v. 4, n. 19, 2024

Journal of Engineering Research

METHOD FOR STRATEGIC RISK ANALYSIS, USING STRATEGIC ADMINISTRATION WITH THE CRITIC METHOD WITH GROUP TECHNOLOGY: CRITIC-STRATADMIN -G

Eder Costa Cassettari
Instituto Militar de Engenharia – IME

Marcos dos Santos
Instituto Militar de Engenharia – IME

Fábio Baldini
Instituto Militar de Engenharia – IME

Abstract: This method proposes a solution for Strategic Risk Analysis to support multi-criteria decision making, MCDA, 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. However, such decisions 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 deciding using science and facilitating the justification of the aforementioned decision.
Keywords: Multicriteria Decision Analysis, Strategic Management, CRITIC 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 the guidance of the organization and also bringing together aspects related to the risk analysis of executing a project or a business redirection to meet new trends and/or market restrictions. The difficulties are numerous due to the subjectivity related to the subject, in most cases. There is a lack of consensus among them 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 work 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 need arises within an organization. It is necessary to establish a strategy to conduct a new business, which has several possible scenarios that are called "alternatives" that make up the set of possible solutions established (Gomes and Gomes, 2019).

In this condition, it will be necessary to establish what "decision criteria" will be established (Gomes and Gomes, 2019). 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 several decision makers, several possible alternatives, a decision support analysis method must be established. The class of methods that will be selected is called Multicriteria Decision Analysis, with group decision, that is, several decision makers working at the same time in the decision-making process.

Finally, establish 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.

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.

THEORETICAL FOUNDATION

According to CERTO & PETER (1993), this new discipline 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 mission and objectives of the organization" (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:

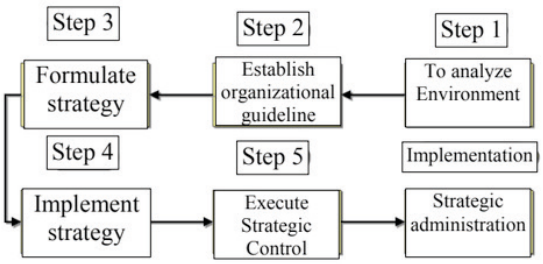

FIGURE 1 - Strategic Management Overview
Source: Adapted from Certo and Peter (1993)

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 & 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 capacity 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.

We can approach the organization 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.

Here we are using the concepts mentioned in General Systems Theory, TGS. 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. So the organization can ultimately be seen as a volume of control 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, which is the primary objective of environmental analysis, will be identified, in which the factors that can affect the success of the organization will be identified, the so-called analysis.

SWOT (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 determining the possibility of occurrence and the respective contingency planning, which is its main objective.

As described in CERTO & 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 MULTICRITERIA 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.

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

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

In step 1 of the solution, the normalized matrix is created, using the formulas below:

$$X_{ij} = \frac{r_{ij} - r_i^-}{r_i^+ - r_i^-}; \quad i = 1, \dots, m, \ \ j = 1, \dots, n \ (1)$$

Where: xij represents a normalized value of the decision matrix, for ith alternative in j-th attribute and $r_i^+ = \max (r_1, r_2 \ r_m)$ $er_i^- = \min (r_1, r_2 \ r_m)$.

It is used for 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, 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.

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

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

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

Next, the index (C) is calculated using.

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

In step 4, the weight of the attributes is calculated:

The weights of the attributes are determined by equation (6).

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

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

METHODOLOGY TO BE USED

To validate the proposed method, CRITIC – StratAdmin – G, we will use the methodology described below:

- Type of Research – Exploratory 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
- Methods - The methods will be Experimental Research, Bibliographic Research and Case Study
- Techniques – The techniques will be the use of a genetic algorithm to generate alternative scores for each of the criteria, to validate the method through quantitative data analysis.

