34.13% and industrial goods with 35.01%. Therefore, it is suggested that the sectors with the lowest performances on average are more concerned with the variables that received the greatest weight in this article, because society and governments claim the environmental, social and corporate governance dimensions for greater corporate responsibility.

Notwithstanding the growing academic interest and the suggestion for a performance analysis that encompasses the environmental dimension (Bachmann et al., 2013; Bititci et al., 2012; Ryszawska, 2016), the results point to Environmental Innovation as the most relevant variable. Thus, this variable is presented as a possible source of competitive advantage, enabling companies with higher scores to disclose their activities, boosting legitimacy gains (Madrigal et al., 2015; Tarmuji et al., 2016). This is due to the interest of investors and other stakeholders in how companies manage resources and conduct business(Atan et al., 2018; Del Bosco & Misani, 2016; Esteban-Sanchez et al., 2017).

5 DISCUSSION

The results of this Article reinforce the use of the multicriteria information entropy method as a sophisticated tool that allows the creation of relative weights of indicators according to the data for each year analyzed. Since Jacintho and Kronke (2021) encouraged the use of other dimensions to evaluate companies that expand economic-financial performance, such as social and environmental aspects, this research approached the conversion of the existing model of economy and finance to one based on the increase in ESG responsibility.

Regarding the informational relevance of environmental innovation, there is a gap between companies about this indicator, suggesting that innovating on environmental issues does not consist of a priority for Brazilian non-financial companies listed in Ibovespa. Although environmental innovation is pointed out as a crucial aspect to be pursued by companies in order to neutralize negative impacts on the environment and promote the responsible use of natural resources (Jakimowicz & Rzeczkowski, 2019), the findings suggest that this perception is not unique among the companies listed. In addition, the lack of regulation or inspection of environmental practices is added to the lack of recognition of the need for the adoption of activities environmentally responsible by managers in Brazil (Duque-Grisales & Aguilera-Caracuel, 2021).

The difference found points to environmental innovation as a possible source of competitive advantage. As an example, in a perspective of legitimacy theory, the result of both performance and disclosure of ESG data makes it possible to reduce the cost of debt to credit

institutions (Eliwa et al., 2021). From this perspective, the high performance, in aspects such as environmental disclosure, also contributes positively to the company's reputation before *stakeholders*, indicating indirect relationships between ESG and economic performance (Li et al., 2021). In addition, companies more concerned with socio-environmental aspects tend to have a higher quality of accounting information, with a lower probability of republishing statements (Freire & Albuquerque Filho, 2022).

Thus, the results of this study suggest a glance at innovative activities developed with an environmental focus, such as spending on research and development, training and acquisition of external knowledge. As a result, a question that unfolds is whether companies see the award of legitimacy or innovation, either from the creation of new markets or from the reduction of costs or environmental charges, offsetting the investments made. Or, then, if innovations related to socio-environmental practices occur, especially for the fulfillment of obligations imposed by regulatory bodies, as pointed out by Furtado et al. (2019).

In addition, the informational relevance of environmental innovation was identified, while broader indicators had lower weights, such as the environmental dimension and ESG. This indicates that using only broad indicators in multicriteria performance analyzes can hide technical efficiency differences between companies. *Stakeholders* can use ESG measures to assess corporate behavior and the companies' future performance (Li et al., 2021). However, ESG's dimensions are not valued uniformly by the market, varying between environmentally sensitive or non-sensitive companies (Miralles-Quirós et al., 2018). In this context, this study suggests that the subsequent breakdown of dimensions may elucidate the relevance given by companies to the different performance factors.

The study contributes to the literature by identifying among the indicators – environmental, social, corporate governance, economic-financial and market – the most relevant in the differentiation of the companies listed in the Bovespa index. In addition, it also contributes to portray, in the Brazilian scenario, the companies and sectors that have been highlighted in the indicators analyzed, encouraging the adoption of initiatives that integrate corporate sustainability practices into investment decision making.

