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MULTICRITERIA MODEL FOR EVALUATING THE PERFORMANCE OF INCUBATED COMPANIES

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Abstract
Objective: Create a performance evaluation model for technology-based incubated companies, using the multicriteria decision aid methodology (MCDA) and also respecting the guidelines of the CERNE model (Reference Center for Support to New Enterprises).
Methodology: This work is classified as exploratory-descriptive, qualitative-quantitative, and, concerning procedures, it adopts the case study, having as the object of analysis a technology-based incubator. The MCDA was used for the construction of the model and the ELECTRE-TRI method for the modeling of the preferences.
Originality: The originality of this study permeates the creation and application of a decision-making method that facilitates performance evaluation for incubated companies.
Main results: The model created to assess the performance of incubated companies has 23 indicators and it was applied to three incubated companies and one graduated company. The developed model proved to be adequate and applicability to the reality of the studied incubator, supporting the decision-making process.
Theoretical contributions: The joint application of MCDA and organizational performance evaluation themes.
Social/management contributions: improving performance measurement models for incubated companies and strengthening the support offered by business incubators.

Keywords: Indicators. MCDA. ELECTRE-TRI.

MODELO MULTICRITÉRIO PARA AVALIAÇÃO DE DESEMPENHO DE EMPRESAS INCUBADAS

Resumo
Objetivo: Criar um modelo de avaliação de desempenho para empresas incubadas de base tecnológica, utilizando a metodologia multicritério de apoio à decisão (MCDA), respeitando também as diretrizes do modelo CERNE (Centro de Referência para Apoio a Novos Empreendimentos).
Metodologia: este trabalho se classifica como exploratório-descritivo, de natureza quali-quantitativa e, no tocante aos procedimentos, adota o estudo de caso, tendo como objeto de análise uma incubadora de base tecnológica. Para a construção do modelo, utilizou-se a MCDA e para a modelagem das preferências, o método ELECTRE-TRI.
Originalidade: a originalidade do presente estudo perpassa pela criação e aplicação de um método de tomada de decisão que facilita a avaliação de desempenho para empresas incubadas.
Resultados: o modelo criado para avaliar o desempenho das empresas incubadas é composto por 23 indicadores e foi aplicado com três empresas incubadas e uma graduada. O modelo desenvolvido demonstrou pertinência e aplicabilidade à realidade da incubadora estudada, apoiando o processo de tomada de decisão.
Contribuições teóricas: o avanço e a aplicação, de forma conjunta, das temáticas de metodologia de multicritério de apoio à decisão e avaliação de desempenho organizacional.
Contribuições sociais: aprimoramento dos modelos de medição de desempenho para empresas incubadas e fortalecimento do apoio oferecido por incubadoras de empresas.

Palavras-chave: Indicadores. MCDA. ELECTRE-TRI.

MODELO MULTICRITERIO PARA EVALUAR EL DESEMPEÑO DE EMPRESAS INCUBADAS

Resumen
Objetivo: Crear un modelo de evaluación del desempeño para empresas incubadas de base tecnológica, utilizando la metodología de soporte de decisiones multicriterio (MCDA) y respetando también los lineamientos del modelo CERNE (Centro de Referencia de Soporte de Nuevas Empresas).
Metodología: Este trabajo se clasifica como exploratorio-descriptivo, cualitativo-cuantitativo y, en lo que respecta a los procedimientos, adopta el estudio de caso, teniendo como objeto de análisis una incubadora de base tecnológica. Se utilizó el MCDA para construir el modelo y el método ELECTRE-TRI se utilizó para modelar las preferencias.
Originalidad: La originalidad de este estudio impregna la creación y aplicación de un método de toma de decisiones que facilita la evaluación del desempeño de las empresas incubadas.
Resultados: El modelo creado para evaluar el desempeño de las empresas incubadas está compuesto por 23 indicadores y fue aplicado a tres empresas incubadas y una empresa egresada. El modelo desarrollado demostró relevancia y aplicabilidad a la realidad de la incubadora estudiada, apoyando el proceso de toma de decisiones.
Contribuciones teóricas: El avance y aplicación, en conjunto, de los temas de la metodología multicriterio de apoyo a la decisión y la evaluación del desempeño organizacional.
Contribuciones sociales: mejorar los modelos de medición del desempeño de las empresas incubadas y fortalecer el apoyo ofrecido por las incubadoras de empresas.

Palabras clave: Indicadores. MCDA. ELECTRE-TRI.

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1 Introduction

Innovation is generated by the search for competitiveness on the part of companies, whether for the development of new products, new processes, new ways to manage the business, new ways of commercialization, or identification of new markets, among others (Calmanovici, 2011; Porter, 1990).

In the search for competitiveness, companies need to be increasingly agile and adaptable, as the changes that occur as a result of a series of conditions such as competition, the introduction of new technologies, economic changes, and changes in customer behavior, become an ever-present and increasingly rigorous challenge (Ireland & Webb, 2007).

Creating value and driving improvements in business performance are fundamental parts of an organization and its decision-making process, regardless of its size or scope (Hughes, Ireland & Morgan, 2007). However, young and smaller companies present a greater difficulty in this process due to the lack of resources, knowledge, or social capital, making them more vulnerable to competition (Hughes *et al*., 2007).

In this context, incubators emerge as an important mechanism, promoting innovation and entrepreneurship through the creation of an environment aimed at supporting and strengthening micro and small companies with the provision of services, infrastructure, and facilities to help them in their development and preparation for the market (Maciel, Cruz, Aroca & Cruz, 2014).

Incubators that are publicly funded are an important element in developing countries for the promotion of entrepreneurship based on science, technology, and innovation (Surana, Singh & Sagar, 2020). Incubators are environments for interaction between the business, government, and academic spheres, promoting the socioeconomic and cultural development of the ecosystem in which they operate (Salles & Iozzi, 2010). The network of industry-government-university relations can be considered as an institutional knowledge infrastructure that carries a system of operations containing science, technology, and knowledge-based innovations (Park, Hong & Leydesdorgg, 2005).

Incubators have a great impact on the economic development of Brazil by supporting micro and small companies which, according to a publication made in 2018 by Banco do Nordeste do Brasil (BNB), are fundamental to the national economy, as they represent 98.5% of the companies in the country, contributing with 27% of the Gross Domestic Product (GDP) and generating 54% of the total jobs (BNB, 2018). In 2017, in Brazil, there were more than 350 incubators in activity, supporting around 3,700 companies that were responsible for generating 14,457 jobs and that jointly generated BRL 551 million (National Association of Entities Promoting Innovative Enterprises, Anprotec, 2019).

For its operation, an incubator can adopt the good practices suggested by the Reference Center for Support to New Enterprises (CERNE). CERNE is an operating model for incubators to promote improvements in their results through the indication of good practices to be adopted, and among them is the practice of "monitoring", in which the degree of evolution of the incubated companies is evaluated. (Anprotec, 2018a).