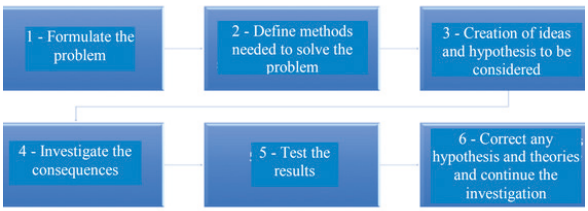

FIGURE 3 - Methodology used

Source: Prepared by the authors

SOLUTION PROPOSAL

Problem Definition - To validate the method solution, 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 all dimensions 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 with 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. The attribute data must have its value switched to a variable using table 1. Next, the data must be inserted for the Internal Environment, using the dimensions: Organization, Marketing, Finance, Personnel and Production as shown in table 2. Then it will be calculated the maximum and minimum value for each criterion, as shown below:

Then, the values are normalized using equation (1) shown previously in table 3

Calculating the Correlation Coefficient ρ, according to formula (2) for each pair of decision attributes, shown in table 4, and in the sequence for (1 – ρ) in table 5:

Calculation of Index (C), formula (5), weights, formula (6) and ranking of attributes:

With this issue, we arrive at the criticality ranking for the Internal Environment attributes. Now we will repeat the same calculations for the operational environment and then for the general environment and we will arrive at table 7 shown below. Once the calculations of all dimensions for all environments have been completed, a consolidation table of dimensions and their general ranking are created.

Internal environment					
Alternatives	/ Organization - Ai	/ Marketing - Ai	/ Finance – Ai	/ Personal – Ai	/ Production - Ai
A1	-1.0000	-1.0000	0.0000	1.0000	-3.0000
A2	3.0000	3.0000	-1.0000	-3.0000	1.0000
A3	-1.0000	1.0000	-1.0000	-2.0000	0.0000
A4	-1.0000	2.0000	3.0000	1.0000	1.0000
A5	-2.0000	2.0000	-1.0000	1.0000	-2.0000
A6	1.0000	3.0000	3.0000	-3.0000	0.0000
A7	3.0000	1.0000	2.0000	1.0000	1.0000
Máx	3.0000	3.0000	3.0000	1.0000	1.0000
Min	-2.0000	-1.0000	-1.0000	-3.0000	-3.0000

TABLE 2 - Internal Environment

Source: Prepared by the authors

Normalized internal environment					
Alternatives	/ Organization - Ai	/ Marketing - Ai	/ Finance – Ai	/ Personal – Ai	/ Production - Ai
A1	0.2000	0.0000	0.2500	1.0000	0.0000
A2	1.0000	1.0000	0.0000	0.0000	1.0000
A3	0.2000	0.5000	0.0000	0.2500	0.7500
A4	0.2000	0.7500	1.0000	1.0000	1.0000
A5	0.0000	0.7500	0.0000	1.0000	0.2500
A6	0.6000	1.0000	1.0000	0.0000	0.7500
A7	1.0000	0.5000	0.7500	1.0000	1.0000
✓	0.4571	0.6429	0.4286	0.6071	0.6786
σ	0.4117	0.3493	0.4725	0.4970	0.4009

TABLE 3 - Standardized Internal Environment

Source: Prepared by the authors

RO	/ Organization - Ai	/ Marketing - Ai	/ Finance – Ai	/ Personal – Ai	/ Production - Ai
Organization - Ai	1.0000	0.3394	0.1958	-0.4014	0.6347
Marketing - Ai	0.3394	1.0000	0.1984	-0.5828	0.6057
Finance – Ai	0.1958	0.1984	1.0000	0.1267	0.4086
Personal – Ai	-0.4014	-0.5828	0.1267	1.0000	-0.3734
Production - Ai	0.6347	0.6057	0.4086	-0.3734	1.0000

TABLE 4 - Paired correlation of attributes

Source: Prepared by the authors

1 - RO	/ Organization - Ai	/ Marketing - Ai	/ Finance – Ai	/ Personal – Ai	/ Production - Ai
Organization - Ai	0.0000	0.6606	0.8042	1.4014	0.3653
Marketing - Ai	0.6606	0.0000	0.8016	1.5828	0.3943
Finance – Ai	0.8042	0.8016	0.0000	0.8733	0.5914
Personal – Ai	1.4014	1.5828	0.8733	0.0000	1.3734
Production – Ai	0.3653	0.3943	0.5914	1.3734	0.0000
Sum	3.2315	3.4394	3.0705	5.2309	2.7245

