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FRAMEWORK PROPOSALCRITIC-SMART - ENTROPIC FOR MULTI-CRITERIA DECISION ANALYSIS AND RISK ANALYSIS

Eder Costa Cassettari
Escola Politécnica – USP / Instituto Militar de Engenharia - IME

Marcos dos Santos
Instituto Militar de Engenharia – IME

João Benito Savastano
Mondial Informática

Abstract: This framework proposal presents a new solution for Multi-Criteria Decision Analysis, including Risk Analysis, with group technology. The area of Strategic Administration has a competitive attribute in relation to the General Theory of Administration, TGA, the "Environmental Analysis" component, which aims to ensure focus and competitiveness for the organization, observing the dimensions General Environment, Operational Environment and Internal Environment. In practice, within organizations, they tend to be very subjective and devoid of any supporting scientific and mathematical frameworks. This method fills this gap, to support the decision maker(s) in making a decision using science and facilitating the justification of the aforementioned decision, allowing the selection of the best alternative in a scientific, objective, quick and assertive way.
Keywords: Multicriteria Decision Analysis, Strategic Management, CRITIC Method, CRITIC STRAT G Method, Risk Analysis

INTRODUCTION

Decision makers often need to perform this task, with strategy problems related to the selection or management of new projects as well as guiding the organization and bringing together aspects related to the risk analysis of executing a project or a business redirection to meet new needs. market trends and/or restrictions.

The difficulties are numerous due to the subjectivity related to the subject, in most cases. There is a lack of consensus among decision makers to reach a verdict and how the matter must be handled, in addition to the need for strong arguments to convince the organization's management and shareholders.

It must be remembered that, most of the time, decisions of this type imply a large financial impact for the organization. This proposal aims to provide scientific/mathematical support for a strategic analysis of the organization, using science and mathematical and computational methods to determine and justify the best solution.

PROBLEM

A new investment opportunity is detected within the organization. It will be necessary to select the best strategy to conduct a new business, which has several possible scenarios that are called within the Multi-Criteria Decision Analysis framework, "alternatives" (GOMES, GOMES, 2019) that make up the set of possible solutions established.

In this condition, it will be necessary to establish what "decision criteria" will be established. After this definition, establish how they must be scored and how the divergence between the understanding between decision makers must be treated.

As it is very common to have, in addition to multiple decision-makers (usually at C-Level, directors and president), several possible alternatives, a decision support analysis method must be established.

The class of methods that will be selected is called Multi-Criteria Decision Analysis, with group decision, that is, several decision-makers working at the same time in the decision-making process.

It is established which is the best method to be used among these established restrictions in order to facilitate decision-making and justify it with arguments aided and based on science and with mathematical/computational tools to strengthen and justify it, avoiding possible problems accepting the final selected alternative.

For this last stage, the CRITIC method, Criteria Importance Through Intercriteria Correlation, proposed by Diakoulaki, Mavrotas and Papayannakis in 1995, was selected.

The main reasons for this decision were:

- Mainly used to determine the weight of attributes,

- Attributes are not in contradiction with each other and attribute weights are determined using the decision matrix,

- There is no need for attribute independence;

- Qualitative attributes are transformed into quantitative attributes.

Regarding qualitative attributes, the table of seven values proposed by Miller (1956) will be used to transform them into quantitative ones.

This work also takes into account the concepts established in the New CRITIC-STRAT-G Framework, proposed by Cassettari, Santos and Baldini (2021), but in this new method the original was improved and became more general in its applications and bringing concepts used in Data Science, Artificial Intelligence and Cognitive Science.

THEORETICAL FOUNDATION

According to CERTO & PETER (1993), Strategic Management emerged in the 1950s, with the publication of the Gordon-Howell report, in which there was a recommendation that business schools broaden their horizons with the inclusion of a new area, a new subject entitled "Business Policy".

During the 1960s, the business policy course was expanded, using this new concept of how the company relates to its environment, together with the development of a "global vision" of the organization, with the aim of show how the company is currently situated and what its condition will be in the future, precisely based on the analysis of the environment in which it finds itself.

The treatment of Strategic Management as a scientific methodology emerged in the early 1960s with the publications of Igor Ansoff. At the same time, the name Strategic Planning appeared, and the first confusion about both concepts emerged. The concept of Strategy can be defined as:

"Strategy is senior management's plans to achieve results consistent with the organization's mission and objectives" (WRIGHT et al, 2000).

"Strategy is a perspective shared by the members of an organization, through their intentions and/or actions" (MINTZBERG, 1994).