CERNE defines that each incubator must establish how the monitoring of its companies will take place, but does not define how this evaluation will be carried out or which instrument will be used for such measurement, leaving each incubator to develop its methodology.

The incubated companies usually present different realities from each other, being in different stages of maturity, operating in different market sectors, using different technologies, and, therefore, it becomes a challenge to define a standard monitoring model to verify the growth of companies. The incubator must be able to verify the maturity of the processes and monitor the results of the ventures supported by it.

In the process of evaluating the performance of companies, there is a multiplicity of criteria that must be considered, and, therefore, for the construction of a monitoring model adopts based on the concept of multicriteria decision-making. The multicriteria decision-making support methodology helps the decision-making process and allows a better understanding of the dimensions of the problem, in addition to incorporating the decision-makers' values in the decision-making process (Gomes & Gomes, 2019).

Given the above, the following research problem was defined: How to create a standard model that allows measuring, monitoring, and evaluating the performance of technology-based companies linked to a business incubator at a federal university?

The objective of this work is to develop a case study focused on the performance evaluation of incubated companies based on the multicriteria decision support methodology (MCDA) and respecting the guidelines of the CERNE model. In this way, the study contributes to the creation of a model that allows monitoring the growth of these companies and establishing the main performance indicators used in this process.

This research presents theoretical and practical contributions by bringing the application of the multicriteria technique in the context of incubators and in the process of evaluating the maturity level of companies. In addition to the positive impacts for incubators and incubated companies, this study contributes, academically, to: (i) the advancement and application, jointly, of the themes of multicriteria methodology for decision support and organizational performance assessment; (ii) improvement of performance measurement models for incubated companies; (iii) expansion of studies on entrepreneurship and business incubators; (iv) use of multivariate techniques, group decision and negotiation.

A model with 23 indicators was proposed and applied to evaluate the performance of companies linked to a business incubator, thus, it was possible to validate its applicability and adequacy to the reality of the studied incubator, supporting the decision-making process.

2 Theoretical background

2.1 Business incubators and the CERNE model

An incubator is a mechanism that promotes the creation and development of micro and small companies, offering various services and facilities such as individualized physical space; physical space for shared use; human resources, and specialized services to support companies in their activities; capacity building and training in different areas; access to laboratories and institutions that develop technology; access to funding sources; networking; consultancies; project assistance (Adegbite, 2001; Ministry of Science and Technology, 2000; Stal, Andreassi & Fujino, 2016).

Business incubators are important for the innovation process and play a key role in the development and consolidation of nascent companies so that they become financially viable and manage to expand their operations, even after the incubation period (Castro & Silva, 2017; Oliveira & Terrence, 2018; Salles & Iozzi, 2010).

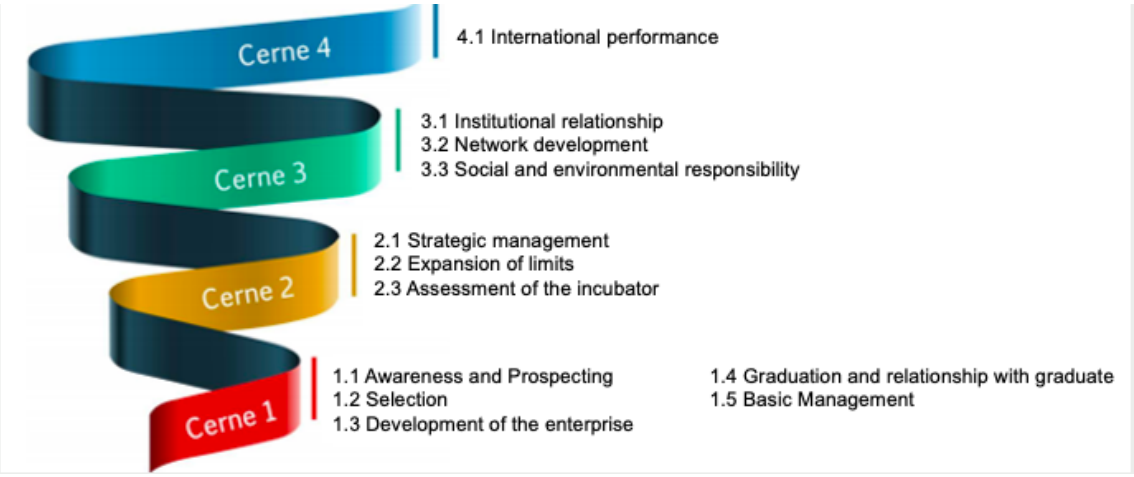
The movement of incubators plays an important role in the development of the regional economy and, for incubators to be able to perform their mission well and expand their results qualitatively and quantitatively, the implementation and standardization of certain processes are necessary (Anprotec, 2018b).

In this context, the National Association of Entities Promoting Innovative Enterprises (ANPROTEC), in partnership with the Brazilian Support Service for Micro and Small Enterprises (SEBRAE), created CERNE so that incubators can reduce the level of variability in achieving success of incubated companies (Anprotec, 2018b).

The CERNE model provides for good practices to be adopted at different maturity levels, considering each level as a step by the incubator towards recognition as an environment of innovation that achieves significant results for regional and national development. Each maturity level (CERNE 1, 2, 3, and 4) is composed of a set of key processes, which in turn contains a group of key practices, as detailed in Figure 1 (Anprotec, 2018a).

Figure 1

Maturity levels x key processes



Source: Terms of Reference (Anprotec, 2018c).

Altogether, CERNE is composed of 12 key processes that are broken down into 29 key practices (Anprotec, 2018a). One of the key processes of CERNE 1 is the "development of the enterprise" which covers the maintenance of a documented and continuous process to enable the growth of the supported companies (Anprotec, 2018a).

Monitoring, the focus of the present work, is a practice belonging to the development process of the enterprise that is aimed at monitoring the development of the business to identify problems and propose corrective actions (Anprotec, 2018a). The objective of monitoring is to define the moment when the enterprise is ready for graduation and, consequently, for leaving the incubator, so that evaluation instruments must be used to monitor these evolutions.

For monitoring must be defined: measures/indicators that demonstrate qualitatively, quantitatively, or graphically the evolution of companies in five business axes: entrepreneur, technology, capital, market, and management; the frequency in which the collection and analysis of information will take place; who will be the actors involved in the process; and what are the criteria for grading companies (Anprotec, 2018a). CERNE does not establish how this monitoring should be carried out or which criteria should be used. Thus, each incubator must create its model, based on its specificities.

2.2 Organizational performance assessment and performance indicators

For an organization to remain competitive and present quick responses to the market, it is necessary to have control and security at the time of decision-making so that its performance is aligned with the strategies and objectives defined by it (Borges, Coelho & Petri, 2018). Until the end of the 1970s, the focus of performance measurement was only on financial indicators. However, it began to be realized that financial indicators should not be the only basis for measuring an organization's

performance but rather part of a broader set wide range of measures (Eccles, 1991; Lavieri, Corrêa & Cunha, 2015).