Based on the findings of this article, practical contributions are aimed. Due to the sample differentiation in relation to environmental innovations, it is suggested that company managers show investments in this type of innovation to seek legitimacy from *stakeholders*. It is also indicated that investors are aiming to influence the strategies on the sustainability of publicly traded companies. For policymakers, regulation and inspection can contribute to the introduction of innovations focused on the environment and to the disclosure of business activities. In addition, this research reinforces the use of information entropy as a decision-making tool in the identification of weights in multicriteria analyzes, and can be used by both collegiates and managers.

6 FINAL CONSIDERATIONS

This study aimed at analyzing the weights of multidimensional performance indicators to determine the *ranking* of the companies listed in Bovespa index. The companies that obtained the best placements in the *ranking* were those that, in addition to obtaining a high general *performance* in the dimensions covered by the study, were particularly differentiated in variables with lower entropy and, consequently, more information. In this context, the environmental innovation indicator was responsible for greater information relevance, while the return on equity obtained the lowest weights each year.

It is concluded that, despite the suggestion that the role of finance is in transition from the vision of maximizing profits to sustainable development, apparently in Brazil, this process is still far from consolidation. These findings also reflect the need to extend the usefulness of accounting information through multidimensional indicators to its distinct users, who need to make decisions

that involve evaluating companies with different criteria and weights. Thus, given the scarcity of studies that consider the sustainable dimensions in rankings classification , this research offers subsidies to emphasize the importance of ESG practices, by showing that the listed companies can gain more benefits, achieving legitimacy through voluntary ESG disclosures.

As for the limitations, initially, the choice of variables from the *Refinitiv Eikon* basis is not exempt form subjectivity. Thus, future studies may include other indicators for the analyzed dimensions. In this context, the division of environmental innovation may allow for more understanding of its types, considering object (e.g., products or processes) or content (e.g., radical or incremental). Second, despite highlighting the level of the companies' technical efficiency and their evolution over the years, it was not possible to explain what led to variations in the scores of these companies in the *rankings*. Therefore, other studies may consider the elements of the companies' sustainability report that are highlighted positively and negatively in the *ranking*. A third limitation is in line with the non-generalization of the results for the Brazilian stock market's companies. In view of this, there are initiatives for future research to analyze a larger sample of companies, especially the companies listed in B3.

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APPENDIX A – Values of the established indicators and demonstration of the Entropy method

Although the present study analyzes the period from 2016 to 2020, this appendix presents the data referring only to the last year and the first five companies of the sample, according to alphabetical order, since it is intended merely to demonstrate the processes performed to identify the variables entropy and, consequently, their weights. Thus, Table 1 shows the values calculated of each variable by company

Table A1
Values calculated of the study variables by companies

Nº	ESG	PMA	IME	PS	DI	PGC	PG	ROA	ROE	LC	AF	MTB	RT
1	51.1	69.5	60.6	52.2	61.67	27	24.2	0.09	0.15	1.05	0.41	1.96	-0.14
2	46.9	51.7	0	35.7	62.7	54.3	51.6	-0.01	-0.02	2.96	0.58	1.87	0.21
3	1.67	0	0	2.63	0.00	1.46	0.4	0.05	0.17	1.03	0.69	0.74	-0.16
4	44.3	38.2	0	47.7	56.4	46.2	63.9	-0.69	0.77	0.53	1.89	0.82	-0.33
5	37.5	19.08	0	45.4	0.00	46.7	46.7	-0.02	-0.03	4.01	0.43	0.45	-0.45
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Legend: Nº 1 - Ambev; Nº 2 – Americanas; Nº 3 – Atacadão; Nº 4 – Azul; Nº 5 – BR Malls. Source: Research data (2022).

After verifying the variables, the minimum value of each column was verified, since Entropy is not applicable for negative numbers. Thus, it was observed that the ROA, ROE, RT indicators presented negative minimum values. To adjust, the module of the minimum of each of these variables was added to all the cells in the same column. In addition, as highlighted in the

method, the AF variable has an inverse interpretation (the lower the better), which also required normalization. Thus, the values of these four indicators were adjusted, as shown in Table A2.