As described in CERTO & PETER (1993), the Strategic Administration process can be didactically and schematically visualized through figure 1:

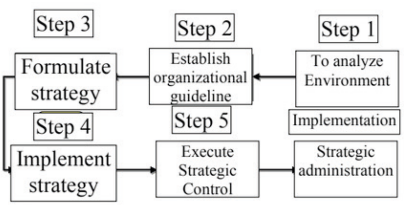

FIGURE1- Strategic Management Overview

Source: Adapted from Certo and Peter (1993)

Strategic Management can be defined as "A continuous and interactive process that aims to maintain an organization as a cohesive whole and appropriately integrated into its environment" (CERTO & PETER, 1993). The definition emphasizes that administrators dedicate themselves to a series of five steps, namely: Carrying out an analysis of the environment, Establishing the organization's guidelines, Formulating the organizational strategy, Implementing the organizational strategy and Exercising strategic control.

Strategic Management is a cultural process, as its objective is to change mentality within organizations, and must be incorporated by all employees and mainly by senior management, while Strategic Planning is a methodological process of Strategic Management, consisting of several steps, by logic, and assisted by various techniques such as scenarios, predictions, simulation, among others.

Strategic Management and Strategic Planning bring many benefits to organizations, in various fields as mentioned in WRIGHT et al (2000) and MINTZBERG (2000). Management programs and operational plans must be developed for administrative and resource use activities that, when carried out in accordance with strategy, enable the company as a whole to achieve objectives.

Control information must be provided to provide facts and values to help people follow strategies, policies, rules and procedures, ultimately being within the new established culture. Measure the company's overall performance in relation to established plans and standards.

Finally, the emphasis in Strategic Management on assessing the environment places this discipline in a situation where the probability of being surprised by market movements is lower.

Certo and Peter (1993) describe Environmental Analysis as the process of monitoring the organizational environment that aims to identify risks and opportunities, both present and future, that may influence the ability of companies to achieve their goals, their purpose of existence.

Therefore, this stage measures the degree of adaptability that the organization has in relation to the environment, selects the most adapted, strong organizations, and eliminates the least adapted, weak ones, the same role that nature plays with species, as described in the Theory of Evolution or Evolutionism by Charles Darwin.

The organization can be approached as an open system, consisting of input, output and processing immersed in an environment, which in turn can be subdivided into other subsystems with the same type of structure.

Such subsystems interact with each other and compete for a single purpose, which in turn are monitored by control instruments, producing new inputs that will be processed again by the system.

Concepts mentioned in General Systems Theory, TGS, are being used here. As the interaction between the environment and the system occurs inevitably, we must ensure that this interaction is focused in the most positive way possible, to assist in work that contributes to organizational success.

The organization can ultimately be seen as a control volume immersed in a universe, which we call the environment, which nourishes the entire organization, which in turn provides it with an output, which will be absorbed by it and will also affect it. Figure 2 illustrates this division:

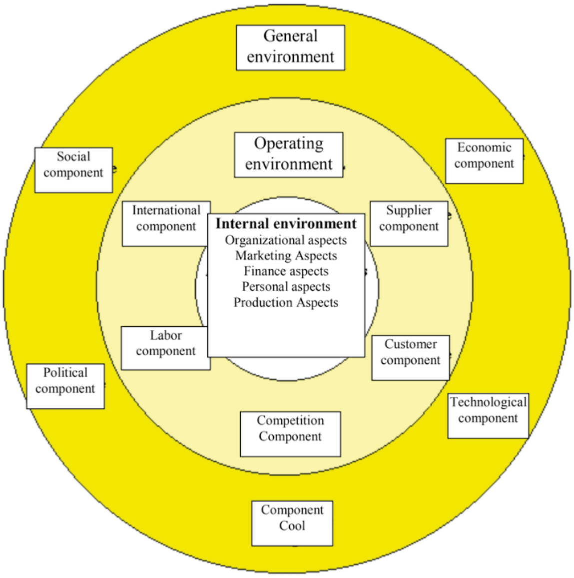

FIGURE 2- Environmental levels and components

Source: Adapted from Certo and Peter (1993)

Environmental scanning is the process in which information about events and their relationships within the external and internal environments of organizations is gathered. After this examination, the analysis of risks and opportunities is the first objective of the environmental analysis, in which the factors that can affect the success of the organization will be identified, the so-called SWOT analysis (WRIGHT et al, 2000).

Environmental Forecasting, according to CERTO & PETER (1993), is the process for determining future conditions within the organizational environment. There are many techniques for implementing it, some simple, others complex such as trend extrapolation.

In terms of methods for environmental forecasting, there are several. Listening to an "expert's opinion" is one of them. Another method is "trend extrapolation," in which researchers prepare adjusted curves over time to serve as a basis for extrapolation.

"Trend correlation" helps researchers identify primary and secondary relationships that can be used in forecasting. In "dynamic modeling", sets of equations are assembled with the aim of describing the underlying systems. "Cross-impact analysis" uses key trends.