It is necessary to identify a balanced amount of financial and operational measures because no single measure can provide an organization's real performance or evidence which are the critical areas of the business (Kaplan & Norton, 1992).

An organizational performance evaluation methodology must be able to: extract from the decision makers the aspects considered relevant for the performance evaluation to take place; measure and evaluate these aspects; and integrate all aspects, allowing a global view of the business (Dutra, 2003).

For performance measurement, performance indicators must be defined. They consist of quantification instruments used to identify quantitative or qualitative elements of a particular event or phenomenon to evaluate it and, thus, facilitate decision-making (Rozados, 2005). For the indicator to be useful to management, it must be standardized and stick to the same measurement method, to allow comparability over time. In addition, it must be measured regularly, aiming at the formation of time series and allowing the visualization of trends in time and data (Rozados, 2005).

For the measurement of performance in companies, there is, in the literature, an infinity of performance indicators that can be used. In this sense, Table 1 presents qualitative and quantitative indicators for monitoring processes and results of incubated companies which are grouped according to the corresponding axis of CERNE.

Table 1

Performance indicators for incubated companies

Axis of CERNE	Indicators	Sources
Entrepreneur	Leadership ability	Chammas and Costa Hernandez (2019)
	Ability to take risks	Morgan and Strong (2003)
	Harmony between business partners	Brinkerhoff (2002)
	Determination and dedication to the business	Díaz-Santamaría and Bulchand-Gidumal (2021)
Technology	Improvement of existing products/services and creation of new products/services	Sulayman, Mendes, Urquhart, Riaz and Tempero (2014)
	Quality and evaluation of the production process	Sulayman *et al.* (2014)
Capital	Billing and revenue growth	Morgan and Strong (2003)
	Financial health indicators	Laitinen (2002); Bulgacov, Bulgacov and Canhada (2009); Díaz-Santamaría and Bulchand-Gidumal (2021)
	Financial planning and control	Bulgacov *et al.* (2009)
Market	Market growth/expansion	Chandler and Hanks (1994); Morgan and Strong (2003); Nunes, Dorion, Olea, Nodari and Pereira (2012)

Axis of CERNE	Indicators	Sources
	Customer relationship and satisfaction	Laitinen (2002); Morgan e Strong (2003); Bulgacov *et al.* (2009); Nunes *et al.* (2012); Sulayman *et al.* (2014); Dobrovic, Lambovska, Gallo and Timkova (2018)
	Degree of dependency of few customers	Bulgacov *et al.* (2009)
	Competitive pricing policy and strategy	Bulgacov *et al.* (2009)
Management	Strategic definitions and planning	Bulgacov *et al.* (2009); Borges, Hashimoto and Limongi (2013); Sulayman *et al.* (2014)
	Definition of company culture and dissemination among employees	Sulayman *et al.* (2014)
	Definition of work standards and monitoring	Sulayman *et al.* (2014); Dobrovic *et al.* (2018)
	Employee satisfaction	Laitinen (2002); Bulgacov *et al.* (2009); Nunes *et al.* (2012); Dobrovic *et al.* (2018)

Source: Prepared by the authors (2020).

2.3 Multicriteria Decision Aid Methodology (MCDA)

Multicriteria analysis emerged as a criticism of the old rational model of Decision Theory, which was based on the conception of a single decision maker and a single criterion with perfect information (Baasch, 1995).

> Decision making is the act of selecting, among several possible decisions, the most appropriate to achieve a certain objective. This choice usually precedes an elaborate process of: adequate representation of the variables and constraints of the problem; survey of viable alternatives; establishment of evaluation criteria for these alternatives; comparison of alternatives; impact analysis of decision making (Goldbarg & Luna, 2005, p. 12).

The relevance of multicriteria decision support methods (Multicriteria Decision Aid – MCDA) is related to the fact that in order to solve most decision problems, there is a need to evaluate different objectives, which are often in conflict with each other (Detoni, 1996).

French author Bernard Roy introduced a general framework, with four steps, to describe the decision support process underlying all MCDA methodologies (Doumpos & Zopounidis, 2002). First, it is necessary to specify the objective of the decision making and a set of possible alternatives to solve the problem, in addition, it must also be defined what type of problem is in which the decision is inserted, as it will direct the choice of method multicriteria that will be used (Campos, 2011; Doumpos & Zopounidis, 2002). Roy (1996) identified four main types of decision problems and one of them is the classification problem, in which the objective is to regroup the alternatives by patterns or similar characteristics and fit them into certain categories.

The second step involves the identification of all factors related to the decision, that is, the criteria and sub-criteria that allow comparing the performance of the alternatives listed based on the decision-maker's preferences (Doumpos & Zopounidis, 2002). Once the criteria have been established, in the third step, the preferences must be modeled and a model must be chosen that meets the

requirements of the nature of the problem (Doumpos & Zopounidis, 2002). Finally, it seeks to provide subsidies to decision-makers through tools so that they will be able to analyze the proposed recommendations (Doumpos & Zopounidis, 2002).

To solve the different types of problems, several methods were developed, among them is the ELECTRE family (Elimination and Choice Translating Algorithm), which is composed of the ELECTRE I, II, III, IV, IS, TRI, TRI-C and TRI-nC methods, which are used according to the type of decision-making problem and its rationality, which can be compensatory or non-compensatory (Gomes & Gomes, 2019; Silva, 2017; Souza, 2017).

In compensatory rationality, there is a trade-off relationship between the criteria, in which there is the idea of compensating a lower performance of an alternative in a given criterion for a better performance in another criterion (Souza, 2017; Vasconcelos, Urtiga, López, Barros & Almeida, 2013). In non-compensatory methods, this rationality does not exist, with a balance between the criteria (Vasconcelos *et al*., 2013; Leão, Almeida & Almeida, 2017; Souza, 2017).

The method used in this work was the ELECTRE TRI, because it is aimed at classification problems and with non-compensatory rationality, thus, considering a set A = [a1, a2, ….. an] of alternatives, the ELECTRE TRI as associates to a set of ordered k-classes C= [c1, c2, ... ck] (Costa, Mansur, Freitas, & Carvalho, 2007). To limit the different classes, reference alternatives are defined that are fictitious and each class has the upper and lower limits constrained by two reference alternatives (Szajubok, 2004).

The method integrates the functions that support the decision maker in the preference process and reduces the cognitive effort required in the modeling phase, classifying the alternatives through the construction of an overclassification relation S, which characterizes how the alternatives are compared to class limits (Costa *et al*., 2007). The outranking relation is constructed to make it possible to compare an alternative a with a limit b_h (Costa *et al*., 2007). In validating the statement aSbh, two conditions must be met (Costa *et al*., 2007; Szajubok, 2004;):

- Concordance: for aSb_h (or b_hSa) to be accepted, a sufficient majority of criteria must be in favor of this claim.
- Non-disagreement: when the agreement condition is not met, none of the criteria should oppose the statement aSb_h (or b_hSa).