Table A2
Values of the variables calculated considering the absence of negative numbers

Nº	ESG	PMA	IME	PS	DI	PGC	PG	ROA	ROE	LC	AF	MTB	RT
1	51.1	69.5	60.6	52.2	61.67	27	24.2	0.79	26.4	1.05	1.72	1.96	0.46
2	46.9	51.7	0	35.7	62.7	54.3	51.6	0.69	26.3	2.96	1.55	1.87	0.81
3	1.67	0	0	2.63	0.00	1.46	0.4	0.75	26.5	1.03	1.43	0.74	0.44
4	44.3	38.2	0	47.7	56.4	46.2	63.9	0.01	27.1	0.53	0.23	0.82	0.27
5	37.5	19.08	0	45.4	0.00	46.7	46.7	0.68	26.3	4.01	1.69	0.45	0.15
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Legend: Nº 1 - Ambev; Nº 2 – Americanas; Nº 3 – Atacadão; Nº 4 – Azul; Nº 5 – BR Malls. Source: Research data (2022).

Then, the values of each column are summed and, from these, a new matrix is built by dividing each cell of the original matrix by the sum of its column, triggering what is conceptualized as the matrix normalization. Due to the fact that this normalization is necessary to obtain a comparative effect, Table A3 is shown.

Table A3
Normalization of data and sum of columns

Nº	ESG	PMA	IME	PS	DI	PGC	PG	ROA	ROE	LC	AF	MTB	RT
1	0.57	0.75	0.61	0.54	0.89	0.30	0.24	0.92	0.90	0.09	0.81	0.25	0.25
2	0.52	0.56	0	0.37	0.91	0.60	0.52	0.80	0.90	0.25	0.73	0.23	0.43
3	0.02	0.00	0	0.03	0.00	0.02	0.00	0.87	0.90	0.09	0.67	0.09	0.24
4	0.49	0.41	0	0.49	0.82	0.51	0.65	0.02	0.92	0.04	0.11	0.10	0.15
5	0.42	0.21	0	0.47	0.00	0.52	0.47	0.80	0.90	0.34	0.80	0.06	0.08
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Sum	41	36.8	17.3	39.5	49.4	41.5	39.3	53.1	56.6	10	43	9.3	23

Legend: Nº 1 - Ambev; Nº 2 – Americanas; Nº 3 – Atacadão; Nº 4 – Azul; Nº 5 – BR Malls. Source: Research data (2022).

After normalization, the alternatives are hierarchized by a specific criterion by calculating the mean of each line of the normalized matrix. It should be emphasized that the sum of these alternatives prioritization indices within a criterion must be equal to 1. This procedure is repeated for all criteria, in order to obtain a hierarchy of alternatives in relation to each criterion, as shown in Table A4.

Table A4
Probabilistic values of the indicators in the alternatives

Nº	ESG	PMA	IME	PS	DI	PGC	PG	ROA	ROE	LC	AF	MTB	RT
1	0.01	0.02	0.04	0.01	0.02	0.01	0.01	0.02	0.02	0.01	0.02	0.03	0.01
2	0.01	0.02	0.00	0.01	0.02	0.01	0.01	0.02	0.02	0.03	0.02	0.03	0.02
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.01	0.02	0.01	0.01
4	0.01	0.01	0.00	0.01	0.02	0.01	0.02	0.00	0.02	0.00	0.00	0.01	0.01
5	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.02	0.03	0.02	0.01	0.00
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Sum	1	1	1	1	1	1	1	1	1	1	1	1	1

Legend: Nº 1 - Ambev; Nº 2 – Americanas; Nº 3 – Atacadão; Nº 4 – Azul; Nº 5 – BR Malls. Source : research data (2022).