"Multiple scenarios" use scenarios of various future alternatives to determine the possibility of occurrence and the respective contingency planning, which is their main objective. As described in Certo and Peter (1993) and Wright et al (2000), environmental analysis is a direct consequence of the application of General Systems Theory in Strategic Management. It is the competitiveness attribute of strategic management in relation to traditional business administration.

THE CRITIC MULTI-CRITERIA DECISION ANALYSIS METHOD

As mentioned previously, the CRITIC method, Importance Through Intercretiria Correlation, was proposed by Diakoulaki, Mavrotas and Papayannakis in 1995. It is used to determine the weight of attributes, there is no need for attribute independence, and qualitative attributes are transformed into quantitative attributes. The decision matrix is based on the method input and the alternatives and attributes are based on the information received from the decision maker, as shown in the equation below.

$$X = \begin{bmatrix} r11 & \cdots & r1j & \cdots & r1n \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ ri1 & \cdots & rij & \cdots & rin \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ rm1 & \cdots & rmj & \cdots & rmn \end{bmatrix}_{mxn} \quad \text{where} : i = 1, \ldots, m, \; j = 1, \ldots, n$$

Where rij indicates the element of the decision matrix for the ith alternative in the jth attribute.

It must initially be classified whether the attribute is monotonic of Profit or Cost. A given function between two ordered sets is monotonic when it preserves or inverts the order relationship. When it preserves, it is called an increasing function, or Profit. When it inverts, it is called a decreasing or cost function.

This classification is important because while the monotonic function looks for a result "the bigger the better" the cost function looks for a "the smaller the better". This conceptually changes the mathematical operations involved in the data normalization process, as will be described below.

In step 1 of the solution, the normalized matrix is created, using the formulas below(1a) and (1b):

For Monotonic Profit Criterion

$$X_{ij} = \frac{(rij - ri \;)}{(ri \quad - ri \;)} \; , i = 1, 2, .. n \; e \; j = 1, 2, \; \ldots, n \quad (1a)$$

For Monotonic Cost Criterion

$$X_{ij} = \frac{(ri' \quad - rij)}{(ri \quad - ri \;)} \; , i = 1, 2, .. n \; e \; j = 1, 2, \; \ldots, n \quad (1b)$$

Where:

Important Note - If $r_i^+ = r_i^-$, (equal scores) is used for X1j' = X1j + 0.001, as a correction factor, with j being the affected criterion. This correction does not exist in the CRITIC Method and was proposed by Cassettari and Santos (2021) within the CRITIC – STRAT - G method.

It is used to positive attributes, that is, monotonic profit attributes. In this analysis, all criteria must be the greatest possible, as it is desired that all components be the best (largest) possible.

In step 2, using the original CRITIC method, the correlation coefficient between the attributes is calculated using the equation below:

$$\rho jk = \frac{\sum_{i=1}^{m}(x_{ij} - \bar{x}_j).(x_{ik} - \bar{x}_k)}{\sqrt{\sum_{i=1}^{m}(x_{ij} - \bar{x}_j)^2 . \sum_{i=1}^{m}(x_{ik} - \bar{x}_k)^2}} \quad (2)$$

Where $\bar{x}_j\bar{x}_j$ It is $\bar{x}_k\bar{x}_k$ represent the average of the j-th and k-th attributes. $\bar{x}_j\bar{x}_j$ is calculated from equation (3). In the same way, it is obtained for $\bar{x}_k\bar{x}_k$ .Furthermore, $\rho_{jk}\rho_{jk}$ is the correlation coefficient between the jth and kth attributes.

$$\bar{X}_j = \frac{1}{n}\sum_{j=1}^{n} X_{ij}; \quad i = 1, \ldots, m \quad (3)$$

For the CRITIC – SMART – ENTROPICO method, it is proposed to use the concepts of Entropy proposed by Claude E. Shannon and Warren Weaver in the book "The Mathematical Theory of Communication" published in 1949, which is also a paired comparison methodology, the which is now widely used within the area of Data Science, Artificial Intelligence and Cognitive Sciences.

In Decision Tree algorithms this concept is widely used. For variables we can do calculations because we have numerical data and do, for example, Regression as a predictive technique.

For categorical values, attribute type data, classification can be performed, better known as "Clustering" or "Clustering". In a given model, the more Entropy (H) increases, the smaller the organization of the model becomes and vice versa.