In order for the method to establish an overclassification relationship between an alternative a and a reference alternative b_h, the indices must be calculated: partial agreement cj(a,b_h), global agreement c(a,b_h) and partial disagreement dj(a,bh) (Costa *et al*., 2007; Miranda & Almeida, 2003; Souza, 2017; Szajubok, 2004).

$$c_j(a, b_h) = \begin{cases} 0 \; se \; g_j(b_h) - g_j(a) \geq p_j(b_h) \\ 1 \; se \; g_j(b_h) - g_j(a) \leq q_j(b_h) \\ \dfrac{p_j(b_h) + g_j(a) - g_j(b_h)}{p_j(b_h) - q_j(b_h)} \; otherwise \end{cases}$$

$$C(a, b_h) = \frac{\sum_{j=1}^{n} k_j \, c_j(a, b_h)}{\sum_{j=1}^{n} k_j}$$

$$d_j(a, b_h) = \begin{cases} 0 \; se \; g_j(b_h) - g_j(a) \leq p_j(b_h) \\ 1 \; se \; g_j(b_h) - g_j(a) > v_j(b_h) \\ \dfrac{g_j(b_h) - g_j(a) - p_j(b_h)}{v_j(b_h) - p_j(b_h)} \; otherwise \end{cases}$$

To demonstrate how "alternative a outperforms the reference alternative b_h", considering the agreement indices $cj(a,b_h)$ and disagreement $dj(a,b_h)$, one must calculate the credibility index, represented by $\sigma(a, b_h)$ (Szajubok, 2004).

$$\sigma(a, b_h) = C(a, b_h) \prod_{j \in F} \frac{1 - d_j(a, b_h)}{1 - C(a, b_h)}$$

Where: $F = \{ j \in F : dj(a, bh) > C(a, bh) \}$

The values of $\sigma(a,b_h)$, $\sigma(b_h,a)$ and λ determine the preference situations between a and bh (Miranda & Almeida, 2003):

- $\sigma(a,b_h) \geq \lambda$ and $\sigma(b_h,a) \geq \lambda \rightarrow a S b_h$ and $b_h S a \rightarrow a$ is indifferent to b_h;
- $\sigma(a,b_h) \geq \lambda$ and $\sigma(b_h,a) < \lambda \rightarrow a S b_h$ and not $b_h S a \rightarrow a$ is preferable to b_h;
- $\sigma(a,b_h) < \lambda$ and $\sigma(b_h,a) \geq \lambda \rightarrow$ not $a S b_h$ and $b_h S a \rightarrow b_h$ is preferable to a;
- $\sigma(a,b_h) < \lambda$ and $\sigma(b_h,a) < \lambda \rightarrow$ not $a S b_h$ and not $b_h S a \rightarrow a$ is incomparable to b_h.

3 Methodology

This research is classified as exploratory-descriptive with deductive logic and uses qualitative and quantitative techniques to approach the problem. About the technical procedures, the work is considered a case study, having as a unit of analysis a technology-based business incubator linked to a

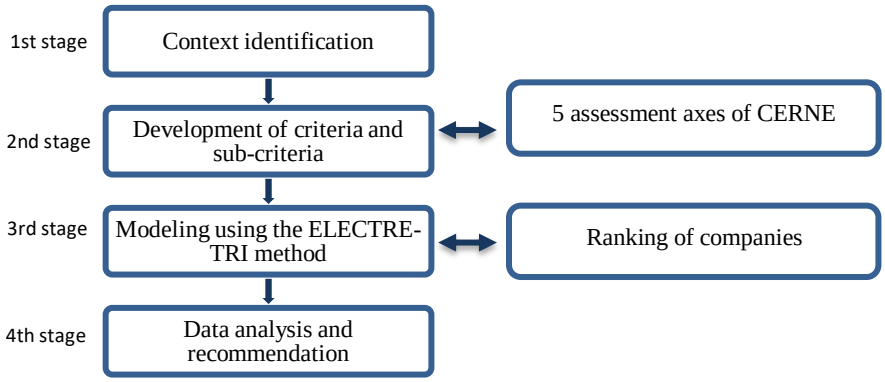
federal university. The incubator was created in 2013 and its mission is to promote the creation and consolidation of innovative ventures in information technology.

For its operation, the incubator offers advisory services, training, physical and technological infrastructure, and has a team formed by an executive manager, an operational manager and four advisors who work in different areas. For the construction of the model, we chose to use the MCDA, using the ELECTRE TRI method, which is focused on classification problems and with non-compensatory rationality.

The problem is one of classification, as the incubated companies were allocated to different classes according to the degree of maturity. In addition, the method chosen has a non-compensatory logic, just there needs to be a balance of the results of each company in the five axes established by CERNE. Thus, a superior performance in one axis can not compensate for an inferior result in another, being necessary that the company has a minimum score in each one of the evaluated axes in order to be classified in a certain class. To build the model, the four steps shown in Figure 2 were followed.

Figure 2

Model construction steps



Source: Prepared by the authors (2020).

Initially, with the support of the decision maker, the problem was structured, also identifying all the actors involved in the process. Then, with the participation of the incubator's advisors and based on the literature review, the sub-criteria were created, that is, the indicators that make up each of the five axes of CERNE. With the determination of the criteria and sub-criteria, the classification classes for the companies were also defined. After building the model, available in Appendix A, we moved on to the modeling stage and, finally, to data analysis and recommendations.

The application of the study took place between the period from May to August 2020. In step 1, to identify the context, observation techniques, document analysis and internal reports of the incubator and semi-structured interview with the decision maker were used. For step 2, a semi-structured interview was carried out with the incubator's advisors, in addition to a meeting with the decision maker to validate the proposed model. The interview scripts can be viewed in Appendices B and C.

For model validation, in step 3, the developed model was applied with three incubated companies and one graduated. In the case of incubated companies, the information necessary to fill in the model was obtained by the incubator's advisors based on the follow-ups carried out with the enterprises throughout the incubation program. As for the graduated company, it was necessary to carry out an interview based on the performance evaluation model created.

4 Results

4.1 Context identification

In the initial stage of building the performance evaluation model, we sought to understand and approach the problem in order to understand: (1) what the decision maker expects at the end of this process; (2) who are the actors involved; (3) the relevance, for the incubator, of the monitoring process of the incubated companies.