As explained in the method, the entropy measurement, according to intensity contrast for the i-*th* attribute, is calculated by $e(d_i)=-\alpha \sum_{k=1}^{m} \frac{d_i^k}{D_i} Ln(\frac{d_i^k}{D_i})$, where $\alpha = \frac{1}{E_{max}} > 0$ and $E_{max}=Ln(m)$, as

shown in Table A5.

Table A5
Values of entropy measurements

Nº	ESG	PMA	IME	PS	DI	PGC	PG	ROA	ROE	LC	AF	MTB	RT
1	-0.06	-0.08	-0.12	-0.06	-0.07	-0.04	-0.03	-0.07	-0.07	-0.04	-0.07	-0.10	-0.05
2	-0.06	-0.06	0.00	-0.04	-0.07	-0.06	-0.06	-0.06	-0.07	-0.09	-0.07	-0.09	-0.07
3	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	-0.07	-0.07	-0.04	-0.07	-0.05	-0.05
4	-0.05	-0.05	0.00	-0.05	-0.07	-0.05	-0.07	0.00	-0.07	-0.02	-0.02	-0.05	-0.03
5	-0.05	-0.03	0.00	-0.05	0.00	-0.05	-0.05	-0.06	-0.07	-0.12	-0.07	-0.03	-0.02
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Sum	-4.09	-4.02	-3.35	-4.09	-4.08	-4.08	-4.05	-4.14	-4.14	-3.98	-4.13	-3.75	-3.98
Entr.	0.984	0.967	0.804	0.983	0.980	0.981	0.974	0.994	0.996	0.956	0.903	0.903	0.984

Legend: Nº 1 - Ambev; Nº 2 – Americanas; Nº 3 – Atacadão; Nº 4 – Azul; Nº 5 – BR Malls. Source: Research data (2022).

Thus , the lower the $e(d_i)$, the greater the information transmitted, that is, the greater the criterion weight. Thus, Table 4, presented in the analysis of the results, shows the entropy calculation among the indicators (variables) and their respective weights. It is noteworthy, therefore, that Tables A1 to A5 merely seek to exemplify the processes that were performed to identify the variables entropy in Table 4 of the Article.

APPENDIX B – Sectoral and consolidated *rankings*

Table B1
Evolution of communication services ranking Companies

Communication Services	2016		2017		2018		2019		2020		*Ranking*
	Cº	Pont	Cº	Pont	Cº	Pont	Cº	Pont	Cº	Pont	CSº
Telefônica Brasil	22nd	0.355	23rd	0.369	29º	0.398	29º	0.372	30th	0.314	2nd
Tim	10th	0.566	8th	0.566	10th	0.603	11th	0.611	12th	0.532	1st

Legend: Cº = General Position, Pont = Score, CSº = Sectorial Classification considering every year.
Source: Research data (2022).

Table B2
Evolution of cyclic consumption services ranking companies (discretionary)

Cyclic consumption	2016		2017		2018		2019		2020		*Ranking*
	Cº	Pont	Cº	Pont	Cº	Cº	Cº	Pont	Cº	Pont	CSº
Americanas	42nd	0.216	39th	0.279	30th	0.392	41st	0.321	43rd	0.269	8th
Cogna Educação	29th	0.302	25th	0.353	39th	0.335	52nd	0.281	52nd	0.214	7th
CVC Viagens	-	-	50th	0.167	58th	0.169	63rd	0.103	63rd	0.130	11th
Cyrela Brazil Realty	39th	0.241	44th	0.238	47th	0.270	55th	0.244	57th	0.193	10th
Lojas Americanas	36th	0.271	41st	0.269	37th	0.344	36th	0.337	41st	0.281	6th
Lojas Renner	8th	0.592	1st	0.623	1st	0.829	1st	0.811	2nd	0.666	1st
Magazine Luiza	-	-	-	-	40th	0.332	48th	0.290	29th	0.322	5th
MRV Engenharia	37th	0.260	32nd	0.311	14th	0.507	19th	0.461	26th	0.363	3rd
Petrobras Distribuidora	-	-	-	-	17th	0.488	22nd	0.432	23rd	0.376	2nd
Via	17th	0.430	17th	0.420	20th	0.464	49th	0.284	42nd	0.270	4th
YDUQS Participações	44th	0.205	27th	0.338	45th	0.290	46th	0.297	59th	0.186	9th

Legend: Cº = General Position, Pont = Score, CSº = Sectorial Classification considering every year.
Source: Research data (2022).