Therefore, using the concept of Entropy proposed by Shannon (H), we have equation (1c) below considering the elements i and j of the decision matrix:

$$H_{ij} = -(P_i - log_2(P_i)) - ((Pj - log_2(P_j))$$
$$i = 1, 2, .. n \, e \, j = 1, 2, \ldots, n \, (1c)$$

Shannon w Weaver (1949) define in a generic way, the equation below (1d) which for the special case of paired comparison provides equation (1c) which is used in this study.

$$H_X = -\sum_{x=1}^{x}(P_i - log_2(P_i)), \; i = 1, 2, .. n \; (1d)$$

Another concept introduced byShannon w Weaver (1949)'s definition of information: "Information quantifies the uncertainty of an event", it is a measure of surprise)". Mathematically, given by equation (1e)

$$I_X = -(log_2(P_X))(1 \text{ and})$$

In step 3, the "C" index is calculated as shown below.The standard deviation of each attribute is estimated by equation (4).

$$\sigma j = \sqrt{\frac{1}{n-1}\sum_{j=1}^{n}(x_{ij} - \bar{x}_j)^2}; \quad i = 1, \ldots, m \quad (4)$$

Next, the index (C) is calculated using.

$$C_j = \sigma_j . \sum_{k=1}^{n}(1 - \rho jk); \quad j = 1, \ldots, n \quad (5)$$

In step 4, the weight of the attributes is calculated. The weights of the attributes are determined by equation (6).

$$W_j = \frac{C_j}{\sum_{j=1}^{n} C_j}; \quad j = 1, \ldots, n \quad (6)$$

In step 5, the final ranking of the attributes is determined and placed on a graph.

METHODOLOGY TO BE USED

To validate the proposed framework, CRITIC – SMART – Entropy, Exploratory Research was used to create familiarity with the topic, Descriptive for a thorough and descriptive analysis of the objective of the study and finally explanatory, detailing the details of the method. The methods will be Experimental Research, Bibliographic Research and Case Study and the techniques will be the use of a genetic algorithm to generate scores for the alternatives for each of the criteria, to validate the method through quantitative data analysis. Figure 3 illustrates this process:

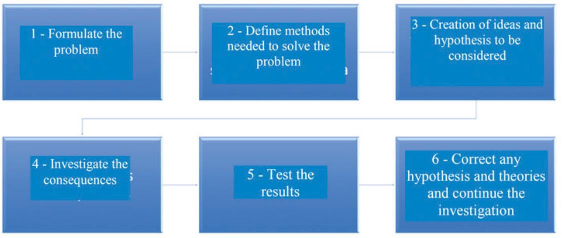

FIGURE3- Methodology used

Source: Prepared by the Authors

Problem Definition - To validate this new framework, a case study will be carried out. A scenario will be assumed in which the organization needs to evaluate a new project that will have a major impact on cash flow.

Hypotheses: The organization's Senior Management wants a risk analysis of the General Environment, Operational Environment and Internal Environment, to guarantee the success of this new venture. Therefore, these dimensions must be ranked in order of importance to improve management focus during project execution and guarantee its success even if there are resource constraints. All decisions must be made by a multifunctional group made up of representatives from all areas. The seven-point Miller table will be used as shown in Table 1 below:

NOTES TABLE	
3	Highly important
2	Very important
1	Important
0	Neutral
-1	Little important
-2	Very unimportant
-3	Highly unimportant

TABLE 1: Miller's Seven Point Table

Source: Miller (1956)

Initially, all decision makers must reach an agreement regarding the grades. You can, for example, use a voting system for the definition. Attribute data must have its value switched to variable using table 1.

Next, data must be entered for the Internal, Operational and General Environment, using the dimensions: Organization, Marketing, Finance, Personnel, Production, Supplier, Customer, Competition, Labor, International, Economy, Technology, Legal, Political and Social as shown in table 2.

Each possible project will be represented by an alternative (Proj01, Proj02, Proj03 and Proj04). Then the maximum and minimum value will be calculated for each alternative within each criterion, according to table 2.

To show the scope of the method, in addition to the attributes of the experimental analysis part, three non-strategic variables were used, namely: Investment in millions of reais, Labor Cost, Automation Cost.

If necessary, the correction factor is applied, as shown in table 2(a)

Then, the values are normalized using equations (1a) and (1b), depending on whether the criterion is monotonic profit or cost, shown previously in table 3

Calculating the Paired Entropy according to formula (1c) for each pair of decision attributes, shown in table 4, and in the sequence for (1 – H) in table 5:

With this, we arrive at the Criticality Ranking for the attributes. The result of the method is table 6. It shows a more structured presentation of the results, pasting the dimensions in ascending order of their weights (w), and concluding the application of this framework and showing its applicability in Strategic Risk Analysis.