Through the interview with the Executive Manager of the incubator, the following minimum requirements were established that must be present in the evaluation:

- Simple model with few indicators.
- Constant monitoring.
- Photograph of the company's situation every six months.
- Contain process and result indicators.
- Based on the notes obtained in the monitoring, the company may be classified into one of the following classes:
    - Disconnected from the incubation program.
    - Able to remain in the incubation program.
    - Able to graduate.

The company needs to be aware that it is being evaluated and what are the rules for its permanence in the incubator, but the monitoring must happen constantly and be carried out by the incubator's own advisors in their respective axes of action. Every six months, the incubator's management will present the entrepreneur with a photograph of the company's results over this period and the comparison with previous evaluations, demonstrating its evolution or decline in performance. The results obtained will reflect in adjustments in the planning and goals of the companies.

The result of the monitoring will allow the incubator to follow the development of the enterprise in order to identify deviations from what was planned and, thus, propose actions that make it possible to reduce problems and/or take advantage of opportunities, enabling the successful graduation, of the company (Anprotec, 2018a).

4.2 Development of criteria and sub-criteria

The model criteria are the axes determined by CERNE: entrepreneur, technology, capital, market and management. For the elaboration of the sub-criteria that make up each axis, the literature review presented in Table 1 and the interviews carried out with the incubator's advisors were taken as a basis.

The monitoring instrument for evaluating the performance of incubated companies includes a total of 23 indicators and each indicator is divided into 5 levels of maturity with predefined answers to avoid variability in the evaluation by the incubator's advisors and, in this way, guarantee that all companies are analyzed by the same parameters. Thus, the following levels were defined: 1. Insufficient; 2. Low; 3. Reasonable; 4. Good; and 5. Excellent.

4.3 Modeling

For the validation of the model and verification of its applicability, three incubated companies and one graduated were randomly chosen. In order to simulate a real application, the scores of the incubated companies were assigned by the incubator's own advisors based on the advice and follow-ups carried out with the companies. Feedback from advisors was collected regarding the ease of application of the model and possible adjustments to the selected indicators.

The evaluation with the graduated company was carried out by the authors in the form of an interview, based on the instrument created. As the company has already left the incubator and is not monitored on a regular basis, it would not be possible to complete the instrument without the interview. The validation of the model with the graduated company was important to verify if the degree of maturity expected for this stage, according to the proposed model, is consistent with reality. Tables 2, 3, 4 and 5 present the scores assigned to each company in each of the indicators.

Table 2

Assessment results - entrepreneurial and technology axes

	Entrepreneur			**Technology**	
	Communication	*Dedication*	*Business partners*	*Improvement*	*Quality*
Company 1	2	5	4	4	4
Company 2	3	5	2	5	5
Company 3	4	5	3	3	4
Graduated	3	5	5	5	5

Source: Research results (2020).

Table 3

Evaluation results - capital axis

	Capital					
	Control	*Planning*	*Invoicing*	*Profitability*	*Gross Margin*	*Contribution Margin*
Company 1	3	2	3	3	2	2
Company 2	3	3	1	1	1	1
Company 3	3	4	3	1	1	1
Graduated	4	5	3	3	2	2

Source: Research results (2020).

Table 4

Result of the evaluation - market axis

	Market					
	Prospecting	*Relationship*	*Price*	*Promotion*	*Dependence*	*Growth*
Company 1	5	5	3	4	5	5
Company 2	5	5	5	5	5	5
Company 3	5	5	3	2	3	4
Graduated	4	4	4	4	4	4

Source: Research results (2020).

Table 5

Evaluation result - management axis

	Management					
	Mission	*Vision*	*Values*	*Strategic planning*	*Monitoring of activities*	*Climate*
Company 1	3	4	3	3	2	4
Company 2	4	4	4	4	3	3
Company 3	5	5	4	3	5	4
Graduated	5	5	5	5	3	2

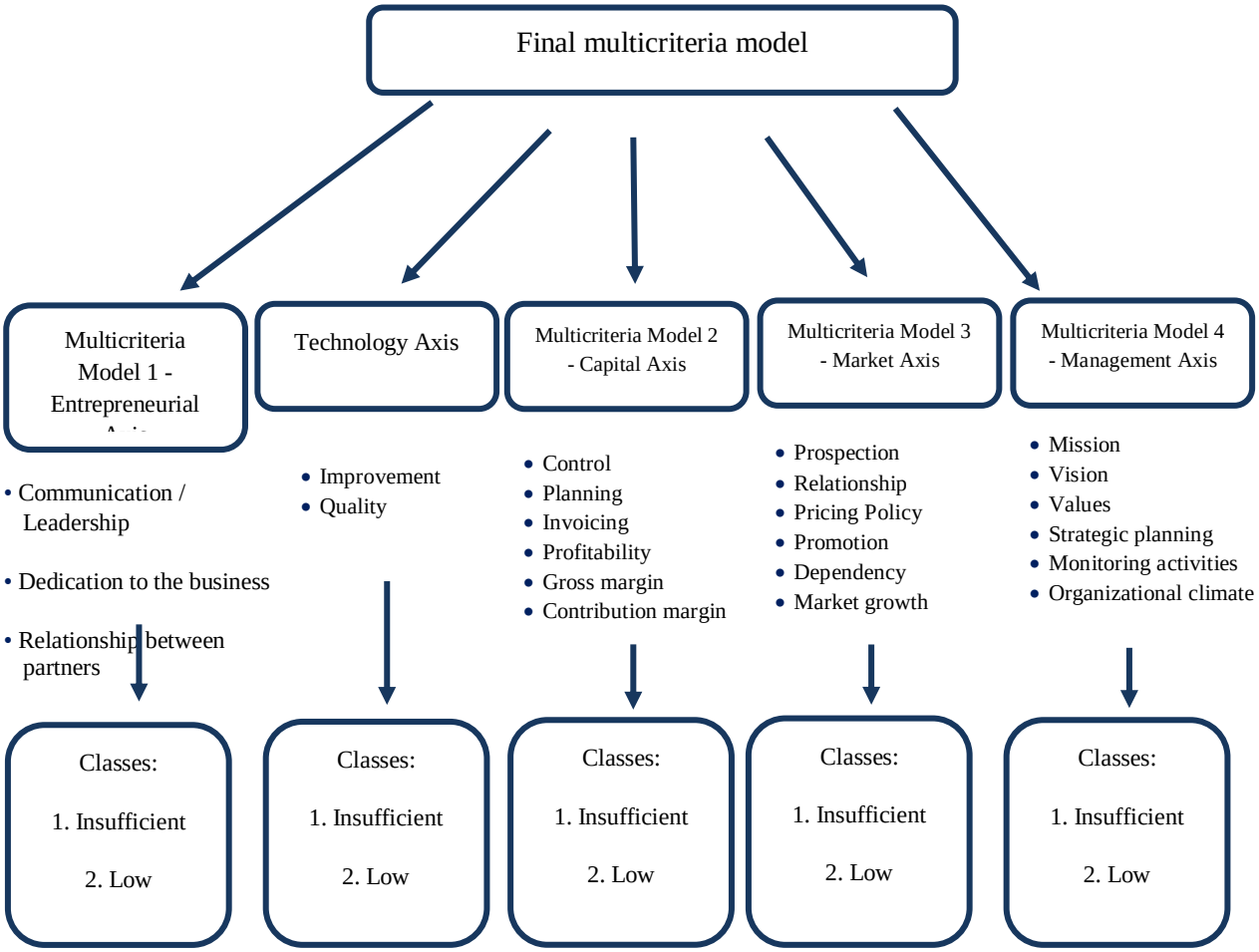
Source: Research results (2020).