TABLE 5 - Calculation of the table (1 – ρ) to calculate the Index (C)

Source: Prepared by the authors

C	W	Ranking
1.7457	0.2293	2
1.3544	0.1779	4
1.4490	0.1904	3
1.1888	0.1562	5
1.8741	0.2462	1
7.6120		

TABLE 6 - Calculation of the index (C), weights (w) and Ranking

Source: Prepared by the Authors

Dimension	W	Ranking
Organization - Ai	0.1734	12
Marketing - Ai	0.1565	13
Finance – Ai	0.1890	8
Personal – Ai	0.3388	1
Production – Ai	0.1423	15
Supplier - OP	0.1905	6
Customer - OP	0.1471	14
Competition - OP	0.1897	7
Labor - OP	0.2120	4
International - OP	0.2608	2
Economics - AG	0.2477	3
Technology - AG	0.1835	10
Cool - Ag	0.1880	9
Political - AG	0.2066	5
Social - AG	0.1742	11

TABLE 7 - General Ranking of Room Dimensions

Source: Prepared by the Authors

For a more structured presentation of the results, a graph was created with all dimensions of the General, Operational and Internal environments and placed in ascending order of their weights (w), concluding the application of the method.

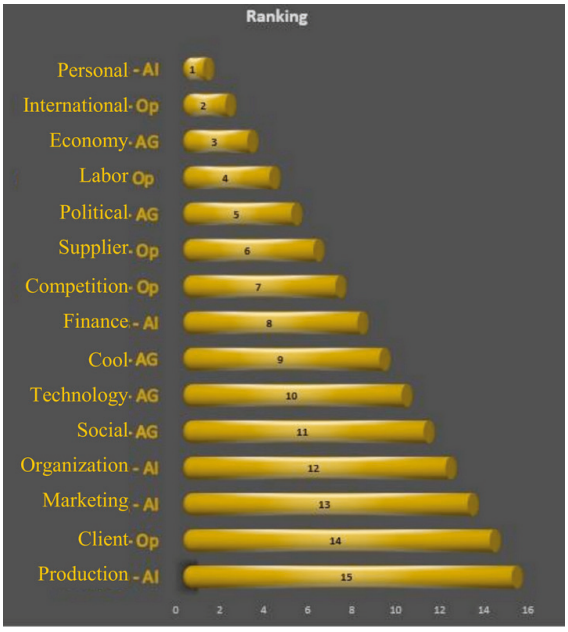

FIGURE 4 - Graph of positions in the General Ranking of Room Dimensions obtained by the CRITIC-StratAdmin-G method.

Source: Prepared by the Authors

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 final 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.

Once again, the great application of Operational Research Science to improve organizations, countries and, mainly, the quality of life of human beings is demonstrated, even more important now, with Industry 4.0 and the COVID19 pandemic that have accelerated the process. digitalization and use of new Artificial Intelligence, Data Science, IoT, Simulation technologies and are creating a new digital revolution in the world, much more aggressive than the previous one.

REFERENCES

CERTO, S.C. e Peter, J.P - **Administração Estratégica: planejamento e implantação da estratégia**. Makron Books do Brasil, São Paulo, 1. ed 1993.

DIAKOULAKI et al; **Determining objective Weights in multiples criteria problems: The CRITIC method**, Computer Ps, Res, Vol 22, No.7, pp763-770, 0305-0548(94)00059-X, 1995

GOMES, L. F. A. M.; GOMES, C. F. S, **Princípios e métodos de tomada de decisão – enfoque multicritério**, 6. ed., Editora Atlas, 2019

MINTZBERG, Henry - **The rise and fall of strategic planning: reconceiving roles for planning**, plans, planners -New York, 1994.

WRIGHT et al, **Administração Estratégica**, Ed. Atlas, São Paulo, 1. ed., 2000