Proposal of Framework Critic - Smart - Entropic

	Non -strategic variables			Strategic variables - monotonic and profit																
				Internal environment					Operating environment					General environment						
	Profit	Cost	Cost	Profit	Profit	Profit	Profit	Profit	Profit	Profit	Profit	Profit	Profit	Profit	Profit	Profit	Profit	Profit		
Alternativas	Investment R $ (mill)	cost of labor	Automation Cost	Organization - Ai	Marketing - Ai	Finance – Ai	Personal – Ai	Production – Ai	Supplier - OP	Customer - OP	Competition - OP	Labor - OP	International - OP	Economics - AG	Technology - AG	Cool - Ag	Political - AG	Social - AG	Sum	Ranking Borda
Proj 01	40,200	-1,000	0,000	2,000	3,000	0,000	1,000	0,000	-3,000	2,000	0,000	1,000	0,000	0,000	3,000	2,000	0,000	-1,000	10,0000	1
Proj 02	26,200	1,000	-2,000	-3,000	-3,000	-2,000	0,000	-3,000	-3,000	0,000	-3,000	-2,000	-1,000	-2,000	2,000	-3,000	0,000	2,000	-21,0000	4
Proj 03	31,000	0,000	-3,000	2,000	0,000	-3,000	-3,000	-1,000	-3,000	-2,000	-3,000	0,000	0,000	1,000	0,000	-1,000	3,000	-2,000	-12,0000	3
Proj 04	39,900	-2,000	-3,000	1,000	-1,000	-2,000	-3,000	-2,000	1,000	-3,000	1,000	3,000	1,000	2,000	-2,000	-1,000	-2,000	2,000	-5,0000	2
						1,000														
Máx	40,200	2,000	2,000	2,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000		
Min	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000		
Correction factor: All equal notes?	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No		

TABLE 2– Data Matrix

Source: Prepared by the Authors

	Non -strategic variables			Data matrix with correction factor																
				Internal environment					Operating environment					General environment						
	Profit	Cost	Cost	Profit	Profit	Profit	Profit	Profit	Profit	Profit	Profit	Profit	Profit	Profit	Profit	Profit	Profit	Profit		
Alternativas	Investment R $ (mill)	cost of labor	Automation Cost	Organization - Ai	Marketing - Ai	Finance – Ai	Personal – Ai	Production – Ai	Supplier - OP	Customer - OP	Competition - OP	Labor - OP	International - OP	Economics - AG	Technology - AG	Cool - Ag	Political - AG	Social - AG	Sum	Ranking Borda
Proj 01	40,200	-1,000	0,000	2,000	3,000	0,000	1,000	0,000	-3,000	2,000	0,000	1,000	0,000	0,000	3,000	2,000	0,000	-1,000	10,0000	1
Proj 02	34,000	2,000	0,000	-3,000	-3,000	-2,000	0,000	-3,000	-3,000	0,000	-3,000	-2,000	-1,000	-2,000	2,000	-3,000	0,000	2,000	-21,0000	4
Proj 03	32,100	3,000	-3,000	2,000	0,000	-3,000	-3,000	-1,000	-3,000	-2,000	-3,000	0,000	0,000	1,000	0,000	-1,000	3,000	-2,000	-12,0000	3
Proj 04	32,100	-2,000	-1,000	1,000	-1,000	-2,000	-3,000	-2,000	1,000	-3,000	1,000	3,000	1,000	2,000	-2,000	-1,000	-2,000	2,000	-5,0000	2
Máx	40,200	2,000	2,000	2,000	3,000	0,000	1,000	0,000	1,000	2,000	1,000	3,000	1,000	2,000	3,000	2,000	3,000	2,000		
Min	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-2,000	-1,000	-2,000	-2,000	-3,000	-2,000	-2,000		

TABLE 2(a) – Data Matrix with Correction Factor

Source: Prepared by the Authors

	Non -strategic variables			Standardized Data Matrix														
				Internal environment					Operating environment					General environment				
Alternativas	Investment R $ (mill)	cost of labor	Automation Cost	Organization - Ai	Marketing - Ai	Finance – Ai	Personal – Ai	Production – Ai	Supplier - OP	Customer - OP	Competition - OP	Labor - OP	International - OP	Economics - AG	Technology - AG	Cool - Ag	Political - AG	Social - AG
				Org	Ma	Fin	Pes	Prc	For	Clie	Cor	Mã	Inte	Eco	Tec	Leg	Pol	Soc
Proj 01	1,000	0,954	0,931	1,000	1,000	1,000	1,000	1,000	0,000	1,000	0,750	0,600	0,500	0,500	1,000	1,000	0,400	0,250
Proj 02	0,144	0,884	0,931	0,000	0,000	0,333	0,750	0,000	0,000	0,600	0,000	0,000	0,000	0,000	0,800	0,000	0,400	1,000
Proj 03	0,188	0,861	1,000	1,000	0,500	0,000	0,000	0,667	0,000	0,200	0,000	0,400	0,500	0,750	0,400	0,400	1,000	0,000
Proj 04	0,188	0,977	0,954	0,800	0,333	0,333	0,000	0,333	1,000	0,000	1,000	1,000	1,000	1,000	0,000	0,400	0,000	1,000
DESVPAD	0,414	0,055	0,033	0,476	0,417	0,419	0,515	0,430	0,500	0,443	0,515	0,416	0,408	0,427	0,443	0,412	0,412	0,515