The incubation program lasts for up to four years. Company 1 is near the end of its second year and companies 2 and 3 are at the end of their fourth year, being very close to the deadline for leaving the incubator.

After the application with the companies and obtaining the results, we moved on to the modeling stage using ELECTRE-TRI. With the classification problem, the objective is to place companies in a certain class, according to the results obtained during the evaluation. First, the ELECTRE-TRI was used within each axis, as shown in Figure 3, to classify the incubated companies within a class (c) referring to each of the five maturity levels: c1. Insufficient; c2. Low; c3. Reasonable; c4. Good and c5. Great.

Figure 3

Multicriteria models



Source: Prepared by the authors (2020).

Classes are delimited by reference limits (b). The limits, as shown in Table 6, are applied to all indicators (sub-criteria) within the axes: entrepreneur, capital, market and management.

Table 6

Class reference limits for the axes: entrepreneur, capital, market and management

Class	Reference Limits	Limit Values
c1	-	-
c2	b1	2
c3	b2	3
c4	b3	4
c5	b4	5

Source: Research results (2020).

All ELECTRE-TRI calculations were performed using Microsoft Excel spreadsheets. The thresholds of agreement and disagreement were defined by the decision maker, and are, respectively, 0.6 and 0.4. With the parameters defined, the overclassification ratio S is calculated, which characterizes how the alternatives are compared to the class limits (Costa *et al*., 2007).

The technology axis is composed of only two indicators and, therefore, it would not make sense to use a multicriteria method to evaluate it. Thus, it was decided to multiply the scores of the two indicators and the product resulting from this multiplication will be classified in a certain maturity class, as shown in Table 7.

Table 7

Technology axis parameters

Product (∏)	Class
∏ ≤ 3	1
∏ ≤ 6	2
∏ ≤ 10	3
∏ ≤ 16	4
∏ > 16	5

Source: Research results (2020).

After calculating the technology axis and the credibility matrices for the other axes, the companies evaluated were classified into the classes, as shown in Table 8.

Table 8

Classification of companies for each of the axes

Company	Entrepreneur	Technology	Capital	Market	Management
Company 1	4	4	2	5	3
Company 2	3	5	1	5	4
Company 3	4	4	1	3	4
Graduated	5	5	3	4	5

Source: Research results (2020).

This first classification was used as a calculation parameter for the final multicriteria model. The ELECTRE-TRI method was used again to categorize companies into three groups: 1. Unable (company that presents insufficient performance, making it impossible to continue in the incubation program); 2. Satisfactory (company that performs as expected, remaining in the incubator); 3. Able to graduate (the company's results are sufficient for it to grow without the support of the incubator).

Classes are delimited by boundaries (b). The values of the reference limits, presented in Table 9, change every year of the incubation period, with the objective of increasing the rigor for permanence in the incubator. Class 3 limits do not change over the years, because to be considered fit to graduate,

and be able to overcome this limit, the company will need to perform in the criteria of at least "good" (limit 4). To be classified in class 2, companies, year after year, will have to overcome a new limit so that their graduation within the maximum time foreseen for the incubation period is also feasible. Class limits are the same for all axes.

Table 9

Class reference limits for the final model

Class	Reference limits	Limit values/year 1	Limit values/year 2	Limit values/years 3 and 4
c1	-	-	-	-
c2	b1	1	2	3
c3	b2	4	4	4

Source: Research results (2020).

For company 1, the values of class limits for year 2 will be used for each axis. For the others, the values corresponding to year 4 will be used. The thresholds of agreement and disagreement, for the final model, are, respectively, 0.6 and 0.4. Then, there is the calculation of the overclassification ratio S, as shown in Table 10.

Table 10

Final model credibility matrix

Credibility matrix		
	b1	b2
Company 1	1	0
Company 2	1	0
Company 3	1	0
Graduated	1	1

Source: Research results (2020).

4.4 Recommendations

According to Gomes and Gomes (2019), it is important to verify how variations applied to the characteristic parameters of the method influence the results obtained. This check is called sensitivity analysis. Thus, it was decided to verify the impacts by changing the thresholds of the agreement to 0.7 (previously 0.6) and disagreement to 0.3 (previously 0.4), thus increasing the model's demand.

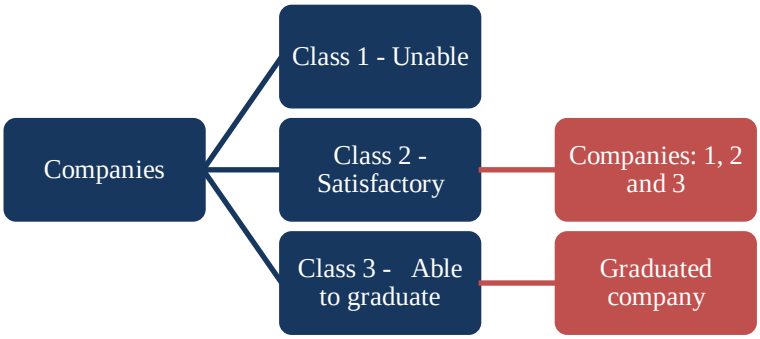
With a higher level of demand for multicriteria models, there were changes in the results of company 2, which is now in class 1 of the final model, being classified as unable to remain in the incubator; and the graduated company, which with the change is qualified for group 2, presenting only satisfactory results. This analysis showed that a low increase in the threshold of the agreement made the final model more rigorous and demanding, making it difficult for companies to break the limits of class references.

Thus, the ideal parameters for the model are: the threshold of the agreement being 0.6 and the of disagreement being 0.4. These values are for both the final multicriteria model and the axes. The changes that occurred in the sensitivity analysis made the model more demanding, not presenting the appropriate parameters for decision-making.

Figure 4 represents the final ranking of companies based on the chosen parameters. Company 1 is in an appropriate class for its incubation period, as well as the graduated company, which was classified in class 3. Companies 2 and 3, as they are very close to the final incubation period, should have been classified in class 3, as there is not enough time for them to evolve in various processes and results and thus reach the expected level of maturity to leave the incubator as graduates.

Figure 4

Classification of companies



Source: Prepared by the authors (2020).