Table B3
Evolution of non-cyclic services consumption ranking Companies

Non-cyclic consumption	2016		2017		2018		2019		2020		*Ranking*
	Cº	Pont	Cº	Pont	Cº	Cº	Cº	Pont	Cº	Pont	CSº
Ambev	9th	0.578	6th	0.583	13th	0.555	15th	0.565	17th	0.464	2nd
Atacadão	-	-	-	-	62nd	0.101	64th	0.091	64th	0.072	9th
BRF	26th	0.310	38th	0.286	35th	0.348	33rd	0.342	44th	0.269	7th
Comp. de Distribuição	19th	0.365	19th	0.411	23rd	0.452	25th	0.394	28th	0.327	4th
JBS	14th	0.489	13th	0.460	26th	0.435	6th	0.671	9th	0.586	3rd
Marfrig Global Foods	21st	0.358	24th	0.364	34th	0.350	27th	0.385	27th	0.346	5th
Minerva	-	-	-	-	12th	0.567	10th	0.632	14th	0.520	1st
Natura & Co Holding	-	-	-	-	-	-	39th	0.328	39th	0.288	8th
Raia Drogasil	20th	0.359	21st	0.401	32nd	0.366	32nd	0.362	34th	0.303	6th

Legend: Cº = General Position, Pont = Score, CSº = Sectorial Classification.
Source: Research data (2022).

Table B4
Evolution of Energy ranking Companies

Energy	2016		2017		2018		2019		2020		*Ranking*
	Cº	Pont	Cº	Pont	Cº	Cº	Cº	Pont	Cº	Pont	CSº
Cosan	38th	0.253	46th	0.228	51st	0.243	31st	0.362	33rd	0.308	3rd
Petro Rio	47th	0.197	43rd	0.254	55th	0.212	58th	0.211	54th	0.201	4th
Petrobras	15th	0.439	20th	0.405	17th	0.488	22nd	0.432	23rd	0.376	1st
Ultrapar Participações	28th	0.309	30th	0.313	38th	0.343	42nd	0.319	45th	0.264	2nd

Legend: Cº = General Position, Pont = Score, CSº = Sectorial Classification.
Source: Research data (2022).

Table B5
Evolution of Health ranking Companies

Health	2016		2017		2018		2019		2020		*Ranking*
	Cº	Pont	Cº	Pont	Cº	Cº	Cº	Pont	Cº	Pont	CSº
Fleury	-	-	-	-	41st	0.331	30th	0.362	36th	0.296	1st
Hypera	46th	0.199	40th	0.270	46th	0.280	28th	0.372	35th	0.299	3rd
Notre Dame Intermédica	-	-	-	-	-	-	40th	0.325	40th	0.287	2nd
Qualicorp	41st	0.227	33rd	0.306	49th	0.255	38th	0.329	55th	0.199	4th

Legend: Cº = General Position, Pont = Score, CSº = Sectorial Classification.
Source: Research data (2022).