TABLE3– Normalized Data Matrix

Source: Prepared by the Authors

Tabela	Non -strategic variables			Entropy matrix: Internal environment					Operating environment					General environment				
	Investment R $ (mill)	cost of labor	Automation Cost	Organization - Ai	Marketing - Ai	Finance – Ai	Personal – Ai	Production – Ai	Supplier - OP	Customer - OP	Competition - OP	Labor - OP	International - OP	Economics - AG	Technology - AG	Cool - Ag	Political - AG	Social - AG
Investment R $ (mill)	0,000	0,205	0,253	0,012	0,000	0,001	0,023	0,002	0,019	0,004	0,023	0,000	-0,001	0,002	0,004	0,000	0,000	0,023
cost of labor	0,205	0,000	0,048	-0,194	-0,205	-0,205	-0,182	-0,203	-0,187	-0,201	-0,182	-0,205	-0,206	-0,204	-0,201	-0,206	-0,206	-0,182
Automation Cost	0,253	0,048	0,000	-0,241	-0,253	-0,252	-0,230	-0,251	-0,235	-0,249	-0,230	-0,253	-0,254	-0,251	-0,249	-0,253	-0,253	-0,230
Organization - Ai	0,012	-0,194	-0,241	0,000	0,052	0,049	-0,026	0,039	-0,017	0,027	-0,026	0,052	0,061	0,042	0,027	0,057	0,057	-0,026
Marketing - Ai	0,000	-0,205	-0,253	0,052	0,000	0,000	0,023	0,002	0,018	0,004	0,023	0,000	-0,001	0,001	0,004	-0,001	-0,001	0,023
Finance – Ai	0,001	-0,205	-0,252	0,049	0,000	0,000	0,023	0,002	0,018	0,004	0,023	0,000	-0,001	0,001	0,004	-0,001	-0,001	0,023
Personal – Ai	0,023	-0,205	-0,230	-0,026	0,023	0,023	0,000	-0,021	-0,005	-0,019	0,000	-0,023	-0,024	-0,022	-0,019	-0,024	-0,024	0,000
Production – Ai	0,002	-0,203	-0,251	0,039	0,002	0,002	-0,021	0,000	0,016	0,002	0,021	-0,002	-0,003	-0,001	0,002	-0,002	-0,002	0,021
Supplier - OP	0,019	-0,187	-0,235	-0,017	0,018	0,018	-0,005	0,016	0,000	-0,014	0,005	-0,018	-0,019	-0,017	-0,014	-0,019	-0,019	0,005
Customer - OP	0,004	-0,201	-0,249	0,027	0,004	0,004	-0,019	0,002	-0,014	0,000	0,019	-0,004	-0,005	-0,003	0,000	-0,005	-0,005	0,019
Competition - OP	0,023	-0,182	-0,230	-0,026	0,023	0,023	0,000	0,021	0,005	0,019	0,000	-0,023	-0,024	-0,022	-0,019	-0,024	-0,024	0,000
Labor - OP	0,000	-0,205	-0,253	0,052	0,000	0,000	-0,023	-0,002	-0,018	-0,004	-0,023	0,000	-0,001	0,001	0,004	0,000	0,000	0,023
International - OP	-0,001	-0,206	-0,254	0,061	-0,001	-0,001	-0,024	-0,003	-0,019	-0,005	-0,024	-0,001	0,000	0,002	0,005	0,000	0,000	0,024
Economics - AG	0,002	-0,204	-0,251	0,042	0,001	0,001	-0,022	-0,001	-0,017	-0,003	-0,022	0,001	0,002	0,000	0,003	-0,002	-0,002	0,022
Technology - AG	0,004	-0,201	-0,249	0,027	0,004	0,004	-0,019	0,002	-0,014	0,000	-0,019	0,004	0,005	0,003	0,000	-0,005	-0,005	0,019
Cool - Ag	0,000	-0,206	-0,253	0,057	-0,001	-0,001	-0,024	-0,002	-0,019	-0,005	-0,024	0,000	0,000	-0,002	-0,005	0,000	0,000	0,024
Political - AG	0,000	-0,206	-0,253	0,057	-0,001	-0,001	-0,024	-0,002	-0,019	-0,005	-0,024	0,000	0,000	-0,002	-0,005	0,000	0,000	0,024
Social - AG	0,023	-0,182	-0,230	-0,026	0,023	0,023	0,000	0,021	0,005	0,019	0,000	0,023	0,024	0,022	0,019	0,024	0,024	0,000