Some factors may have contributed to these results: 1. Not all processes and results listed in the performance measurement instrument were monitored and guided by the advisors, causing a drop in the performance of companies 2 and 3; 2. The current economic situation has brought negative impacts, hindering the results obtained; 3. As there are no defined parameters for companies with low performance and/or low participation in the incubator's actions to be turned off, incubated companies that do not have a chance to graduate continue to participate in the incubation program even without obtaining satisfactory results.

With the validation, it was noticed that, with the accompaniments carried out by the advisors, it is possible to obtain more easily the necessary information for the evaluation of the companies and that the listed indicators are sufficient for effective measurement of the performance of the incubated enterprises.

The multicriteria methodology supports the decision-maker in his decision-making process, presenting the best possible result according to the established criteria and parameters. The method allowed incorporating the values and preferences of the incubator manager, providing adequate subsidies for more assertive decisions and improvements in the management of the incubator. The information generated by the created model will serve as a basis for the decision-making process

concerning the performance of the incubated company and its permanence in the incubator, whether its exit occurs due to good performance (able to graduate) or for performance below what is considered the minimum for its incubation time.

The results will facilitate the decision-making process but will not be the only source of information for decision-making, also influencing economic and market aspects that can impact the company's results, such as its participation in the actions of the incubation program. The information from the monitoring instrument will also be used to adjust the companies' action plans and goals so that they can improve their performance.

5 Conclusions

As incubators propose to develop financially sustainable companies, they must have well-defined processes and criteria, both for the selection of companies that will participate in their incubation process, as well as for monitoring and evaluating the maturity of these companies, to that, it is possible to more easily see the troubles of these enterprises and ensure that the support offered during the incubation period is more As incubators propose to develop financially sustainable companies, they must have well-defined processes and criteria, both for the selection of companies that will participate in their incubation process, as well as for monitoring and evaluating the maturity of these companies, to that, it is possible to more easily see the troubles of these enterprises and ensure that the support offered during the incubation period is more effective.

A performance evaluation model was created with 23 indicators in total, which was divided as follows: entrepreneurial axis – 3 indicators; technology axis – 2 indicators; capital axis – 6 indicators; market axis – 6 indicators; and management axis – 6 indicators. The MCDA was used and the mathematical modeling was done using the ELECTRE-TRI because it is a problem of classification of non-compensatory logic, in which the purpose is to fit each incubated company into different classes according to its level of performance.

The MCDA allowed a better understanding of the problem and the context in which it is inserted. It was possible to evaluate alternatives and establish parameters to help the manager in the decision-making process and, thus, indicate the possible directions to be followed. The monitoring model created will be important for the incubator to carry out more accurate monitoring of its incubated companies and thus better target the services offered, providing greater value delivery to companies.

A perceived limitation in the development of this research was that the model developed fits the reality of the incubator studied. The multicriteria methodology makes mathematical modeling according to the values and preferences of the decision maker, thus, it is not intended to generalize the results. However, this research also opens the possibility of applying the performance evaluation model in companies incubated in other incubators to test its applicability in different realities, making, when necessary, some adjustments in the indicators or the parameters of the multicriteria models.

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Appendix A

Monitoring instrument

Entrepreneur	
Indicator	**Grade**
Communication/Leadership 1. The entrepreneur does not have a good dialogue with the team and has difficulty in delegating activities. 2. The entrepreneur communicates clearly, but continues to centralize activities. 3. The entrepreneur communicates clearly and can delegate activities satisfactorily. 4. The entrepreneur manages to engage and stimulate the team to achieve the objectives and goals. 5. The entrepreneur manages to maintain a good relationship with the team, monitor the performance of the activities transferred and propose improvement actions.	
Dedication to the business 1. The time dedicated to the business is not enough for the development of the company. 2. The time dedicated to the business is low and there are no indications and actions for a more effective participation. 3. The time dedicated to the business is low, but there are signs and improvement actions for a more effective participation. 4. The time dedicated to the business is reasonable and there are signs and improvement actions for an even more effective participation. 5. The time dedicated to the business is sufficient for the development of the company.	
Relationship of partners 1. Relationship and communication problems are identified among members that are not perceived by them. 2. The partners know that they have relationship and communication problems, but they do not develop improvement actions. 3. The partners know that they have relationship and communication problems, they develop actions for improvement, but without satisfactory results. 4. The partners present relationship and communication problems and develop actions for improvement with satisfactory results. 5. Members do not have relationship and communication problems.	
Technology	
Product/Service Improvement Process 1. No improvements are made to products/services. 2. Corrections and adjustments are made, reactively, to products/services based on customer feedback. 3. Improvements are made to products/services or new products/services are created, but without consulting the market's needs. 4. Market needs and demands are identified to make improvements to existing products/services or to create new products/services. 5. A process or methodology is established to identify market demands and needs, aiming to improve existing products/services or to create new products/services. Indicators and targets are also established to monitor this process and enable improvements.	
Quality of products/services 1. There are no parameters to assess the quality of the product/service. 2. Quality monitoring is not done in a systematic way, occurring only at the initiative of the customers. 3. Evaluation parameters and a process for collecting information are established. 4. The company establishes action plans to improve the production process and products/services based on customer feedback. 5. Indicators and targets are established for monitoring and improving the process.	
Capital	
Financial control 1. Cash control is not carried out. 2. Cash control is carried out, but there is no identification of fixed and variable costs/expenses, and there is no separation by cost center. 3. Cash control is performed with identification of fixed and variable costs/expenses, with a separation by cost center.	

4. Possible cost reductions are identified. 5. Indicators are established for the analysis of financial control and actions and goals are defined to achieve strategies defined by the company.	
Financial planning 1. Does not make financial projections. 2. Makes financial projections for control purposes only. 3. Makes financial projections for the achievement of short-term strategies and action plans. 4. Makes financial projections for the achievement of medium-term strategies and action plans. 5. Indicators and goals are established for the achievement of strategies defined by the company.	
Invoicing* 1. Achieved the target by up to 30%. 2. Achieved target between 30.1%-60%. 3. Achieved target between 60.1%-80%. 4. Achieved target between 80.1%-100%. 5. Exceeded the target.	
Profitability* 1. Achieved the target by up to 30%. 2. Achieved target between 30.1%-60%. 3. Achieved target between 60.1%-80%. 4. Achieved target between 80.1%-100%. 5. Exceeded the target.	
Gross Margin* 1. Achieved the target by up to 30%. 2. Achieved target between 30.1%-60%. 3. Achieved target between 60.1%-80%. 4. Achieved target between 80.1%-100%. 5. Exceeded the target.	
Contribution Margin* 1. Achieved the target by up to 30%. 2. Achieved target between 30.1%-60%. 3. Achieved target between 60.1%-80%. 4. Achieved target between 80.1%-100%. 5. Exceeded the target.	
*For companies with more than one product/service, do it segmented as well.	
Market	
Prospection 1. There is no defined process for attracting customers. 2. The company is aware of who its potential customers are, minimally defines some actions for prospecting and attracting customers, but still does not have well-defined processes or consistency in execution. 3. A sales pipeline is defined and put into practice, with reasonable results. 4. Strategies for market expansion are defined and put into practice, with satisfactory results. Strategies are based on market analysis and the customer journey process. 5. Has full control over the process of prospecting and attracting customers, in addition to establishing indicators and goals for monitoring and improving the process.	
Relationship with customers 1. There is no policy for customer relationship and retention, nor are official service and communication channels established. 2. There is no policy for customer relationship and retention, but official service and communication channels are already in use. 3. Customer relationship and retention strategies are defined and implemented, but satisfaction surveys are not yet carried out. 4. Evaluations are carried out regarding customer satisfaction and their experience in using the product/service. 5. It has a good level of customer satisfaction, service and communication channels are well defined and indicators and goals are established for monitoring and improving the process.	
Pricing policy 1. There is still no clear definition of the best pricing policy to be adopted.	