Table B6
Evolution of Industrial Goods ranking Companies

Industrial Goods	2016		2017		2018		2019		2020		*Ranking*
	Cº	Pont	Cº	Pont	Cº	Pont	Cº	Pont	Cº	Pont	CSº
Azul	-	-	-	-	56th	0.209	57th	0.225	60th	0.180	8th
CCR	31st	0.285	35th	0.295	43rd	0.320	45th	0.300	49th	0.230	6th
Ecorodovias	33rd	0.275	28th	0.325	33rd	0.353	43rd	0.304	47th	0.256	5th
Embraer	18th	0.372	16th	0.445	18th	0.483	20th	0.451	24th	0.370	3rd
Gol Linhas Aéreas	49th	0.171	31st	0.313	42nd	0.322	53rd	0.264	56th	0.196	7th
Localiza Rent a Car	32nd	0.282	29th	0.317	31st	0.387	37th	0.329	31st	0.313	4th
Rumo	25th	0.323	15th	0.450	19th	0.476	18th	0.480	20th	0.398	2nd
WEG	16th	0.435	12th	0.483	15th	0.501	14th	0.579	4th	0.607	1st

Legend: Cº = General Position, Pont = Score, CSº = Sectorial Classification.
Source: Research data (2022).

Table B7
Evolution of Information Technology ranking Companies

Information Technology	2016		2017		2018		2019		2020		*Ranking*
	Cº	Pont	Cº	Pont	Cº	Cº	Cº	Pont	Cº	Pont	CSº
Cielo	24th	0.335	34th	0.297	36th	0.345	47th	0.293	50th	0.229	2nd
Totvs	35th	0.273	36th	0.294	11th	0.578	9th	0.655	10th	0.555	1st

Legend: Cº = General Position, Pont = Score, CSº = Sectorial Classification considering every year.
Source: Research data (2022).

Table B8
Evolution of Materials ranking Companies

Materials	2016		2017		2018		2019		2020		*Ranking*
	Cº	Pont	Cº	Pont	Cº	Pont	Cº	Pont	Cº	Pont	CSº
Bradespar	40th	0.236	42nd	0.263	48th	0.262	59th	0.202	38th	0.293	9th
Braskem	23rd	0.352	22nd	0.387	27th	0.434	35th	0.337	32nd	0.309	6th
Siderúrgica Nacional	13th	0.498	18th	0.420	21st	0.460	21st	0.439	16th	0.465	3rd
Dexco	7th	0.596	14th	0.457	5th	0.687	7th	0.658	8th	0.590	2nd
Gerdau	48th	0.191	51st	0.164	54th	0.221	54th	0.264	48th	0.255	10th
Klabin	6th	0.597	5th	0.585	6th	0.665	4th	0.679	5th	0.606	1st
Metalúrgica Gerdau	43rd	0.213	49th	0.172	50th	0.243	16th	0.502	18th	0.440	7th
Suzano	-	-	-	-	16th	0.491	26th	0.386	22nd	0.382	4th
Usiminas	30th	0.293	45th	0.228	53rd	0.229	44th	0.303	37th	0.295	8th
Vale	27th	0.309	26th	0.345	28th	0.409	34th	0.342	13th	0.526	5th

Legend: Cº = General Position, Pont = Score, CSº = Sectorial Classification considering every year.
Source: Research data (2022).

Table B9
Evolution of Real Estate ranking Companies

Real estate	2016		2017		2018		2019		2020		*Ranking*
	Cº	Pont	Cº	Pont	Cº	Pont	Cº	Pont	Cº	Pont	CSº
BR Malls Participações	51st	0.135	52nd	0.148	59th	0.168	60th	0.191	61st	0.154	3rd
Iguatemi Centers	-	-	-	-	60th	0.166	51st	0.282	58th	0.188	2nd
Multiplan Imobiliários	5th	0.605	7th	0.569	9th	0.603	12th	0.604	15th	0.496	1st

Legend: Cº = General Position, Pont = Score, CSº = Sectorial Classification considering every year.
Source: Research data (2022).