TABLE4- Paired entropy of attributes

Source: Prepared by the authors

				Matrix (1 - h): Internal environment					Operating environment					General environment					Analysis		
	Investment R $ (mill)	cost of labor	Automation Cost	Organization - Ai	Marketing - Ai	Finance – Ai	Personal – Ai	Production – Ai	Supplier - OP	Customer - OP	Competition - OP	Labor - OP	International - OP	Economics - AG	Technology - AG	Cool - Ag	Political - AG	Social – AG	Coefficient (CJ)	Weight (WJ)	Ranking
Investment R $ (mill)	1,000	0,287	0,257	0,009	-0,003	-0,002	0,020	-0,001	0,015	0,001	0,020	-0,003	-0,004	-0,001	0,001	-0,003	-0,003	0,020	0,7666	0,0058	16
cost of labor	0,713	1,000	-0,030	-0,278	-0,290	-0,289	-0,267	-0,288	-0,272	-0,286	-0,267	-0,290	-0,291	-0,288	-0,286	-0,290	-0,290	-0,267	-1,2161	-0,0092	18
Automation Cost	0,743	1,030	1,000	-0,248	-0,260	-0,260	-0,237	-0,258	-0,242	-0,256	-0,237	-0,260	-0,261	-0,258	-0,256	-0,260	-0,260	-0,237	-0,4837	-0,0037	17
Organization - Ai	0,991	1,278	1,248	1,000	0,948	0,951	1,026	0,961	1,017	0,973	1,026	0,948	0,939	0,958	0,973	0,943	0,943	1,026	8,6421	0,0655	15
Marketing - Ai	1,003	1,290	1,260	0,948	1,000	1,000	0,977	0,998	0,982	0,996	0,977	1,000	1,001	0,999	0,996	1,001	1,001	0,977	8,7615	0,0664	13
Finance – Ai	1,002	1,289	1,260	0,951	1,000	1,000	0,977	0,998	0,982	0,996	0,977	1,000	1,001	0,999	0,996	1,001	1,001	0,977	8,7643	0,0664	12
Personal – Ai	0,980	1,289	1,237	1,026	0,977	0,977	1,000	1,021	1,005	1,019	1,000	1,023	1,024	1,022	1,019	1,024	1,024	1,000	8,8870	0,0673	1
Production – Ai	1,001	1,288	1,258	0,961	0,998	0,998	1,021	1,000	0,984	0,998	0,979	1,002	1,003	1,001	0,998	1,002	1,002	0,979	8,7948	0,0666	11
Supplier - OP	0,985	1,272	1,242	1,017	0,982	0,982	1,005	0,984	1,000	1,014	0,995	1,018	1,019	1,017	1,014	1,019	1,019	0,995	8,8444	0,0670	2
Customer - OP	0,999	1,286	1,256	0,973	0,996	0,996	1,019	0,998	1,014	1,000	0,981	1,004	1,005	1,003	1,000	1,005	1,005	0,981	8,8172	0,0668	10
Competition - OP	0,980	1,267	1,237	1,026	0,977	0,977	1,000	0,979	0,995	0,981	1,000	1,023	1,024	1,022	1,019	1,024	1,024	1,000	8,8332	0,0669	5
Labor - OP	1,003	1,290	1,260	0,948	1,000	1,000	1,023	1,002	1,018	1,004	1,023	1,000	1,001	0,999	0,996	1,000	1,000	0,977	8,8290	0,0669	6
International - OP	1,004	1,291	1,261	0,939	1,001	1,001	1,024	1,003	1,019	1,005	1,024	1,001	1,000	0,998	0,995	1,000	1,000	0,976	8,8272	0,0669	8
Economics - AG	1,001	1,288	1,258	0,958	0,999	0,999	1,022	1,001	1,017	1,003	1,022	0,999	0,998	1,000	0,997	1,002	1,002	0,978	8,8283	0,0669	7
Technology - AG	0,999	1,286	1,256	0,973	0,996	0,996	1,019	0,998	1,014	1,000	1,019	0,996	0,995	0,997	1,000	1,005	1,005	0,981	8,8237	0,0668	9
Cool - Ag	1,003	1,290	1,260	0,943	1,001	1,001	1,024	1,002	1,019	1,005	1,024	1,000	1,000	1,002	1,005	1,000	1,000	0,976	8,8340	0,0669	3
Political - AG	1,003	1,290	1,260	0,943	1,001	1,001	1,024	1,002	1,019	1,005	1,024	1,000	1,000	1,002	1,005	1,000	1,000	0,976	8,8340	0,0669	4
Social - AG	0,980	1,267	1,237	1,026	0,977	0,977	1,000	0,979	0,995	0,981	1,000	0,977	0,976	0,978	0,981	0,976	0,976	1,000	8,7042	0,0659	14