2. The pricing policy adopted is not based on the company's costs and expenses, nor on a market positioning strategy. 3. Has a defined and satisfactory pricing policy, considering the analysis of the competition. 4. The definition of the price policy used was based on information related to: costs and expenses, market positioning, profit margin targets, among other points. 5. The company has consolidated its pricing policy and demonstrates the ability to make periodic reviews when necessary.	
Promotion Strategies 1. Actions to promote the company and the product/service are not defined. 2. Minimum actions to promote the company and the product/service are defined. 3. The company periodically collects information about the market to define the company's and product/service promotion strategies, which are aligned with the company's strategic planning. 4. Strategic actions to promote the company and the product/service are well executed and bring satisfactory results. 5. Masters the execution of promotion strategies and defines indicators and targets for monitoring and process improvements.	
Dependence on few customers 1. There is a high dependency on few customers. 2. There is a dependence on few customers, but it defines and executes an action plan to acquire new customers. 3. There is a low dependency on a few clients, with satisfactorily controlled risk. 4. The customer portfolio is diversified, with no dependence on a few customers. 5. The diversification of the customer portfolio allows financial stability for the business, with no dependence on a specific group of customers.	
Market growth 1. The number of customers/sales volume is still insignificant and there are no actions to expand the market. 2. Actions are taken to expand the market, but there is no significant variation in the number of customers/sales volume. 3. The number of customers/sales volume is growing, but still not at the desired level. 4. The number of customers/sales volume shows significant growth and is close to the desired level. 5. The number of customers/sales volume shows significant growth and is at a higher than desired level.	
Management	
Mission 1. There is no defined mission. 2. The mission has been defined, but it is not coherent with the purpose of the business or does not match the moment experienced by the company. 3. The defined mission is aligned with the purpose of the business and with the moment experienced by the company, but it is not yet disseminated and known by the company's employees. 4. The defined mission is aligned with the purpose of the business and with the moment experienced by the company and actions are defined that reinforce its importance and knowledge by everyone in the company. 5. The company has a consolidated mission that is known and lived by all employees, being used as a basis for the development of the business.	
Vision 1. There is no defined vision. 2. The vision has been defined, but it is not coherent with the company's desired destination or does not match reality. 3. The defined vision is coherent with the reality and with the desired destination, but it is not known by the company's employees. 4. The vision is known and experienced by all company employees and managers see its relevance to the development of the business. 5. The company establishes action plans to achieve the vision and demonstrates the ability to make periodic reviews to outline new visions.	
Values 1. There are no defined values. 2. Values were created, but in a generic way.	

3. The values created are consistent with the principles desired by the company, but are not yet experienced and known by its managers and employees. 4. The values created are consistent with the principles desired by the company and actions are defined that reinforce the knowledge of the values by everyone in the company. 5. The values are known and lived by the company's managers and employees.	
Strategic planning 1. There is no definition of objectives and strategies. 2. Objectives and strategies are defined, but not aligned with the company's mission, vision and values. 3. Objectives and strategies are defined, aligned with the company's mission, vision and values, and broken down into action plans. 4. Indicators and targets are defined to monitor the achievement of objectives, strategies and business development. 5. The company masters the strategic planning process and can successfully create and execute it.	
Monitoring of activities 1. There is no clear definition of roles and responsibilities, and there is no defined process for transferring and monitoring activities. 2. Roles and responsibilities are defined and there is a defined internal communication process to transfer and monitor activities and their results. 3. Tools are used to monitor activities and their results. 4. A feedback and performance evaluation process is established for employees and managers. 5. Individual and sector performance goals are defined that are aligned with the company's objectives and goals.	
Organizational climate 1. Actions to improve interpersonal relationships and team integration are not promoted. There are also no defined processes to identify employee satisfaction and organizational climate. 2. The company promotes, in an unstructured way, actions to improve interpersonal relationships and team integration, but there is no monitoring of employee satisfaction and organizational climate. 3. The company promotes, in a structured way, actions to improve interpersonal relationships and team integration, but there is no monitoring of employee satisfaction and organizational climate. 4. The company promotes, in a structured way, actions to improve interpersonal relationships and team integration, carries out evaluations to identify employee satisfaction and organizational climate, in addition to establishing a feedback process. 5. The company obtains positive results in the actions and evaluations carried out.	

Appendix B

Interview script to identify the context

Interviewee: Executive Manager of the Incubator

Date of the interview: ___/___/____

1. What is the relevance of the process of monitoring and evaluating incubated companies?
2. How is the performance evaluation of incubated companies currently carried out?
3. What are the positive aspects of the current form of evaluation?
4. What is the problem with the current form of evaluation?
5. Who are the participants in the process?
6. What information would you like to have/view with this follow-up?
7. What is the result, expected by you, of this follow-up process?
8. Are there any factors that make it difficult or prevent the incubator from monitoring companies?
9. What would be the classification categories of companies during the incubation program period?
10. What results are expected from a graduated company? What criteria are considered to classify this company as succeeding outside the incubator?
11. What are the main processes that must be monitored by the incubator?
12. What are the main results that an incubated company must achieve to be considered graduated?
13. What are the main difficulties faced by companies?
14. Which companies stand out positively and why? What processes do they perform differently? What results do they show?

Appendix C

Interview script – Advisors

Interviewed:

Position/function:

Occupation area:

Interview date: ___/___/____

1. How do you characterize a company as being successful?
2. What are the main processes in your area of activity that should be monitored by the incubator? Are all these processes essential? Are these processes adequate to the reality of the incubated companies?
3. What are the main results that an incubated company must achieve, in its area of activity, to be considered graduated? Are these results adequate with the reality of the incubated companies?
4. What are the main difficulties faced by companies?
5. Which companies stand out positively and why? What processes do they perform differently? What results do they show?
6. Are there factors that make it difficult or prevent companies to monitor?