Table B10
Evolution of Public Service ranking Companies

Public Service	2016		2017		2018		2019		2020		*Ranking*
	Cº	Pont	Cº	Pont	Cº	Pont	Cº	Pont	Cº	Pont	CSº
Centrais Elétricas	3rd	0.631	4th	0.595	2nd	0.705	3rd	0.715	3rd	0.642	2nd
SABESP	12th	0.507	11th	0.486	24th	0.441	17th	0.489	25th	0.364	6th
CEMIG	11th	0.558	9th	0.534	7th	0.649	5th	0.677	7th	0.595	4th
COPEL	34th	0.275	37th	0.291	25th	0.439	23rd	0.426	19th	0.430	7th
CPFL Energia	4th	0.623	2nd	0.607	3rd	0.702	8th	0.658	6th	0.600	3rd
EDP Energias do Brasil	2nd	0.644	10th	0.533	8th	0.625	13th	0.591	11th	0.544	5th
Energisa	-	-	-	-	52nd	0.242	56th	0.240	53rd	0.208	9th
Eneva	45th	0.204	47th	0.226	44th	0.307	50th	0.284	46th	0.258	8th
Engie	1st	0.690	3rd	0.603	4th	0.688	2nd	0.763	1st	0.666	1st
Equatorial Energia	52nd	0.105	53rd	0.100	61st	0.114	62nd	0.185	62nd	0.138	11th
Transmissora Aliança	50th	0.139	48th	0.174	57th	0.203	61st	0.189	51st	0.216	10th

Legend: Cº = General Position, Pont = Score, CSº = Sectorial Classification considering every year. Source: Research data (2022).

Table B11
Consolidated ranking of companies

Cº	Institution	Pont.	Cº	Institution	Pont.
1st	Lojas Renner	0.704	33rd	Localiza Rent a Car	0.326
2nd	Engie Brasil Energia	0.682	34th	Magazine Luiza	0.314
3rd	Centrais Elétricas Brasileiras	0.657	35th	Metalúrgica Gerdau	0.314
4th	CPFL Energia	0.638	36th	BRF	0.311
5th	Klabin	0.626	37th	Ultrapar Participações	0.310
6th	CEMIG	0.602	38th	Natura & Co Holding	0.308
7th	Dexco	0.598	39th	Notre Dame Participações	0.306
8th	EDP Energias do Brasil	0.587	40th	Ecorodovias	0.303
9th	Tim	0.575	41st	Lojas Americanas	0.300
10th	Multiplan Empreend. Imob.	0.575	42nd	Cielo	0.300
11th	Minerva	0.573	43rd	Cogna Educação	0.297
12th	Ambev	0.549	44th	Americanas	0.295
13th	JBS	0.528	45th	CCR	0.286
14th	WEG	0.521	46th	Hypera	0.284
15th	Totvs	0.471	47th	Con	0.279
16th	BESP	0.457	48th	USIMINAS	0.270
17th	Companhia Siderúrgica Nacional	0.456	49th	YDUQS Participações	0.263
18th	Petrobras Distribuidora	0.432	50th	Qualicorp e Corretora de Seguros	0.263
19th	Petróleo Brasileiro Petrobras	0.428	51st	Eneva	0.256
20th	Rumo	0.426	52nd	Gol Linhas Aéreas Inteligentes	0.253
21st	Embraer	0.424	53rd	Bradespar	0.251
22nd	Suzano	0.420	54th	Cyrela Brazil Realty	0.237
23rd	Companhia Brasileira de Distribuição	0.390	55th	Energi	0.230
24th	Vale	0.386	56th	Gerdau	0.219
25th	MRV Engenharia e Participações	0.380	57th	Petro Rio	0.215
26th	Via	0.374	58th	Iguatemi Shopping Centers	0.212
27th	Companhia Paranaense de Energia	0.372	59th	Azul	0.205
28th	Braskem	0.364	60th	Transmissora Aliança	0.184
29th	Telefônica Brasil	0.362	61st	BR Malls Participações	0.159
30th	Marfrig Global Foods	0.361	62nd	CVC Brasil	0.142
31st	Raia Drogasil	0.358	63rd	Equatorial Energia	0.128
32nd	Fleury	0.330	64th	Atacadão	0.088

Legend: Cº = Position; Pont. = Score.
Source: Research data (2022).