TABLE5- Calculation of the table (1 – H) to calculate the Index (Cj), weights (Wj) and Ranking

Source: Prepared by the authors

	Non -strategic variables			Data matrix: Internal environment					Operating environment					General environment								
Alternativas	Investment R $ (mill)	cost of labor	Automation Cost	Organization - Ai	Marketing - Ai	Finance – Ai	Personal – Ai	Production – Ai	Supplier - OP	Customer - OP	Competition - OP	Labor - OP	International - OP	Economics - AG	Technology - AG	Cool - Ag	Political - AG	Social - AG	SMART com CRITIC	ranking	Borda	CRITIC SMART Entrópico
Proj 01	1,000	0,954	0,931	2,000	3,000	0,000	1,000	0,000	-3,000	2,000	0,000	1,000	0,000	0,000	3,000	2,000	0,000	-1,000	0,6665	1	1	1
Proj 02	0,132	0,861	1,000	-3,000	-3,000	-2,000	0,000	-3,000	-3,000	0,000	-3,000	-2,000	-1,000	-2,000	2,000	-3,000	0,000	2,000	-1,4022	4	4	4
Proj 03	0,201	0,884	0,861	2,000	0,000	-3,000	-3,000	-1,000	-3,000	-2,000	-3,000	0,000	0,000	1,000	0,000	-1,000	3,000	-2,000	-0,8059	3	3	3
Proj 04	0,118	0,977	0,977	1,000	-1,000	-2,000	-3,000	-2,000	1,000	-3,000	1,000	3,000	1,000	2,000	-2,000	-1,000	-2,000	2,000	-0,3401	2	2	2
Pesos CRITC- SMART - ENTRÓPICO	0,0054	-0,0043	0,0001	0,0654	0,0664	0,0664	0,0673	0,0666	0,0670	0,0668	0,0669	0,0669	0,0669	0,0669	0,0668	0,0669	0,0669	0,0659				

TABLE 7 – Project selection

Source – Prepared by the Authors

CRITIC SMART Entrópic	
Dimension	Risk ranking
Personal - Ai	1
Supplier - OP	2
Cool - Ag	3
Political - AG	4
Competition - OP	5
Labor - OP	6
Economics - AG	7
International - OP	8
Technology - AG	9
Customer - OP	10
Production _ Ai	11
Finance - Ai	12
Marketing - Ai	13
Social - AG	14
Organization - AI	15

TABLE 6 - General Ranking of Room Dimensions

Source: Prepared by the Authors

Graphically we have figure 4.

Figure4- Strategic Dimensions Risk

Source – Prepared by the Authors

And for project selection, table 7 is available with the weights:

RESULTS AND FINAL CONSIDERATIONS

Through the proposed methodology, it was possible to achieve the expected results. Combining the concepts of Strategic Management, specifically with its Environmental Analysis stage, it was possible to address the dimensions that are necessary in the elaboration of a robust strategy, with consensus from all decision-makers involved and also reduce the variability of possible subjectivities in the evaluation of each dimension of the Environments.

This tool shows a well-defined ranking supported by a mathematical framework and the opinion of all decision makers reflected in the result. With them, the Senior Management or Project Manager is able to work more efficiently, focusing their efforts in the right places, making the tool an excellent way to check potential problems in execution, carry out Risk Analysis, and ensure that decisions are facilitated using a mathematical tool, which makes justifying the result much easier.

It is worth highlighting the innovation proposed in the work of using Shannon's Entropy (1949) for the pairwise comparison of vectors, instead of the Correlation coefficient proposed in the original CRITIC method, as well as the correction to eliminate the mathematical limitation regarding attributes and/or values are equal, which comes from the CRITIC-STRAT-G method proposed by Cassettari, Santos and Baldini (2021), which were also used.

This concept of Entropy has been widely used in Data Science, Artificial Intelligence and Cognitive Science, so naturally it must permeate the field of application within Operational Research to enhance Decision responses in a faster and more assertive way.

Once again, the great application of Operational Research Science to improve organizations, countries and, mainly, the quality of life of human beings has been demonstrated, even more important now, with Industry 4.0 and the SARS-COVID-19 pandemic., which accelerated the process of digitalization and use of new technologies of Artificial Intelligence, Data Science, IoT, Simulation, among others, and are creating a new digital revolution in the world, much more aggressive than the previous one.

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